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The Mortgage Debt Channel of Monetary Policy when Mortgages are Liquid

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The Mortgage Debt Channel of Monetary Policy when Mortgages are Liquid*

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Abstract

We examine what is widely considered to be one of the strongest channels of monetary policy transmission into household spending – the effect of changes in mortgage payments when mortgage rates are linked to the short-term policy rate. Using bank transactions data from Australia, we analyze a cumulative 425 basis point increase in the central bank policy rate, which caused mortgage repayments for homeowners with adjustable-rate mortgages to increase by $13,800. We find little change in the spending of adjustable-rate mortgagors relative to fixed-rate mortgagors. This is because adjustable-rate mortgages come with redraw facilities that make mortgages liquid, and households had large excess buffers due to pandemic-era transfer programs and restrictions on spending. Our findings demonstrate that the direct effects of a monetary policy tightening on household spending need not be large.

Keywords: monetary policy, spending, borrowing, liquid wealth, mortgage market design

JEL: E21, E52, G21

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1 Introduction

The post-pandemic monetary policy tightening cycle has been the sharpest and most globally synchronized cycle since at least the 1970s.[1] We investigate how this affected household spending through higher required mortgage repayments – generally considered to be one of the most powerful channels of monetary policy transmission. According to this channel, a higher central bank policy rate raises mortgage rates and hence required repayments on adjustable rate mortgage debt, reducing disposable income and lowering spending.

It is widely believed that monetary policy is more potent in economies with a larger share of adjustable rate mortgage debt. Bernanke (2007) hypothesizes that if households' cashflows affect their spending, then changes in the policy rate will have a more immediate effect on spending if mortgages are predominantly adjustable than fixed rate. Auclert (2019) infers from a model that increasing the share of adjustable rate mortgages would raise the sensitivity of aggregate consumption to monetary policy. These predictions assume a sizable share of adjustable rate mortgage holders have a large MPC out of required mortgage repayments, which is likely to be the case if households have low liquid saving buffers they can draw upon.

Australia provides an ideal setting to study this channel of monetary policy transmission. Australia has among the highest shares of adjustable rate mortgage debt in the world (Calza, Monacelli and Stracca, 2013) and the pass through of changes in the central bank's policy rate onto adjustable mortgage rates is rapid, with interest rate changes typically passed on within two weeks. Around a third of households have a mortgage and households with a mortgage account for over 50 percent of private income. The household debt to income ratio is the third highest of any OECD country (OECD, 2025). Taken at face value, these observations suggest that when the Reserve Bank of Australia (RBA) raised the policy rate from its effective lower bound of 0.1 percent to 4.35 percent between May 2022 and November 2023, leading to a cumulative increase in average adjustable rate mortgage repayments of $13,800, it would have a potent effect on household spending.

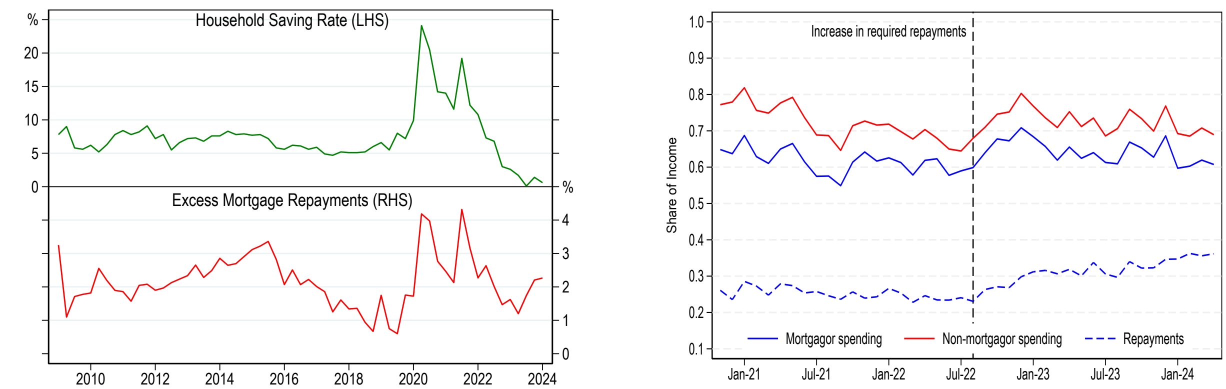
But this narrative misses an important structural feature of the Australian mortgage market. Households with adjustable-rate mortgages can make excess repayments on their loan which reduces the balance on which interest is charged. These excess repayments can be redrawn from the mortgage in the future at the borrower's discretion, typically at no additional cost. Since mortgage interest rates are higher than deposit interest rates, these excess repayment buffers effectively provide adjustable-rate mortgagors with a high-return, liquid, risk-free savings account. Prior to the RBA starting its tightening cycle in May 2022, households had accumulated particularly large excess repayment buffers, as a result of pandemic-era transfer payments and mobility restrictions which reduced consumption (Figure 1a).

We start with a simple analytical model to explain how adjustable-rate mortgages work, and to analyze how the option to accumulate an excess repayment buffer affects the behavior of adjustable-

[1] See Forbes, Ha and Kose (2024) who analyze policy rate cycles for advanced economies. They find that the post-pandemic policy rate cycle has been the most aggressive tightening cycle over the past 50 year, with the fastest transition from an active easing to tightening phase.

Figure 1: Background

(a) Savings (b) Consumption by Mortgage Status



Notes: Panel (a) shows the household saving ratio and excess mortgage repayments as a share of household disposable income. Panel (b) shows mean spending of mortgagors and non-mortgagors as a share of mean income for each group. *Repayments* is mean mortgage repayments by mortgagors, as a share of mean mortgagor income.

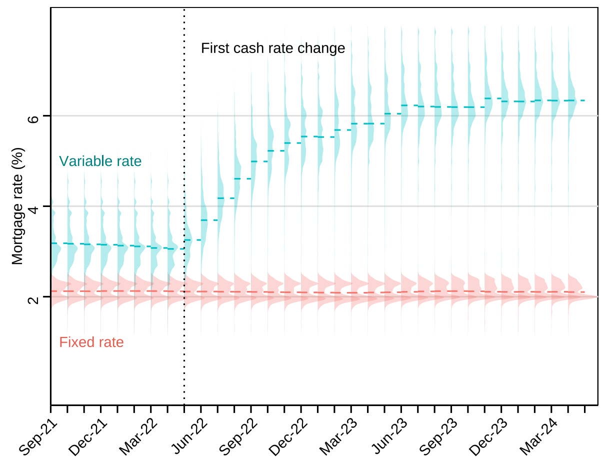
Summary: Mortgage repayments rose by around 10 percent of income for mortgagors between mid-2022 and early 2024. Despite this, there was little change in spending of mortgagors relative to non-mortgagors. Consumption smoothing for mortgagors was facilitated by a large increase in saving during the pandemic, part of which was accumulated in the form of excess mortgage repayments.

rate mortgagors when the mortgage interest rate rises. Our model can rationalize a wide range of spending responses. The spending response is smaller when the share of mortgagors with an excess repayment buffer is larger, and the smaller is the intertemporal elasticity of substitution. These mortgagors smooth consumption in response to higher required repayments by drawing down on their buffers. The spending response is larger if the share of hand-to-mouth households is large, or if the intertemporal elasticity of substitution is large. The wide range of theoretical possibilities motivates our empirical investigation of the effect of monetary policy in a setting where mortgage rates are adjustable.

We find a only a small spending response to the large and sharp 425 basis point monetary policy tightening by the RBA starting in May 2022. A comparison of spending for mortgage and non-mortgage holders previews our results (Figure 1b). Despite the large increase in required mortgage repayments, relative spending for the two groups remained little changed until at least early 2024. These results provide a cautionary tale. Even in a country with a high share of adjustable rate mortgages, where the transmission from interest rates to required repayments is large and immediate, the effect on spending of increased required repayments need not be large.

Our main identification approach is based on a comparison of spending for households with fixed and adjustable-rate mortgages. While the share of fixed rate mortgages has historically been low in Australia, there was a sharp take-up during the pandemic. This was in part because the RBA provided a three year term funding facility at 0.1 percent, which banks could access to fund fixed rate mortgages. The term funding facility complemented the RBA's forward guidance that the

Figure 2: Distribution of Interest Rates



This figure shows the mean (horizontal bars) and distribution of interest rates classified as adjustable and fixed in our sample.

Summary: Interest rates on adjustable rate loans increased noticeably relative to fixed rate loans during the RBA's tightening cycle.

policy rate would remain at 0.1 percent until at least early 2024. Fixed rate mortgages constituted approximately 40 percent of new mortgage lending in 2020 and 2021. Most fixed rate mortgages had a 2 or 3 year fixed-interest period, automatically reverting to adjustable rate loans on expiry.

We construct a monthly dataset of bank accounts based on aggregated, consented and de-identified transaction data. The dataset is based on mortgage accounts and linked transaction and saving accounts for customers of a large Australian bank. Spending is measured from flows out of transaction accounts, as in Ganong and Noel (2019). We show that the data are representative of the population of mortgage holders.

We adopt an event study framework and compare the evolution of spending and other variables for adjustable-rate mortgagors to fixed-rate mortgagors. Interest rates on adjustable-rate mortgages rose noticeably compared to interest rates on fixed rate mortgages after the RBA commenced its tightening cycle (Figure 2). This resulted in mortgage repayments increasing by an average of $13,800 cumulatively for adjustable-rate relative to fixed-rate mortgagors. Despite this large increase in repayments for adjustable rate borrowers, we find little change in non-durable, durable and services spending for adjustable rate mortgagors relative to fixed rate mortgagors. There was also little difference in income between fixed and adjustable rate mortgagors over this period. In an accounting sense, our results are mostly explained by a drawdown of liquid assets by adjustable rate mortgagors. Lower liquid bank account balances paid for 70 percent of the increase in repayments, with the remainder mostly coming from additional net inflows.

We discuss and address threats to identification from selection into mortgage type, attrition and anticipatory behavior. Observable characteristics of fixed and adjustable rate mortgage holders are broadly similar and substantial common support allows us to perform robustness exercises to control for the observable differences that do exist. Another concern is that short panel dimension of our dataset may prevent us from observing the conversion of expired fixed-rate mortgages to adjustable rate mortgages. However, few fixed-rate mortgages expired prior to 2023 and the panel dimension of the dataset is sufficient to address this concern. Finally, the limited difference in spending between adjustable and fixed rate mortgagors could partly reflect fixed rate mortgagors reducing spending in anticipation of expiry to adjustable rate loans with higher repayments. We address this concern with a supplementary analysis comparing spending of mortgagors and non-mortgagors, which shows little difference in spending between the two groups, reinforcing the results of the main analysis.

In the final section, we use our analytical model to compute the overall effect of the interest rate rise on both adjustable and fixed-rate mortgagors, so as to get an estimate of the "missing intercept" that comes from common intertemporal substitution effects. We find that the intertemporal substitution motive leads to a small common spending drop for the two mortgagor types. We estimate this component of the missing intercept to be less than one-half of a percent of consumption.

We stop short of attempting to use a general equilibrium structural model to measure the part of the missing intercept that operates through the labor market and other equilibrium channels. Instead, we consider the implications of our estimates for the overall effect of monetary policy on household consumption by constructing plausible macroeconomic counterfactuals. Had the RBA kept interest rates unchanged through to 2024 — as signaled until early 2022 — our estimates imply that aggregate consumption would have been no more than 1 percent higher at the peak. In contrast, a representative optimizing household model with unitary elasticity of intertemporal substitution would imply 5 percent higher spending at the peak. For one to believe that the aggregate effect were this large, it would mean that the mortgage debt channel explains no more than one-fifth of the overall response predicted by a standard model. While it is possible that other equilibrium channels of monetary policy could explain the remainder, we think this is unlikely. Indirect effects operating through wealth, labor demand and the exchange rate were likely small – there were few constrained households implying small wealth effects; the unemployment rate was at 50-year lows, implying limited scope for labor demand; and the real exchange rate appreciated only modestly over this period. Therefore we conclude that monetary policy likely had at most a small effect on aggregate consumption in this episode.

Overall, our findings suggest that structural features that make mortgages liquid matter a lot. In this episode, mortgagors were able to smooth their consumption because they had a high level of liquid assets going into the tightening cycle. In the 5 years prior to the pandemic, households had accumulated excess repayments buffers that averaged 26 percent of required repayments. Excess repayment buffers rose to 42 percent of required repayments during the pandemic period (RBA, 2025). Although in this period, the level of excess repayment buffers dampened the transmission of the monetary tightening, in general the these buffers vary over time, indicating the effect of monetary policy via the mortgage debt channel may be larger in periods where buffers are substantially smaller.

Related literature We contribute to a growing literature on the transmission of mortgage rate changes to household consumption. Important early papers in the literature are Di Maggio et al.

(2017) and La Cava et al. (2016). Di Maggio et al. (2017) find a large increase in car purchases upon reset of fixed rate mortgages to lower-rate adjustable rate mortgages in the 2010-2012 period in the US. La Cava et al. (2016) exploited the fall in required repayments on adjustable relative to fixed rate mortgages in Australia at the onset of the financial crisis and estimate that households with adjustable-rate mortgages predominantly used additional funds to increase mortgage prepayments. Agarwal et al. (2022*b*) also study the effect of unexpected interest rate decreases during the financial crisis period. They compare credit card spending of mortgagors and non-mortgagors and infer an MPC of 0.4-0.5.

In contrast to the earlier literature, recent work has exploited more comprehensive administrative data to measure consumption. Flodén et al. (2021), Ahn, Galaasen and Mæhlum (2024) and Caspi, Eshel and Segev (2024) exploit variation in households' exposure of mortgage debt to short-term interest rates. They estimate large MPCs in response to changes in disposable income: 0.19-0.50 (Flodén et al., 2021); 0.185-0.38 (Ahn, Galaasen and Mæhlum, 2024) and; 0.4 (Caspi, Eshel and Segev, 2024). Caspi, Eshel and Segev (2024) find spending responses to be largest for mid- to lower-income households while Flodén et al. (2021) found the most pronounced effects for households with low liquidity. In contrast, Ahn, Galaasen and Mæhlum (2024) find variation in spending responses across the liquidity distribution only in the first few months after an interest rate change.

A related literature examines refinancing activity. Abel and Fuster (2021), Agarwal et al. (2022*a*) and Bracke et al. (2024) all find a relative increase in spending for mortgagors who experience a fall in interest rates or can extract housing equity when refinancing.

Most of the literature has studied spending responses to increased disposable income from mortgage rate decreases (Di Maggio et al., 2017; La Cava et al., 2016; Agarwal et al., 2022*b*) or averages over increases and decreases (Ahn, Galaasen and Mæhlum, 2024; Flodén et al., 2021). This matters because households may respond asymmetrically to increases and decreases in cash flow (Baugh et al., 2021). There is disagreement in the literature whether responses are asymmetric for mortgage repayments. Kartashova and Zhou (2023) apply the Di Maggio et al. (2017) research design to Canadian data over a period with increases and decreases in policy interest rates. They find similar effects to Di Maggio et al. (2017) for decreases but no effect for increases. However, Caspi, Eshel and Segev (2024), who study the effect of a large post-pandemic rise in interest rates in Israel, estimate large consumption responses.

Our setting differs from most of the literature because we study consumption responses to a large increase in required repayments in an environment where adjustable rate mortgages are liquid and households had accumulated large savings buffers. Consistent with our findings, Aisbett et al. (2024) find no significant response of non-durable spending to the 2008 economic stimulus payments in Australia—in contrast to estimates for equivalent payments in the U.S. (Parker et al., 2013)—which they attribute to the relative liquidity of Australian mortgages.

2 Background on adjustable rate mortgages in Australia

Adjustable-rate mortgages In Australia there are two types of mortgages: adjustable and fixed-rate. The most common, which have historically accounted for 85 per cent of new lending, are adjustable rate mortgages. Changes in the central bank's policy rate, the cash rate, typically result in changes in the interest rate on adjustable-rate mortgages within two weeks. Adjustable rate mortgages work as follows. At time t, an adjustable rate mortgage contract is defined by a scheduled nominal debt level D_t^{sch}, the number of years remaining on the contract N_t, and the current nominal interest rate i_t. The required nominal level of repayments at time t is M_t, and is calculated as the constant repayment amount needed to repay the scheduled debt at the current interest rate i_t:

$$D_t^{sch} = \int_0^{N_t} M_t e^{-i_t \tau} d\tau \tag{1}$$

which implies

$$M_t = \frac{i_t D_t^{sch}}{1 - e^{-i_t N_t}}. \tag{2}$$

The semi-elasticity of required repayments with respect to the nominal interest rate is

$$\frac{dM_t/M_t}{di_t} = \frac{1}{i_t}\left(\frac{1 - (1 + i_t N_t)\, e^{-i_t N_t}}{1 - e^{-i_t N_t}}\right). \tag{3}$$

The semi-elasticity is large when the remaining term on the mortgage N_t is long and the level of the interest rate i_t is low. To put this in perspective, the 4.25 percentage point increase in interest rates observed over our sample would have raised required repayments by approximately 40 percent for an adjustable rate mortgagor with a $N = 20$ year remaining loan term.

Consumption response for hand-to-mouth households Conventional wisdom regarding the consumption response to a change in interest rates for an adjustable-rate borrower assumes that the household consumes its disposable income each period. Required mortgage payments decrease disposable income and therefore a higher interest rate has a large direct effect on spending. For a household with repayments equal to 30 percent of spending prior to the interest rate rise, as in our data (Table 1), the increase in required repayments from the 4.25 percentage point rise is about 10 percent of spending. Therefore, a hand-to-mouth household would have to sharply reduce their spending.

Redraw facilities on adjustable rate mortgages This, however, is not a good description of many adjustable rate mortgagors in Australia. Adjustable rate mortgages come with a redraw facility that allows households to make excess mortgage repayments at no cost, and withdraw those repayments at their discretion.[2] We refer to the time t balance of these past voluntary payments as

[2] There are two types of redraw accounts. All adjustable-rate mortgages have redraw accounts where excess repayments are stored. It takes a day to redraw these excess payments. In addition, around half of all adjustable-rate mortgages contain offset accounts. These are transactions accounts that are linked to a mortgage. An individual's mortgage balance is reduced or "offset" by the balance in their offset account, reducing the interest that has to be paid. Funds in an offset account are at call. Banks charge a small fee for offset accounts. In this paper we use the term "redraw" to refer to both redraw and offset accounts as they are both liquid accounts where adjustable-rate mortgagors can accumulate savings.

their redraw balance, denoted by R_t, which must be positive and cannot be bigger then the scheduled debt, $0 \leq R_t \leq D_t^{sch}$. The net outstanding debt owed, denoted by D_t, is the scheduled debt level, less the redraw balance, so $D_t = D_t^{sch} - R_t$.

Having a positive redraw balance does not change the required mortgage repayments but does reduce the interest expense, which is calculated based on the outstanding balance. This in turn reduces the remaining term of the mortgage which becomes an endogenous choice, that we denote by N^*. However, the duration used in calculating required repayments is unaffected and remains the originally contracted end date.

An adjustable rate mortgage with a redraw facility is therefore effectively a high-return, very liquid, saving account that co-exists alongside the mortgage, with a maximum allowed balance of D_t^{sch}. Interest savings earned on redraw balances are not taxed. An adjustable rate mortgage is high-return because the real mortgage interest rate r^d exceeds the real interest rate on bank deposits r^a, and because of the tax treatment of mortgage payments and interest earnings in Australia. Owner-occupier mortgage interest is not tax deductible in Australia but saving on deposit accounts is taxed at full marginal rates. Therefore there is a strong incentive for adjustable rate mortgagors to save through redraw facilities, and around 90 percent do. Given these incentives, it is also reasonable to assume that households that do not have a redraw balance are likely hand-to-mouth households - on a risk and liquidity adjusted basis, saving through a redraw account likely dominates all other forms of saving.

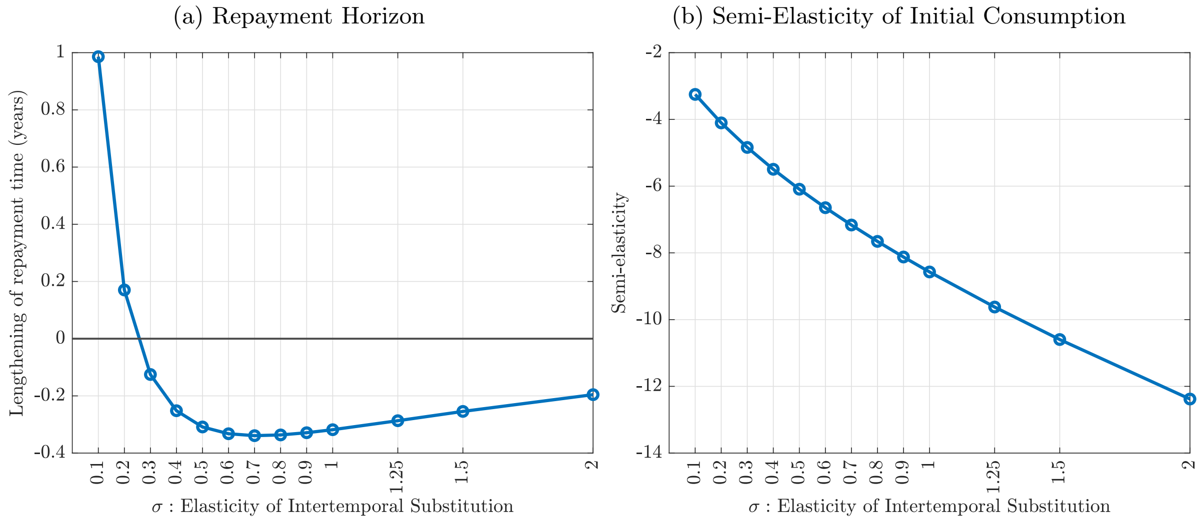
Consumption response for households with a redraw balance To understand how a change in interest rates affects spending for a borrower with a redraw account, we need to know how their repayment behavior changes. In Appendix A, we analytically solve a deterministic consumption-saving problem for an adjustable rate mortgagor and characterize the effects of a change in the interest rate. We consider a mortgagor who has sufficiently strong saving motives that they voluntarily accumulate excess repayments. There are two saving motives in the model: intertemporal substitution, and a lifecycle motive. We capture the intertemporal motive by assuming a rate of time preference ρ that satisfies $\rho < r^d$. We capture the lifecycle motive by assuming a real income path that declines at rate g^y. To illustrate the channels of adjustment to a mortgage interest rate change, we describe some steady-state comparative statics. We postpone a numerical solution of the model for transitory interest rate changes until after the presentation of our empirical findings.

Because the return on savings via excess mortgage repayments exceeds the after-tax return on the mortgagor's deposit account of $r^a(1-\tau)$ (where τ is the tax rate), it is optimal to hold all excess savings in the mortgage account. Therefore, consumption growth for an adjustable rate mortgagor with a positive redraw balance ($R_t > 0$) follows a standard Euler equation

$$\frac{\dot{c}_t}{c_t} = \sigma\left(r^d - \rho\right), \tag{4}$$

where σ is the elasticity of intertemporal substitution (EIS). The relevant interest rate is the mortgage interest rate because the mortgage account is the marginal place to hold savings.

Figure 3: Repayment Horizon and Consumption for an Unconstrained Adjustable Rate Mortgagor: Responses to 1 Percentage Point Permanent Increase in the Real Mortgage Interest Rate



Notes: Panel (a) shows the change (in years) in desired repayment time for an unconstrained adjustable rate mortgagor in response to a permanent 1 percentage point increase in the real mortgage interest rate. Panel (b) shows the associated semi-elasticity of the initial consumption level. The parameter values are: real deposit account interest rate $r^a = 0.03$, real mortgage interest rate $r^d = 0.06$, rate of time preference $\rho = 0.026$, initial debt-to-income ratio $d_0/y = 3$, and real income growth $g_y = -0.005$.

Summary: TBA

We are interested in how a change in the mortgage interest rate affects the level of consumption. In Appendix A, we show that the semi-elasticity of consumption with respect to a permanent increase in the mortgage rate is

$$\frac{d\log c_t}{dr^d} = -\sigma N_t^* - \left[\sigma\left(r^d - \rho\right) - g^y\right] \frac{dN_t^*}{dr^d}. \tag{5}$$

The first term is akin to a duration effect for a bond. Consumption falls by more the longer is the (endogenous) repayment horizon of the mortgage $N_t^* < N_t$. The second term captures the interaction between a standard intertemporal substitution effect and the endogenous choice of mortgage repayment horizon, adjusted for real income growth g^y. Holding N_t^* constant, an increase in the mortgage rate lowers current consumption through intertemporal substitution. However, the optimal repayment horizon of the mortgage changes in response to r^d . The sign of dN_t^*/dr^d is ambiguous and depends on the level of intertemporal substitution σ (see Appendix A for the formula). If the household has a high intertemporal elasticity of substitution, a rise in the mortgage interest rate shortens repayment time and vice-versa. Figure 3a shows an indicative illustration of the strength of this effect by plotting the response of the optimal repayment horizon N_t^* to a 1 percentage point permanent increase in r^d for different values of σ. The net effect of the higher mortgage interest rate on initial consumption is negative but varies in magnitude depending on σ (Figure 3b). When σ is large, consumption falls substantially. But as $\sigma \to 0$ consumption does not respond and the effect of a higher mortgage interest rate is fully absorbed by a lengthening of repayment time.

In summary, we can rationalize a wide range of consumption responses to a rise in the adjustable mortgage interest rate. The response will be small if mortgagors have substantial redraw balances and a weak elasticity of intertemporal substitution. The response will be large if mortgagors have a zero redraw balance (and are therefore likely hand-to-mouth) and/or a large intertemporal elasticity of substitution. This motivates the empirical investigation that follows.

Forward guidance and fixed-rate mortgages In our empirical analysis we exploit a period which saw a sharp increase in the take up of fixed rate mortgages owing to the introduction of forward guidance by the RBA. On the 19 March 2020 the RBA committed to keeping the cash rate at close to zero for an extended period of time, which was defined to be "until 2024 at the earliest" (Lowe, 2021).[3] The RBA provided banks with a three-year term funding facility at a fixed rate of 0.25 per cent. This significantly reduced the cost of funds for banks for fixed rate loan, as interest rates on fixed rate loans in Australia are typically fixed for 2 to 3 years. Over the period forward guidance was in place, interest rates on fixed rate mortgages were on average 0.6 percentage points lower than on adjustable-rate mortgages (Figure 4a). Demand for fixed rate mortgages increased from accounting for 14 per cent of the share of the value of new lending to a peak of 46 per cent (Figure 4b).

The RBA abandoned forward guidance and started its tightening cycle in May 2022. In our empirical analysis we use a difference-in-difference model to compare the spending of adjustable rate mortgagors to fixed rate mortgagors who took out a fixed rate loan during the forward guidance period when interest rates on fixed rate loans were low. Importantly, in the period just prior to forward guidance being abandoned, households expected interest rates to be low into the future.[4]

Consumption response of adjustable relative to fixed-rate borrowers We want to understand what spending responses our difference in difference model identifies. Consider first hand-to-mouth households. For these households, interest rate changes affect spending solely through their impact on required mortgage repayments. Because required repayments are unchanged for fixed-rate mortgagors, any differential spending response between the two groups must reflect the behavior of adjustable-rate hand-to-mouth households.

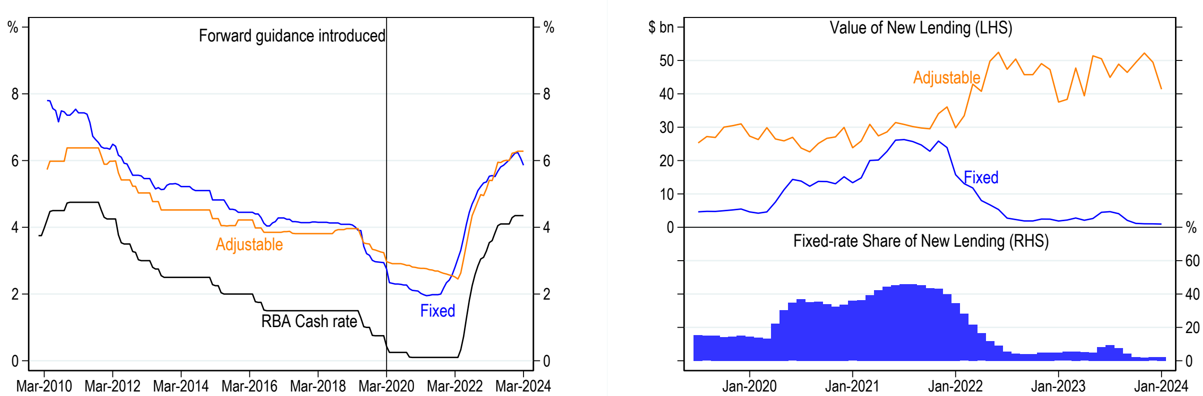
[3] On 19 March 2020 the RBA reduced the policy rate to 0.25 per cent and introduced a target on the yield for 3 year government bonds of 0.25 per cent. It announced that interest rates would not be increased "until progress is being made towards full employment and it is confident that inflation will be sustainably within the 2–3 per cent target band" (Lowe, 2020*a*). On 3 November 2020, the RBA reduced interest rates to 0.1 per cent and announced that it did not expect to increase policy rates for at least three years (Lowe, 2020*b*). On 2 February 2021, the RBA announced that it did not expect policy rates to rise until at least 2024 (Lowe, 2021).

[4] Communications from the RBA into early 2022 indicated that the first increase in the cash rate was not expected until 2024 (RBA, 2023). The bond market started started predicting interest rate increases slightly earlier, with the market implied cash rate from overnight swap markets increasing in November 2021 (Figure A1). Household inflation expectations data did not increase noticeably until the June quarter 2022. The short time period between when interest rate expectations rose and when actual interest rates started rising indicates that households had little time to adjust their behavior.

Figure 4: Home Loan Interest Rates

(a) Lending Interest Rates

(b) Lending Values and Shares



Notes: Panel (a) shows interest rates on new adjustable and fixed rate loans funded in the month from July 2019. Prior to July 2019 data are indicator home loan interest rates. *RBA Cash rate* is the central bank's policy interest rate. Panel (b) shows the value of new adjustable and fixed rate housing loans (top) and fixed rate home loans share of new housing lending (bottom). *Source:* RBA.

Summary: Following the introduction of forward guidance in March 2020, interest rates on fixed rate mortgages fell by 0.6 percentage points relative to adjustable rate mortgages. Demand for fixed-rate home loans increased following the introduction of forward guidance by the RBA.

For non hand-to-mouth mortgagors, changes in interest rates affect spending through intertemporal substitution and potentially a wealth effect. Intertemporal substitution induces both adjustable and fixed-rate mortgagors to cut consumption in response to higher interest rates. However when the policy rate increases, the after-tax real interest rate rises by less for deposit accounts than for mortgage redraw accounts, so the intertemporal response is smaller for fixed than adjustable-rate borrowers. Fixed-rate mortgagors also experience a positive wealth effect on their mortgage debt when interest rates rise because the interest rate on their debt is fixed. This positive wealth effect induces unconstrained fixed rate mortgagors to raise consumption. Adjustable rate mortgagors do not experience a wealth effect on their mortgage debt because the interest rate on their debt is linked to the policy interest rate.

Putting these effects together, the difference between the change in spending for adjustable rate borrowers compared with the change in spending for fixed-rate borrowers consists of: (i) the response of hand-to-mouth adjustable-rate mortgagors to higher required repayments; plus (ii) the additional intertemporal spending response of adjustable relative to fixed-rate mortgagors; less (iii) the positive wealth effect experienced by fixed-rate mortgagors. The main limitation of our empirical strategy is therefore that it differences out the common intertemporal substitution response of fixed and adjustable rate borrowers, the so-called 'missing intercept'. In Section 5, we make additional assumptions and provide an estimate of this common component of the consumption response. We estimate it to be less than one percent of consumption for the episode we study.

Consumption response of adjustable-rate mortgagors relative to non-mortgagors In a supplementary analysis, we also compare spending of adjustable-rate mortgagors to non-mortgagors (households without a mortgage). Hand-to-mouth households without a mortgage (mostly non-homeowners with no or very low assets) are unaffected by interest rate changes by virtue of having no assets. Non hand-to-mouth households without a mortgage (mostly homeowners without a mortgage, or non-homeowners with other assets) have the same intertemporal spending response as fixed rate mortgagors because they both save through deposit accounts. However, there is no wealth effect for non-mortgagors. Accordingly, the difference in spending between adjustable-rate mortgagors and non-mortgagors consists of components (i) and (ii) described above for adjustable relative to fixed-rate borrowers.

3 Data and Empirical Framework

Since theory is ambiguous about the effect of increased required mortgage repayments on the spending of adjustable-rate mortgagors, we turn to an empirical analysis. Our main approach is to compare the spending of adjustable-rate mortgagors to fixed-rate mortgagors to determine the effects of higher mortgage repayments on spending.

3.1 Potential outcomes framework

We start by describing a potential outcomes framework to explain our identification strategy and to discuss threats to identification. Let $c_{i,t}\left(M, \mathbb{E}_t\left[\{M_s\}_{s>t}\right], B\right)$ be consumption of mortgage holder i at time t with current required mortgage repayments M, an expected sequence of future required mortgage repayments $\mathbb{E}_t\left[\{M_s\}_{s>t}\right]$ and balance sheet B, which includes mortgage prepayment buffers. We seek to estimate the effect of a Δ-sized shock to required repayments at time t on consumption of adjustable rate mortgage holders. Formally, we seek to estimate

$$dC_t\left(\Delta\right) = \mathbb{E}_i\left[c_{i,t}\left(M+\Delta, \mathbb{E}_t\left[\{M_s\}_{s>t}\right], B_t\right) - c_{i,t}\left(M, \mathbb{E}_t\left[\{M_s\}_{s>t}\middle|\, \Delta=0\right], B_t\right)\middle|\, D=\mathrm{V}\right], \tag{6}$$

where $\mathbb{E}_t\left[\{M_s\}_{s>t}\middle|\,\Delta=0\right]$ is expected future repayments had there been no shock to current repayments and $D = \mathrm{V}$ denotes always adjustable rate mortgage status (i.e. excluding fixed-rate mortgages that became adjustable on expiry). This definition allows for the increase in current required mortgage repayments to affect expectations of future required repayments. Equation (6) is the average treatment effect on the treated. It cannot be estimated directly because we do not observe adjustable rate mortgage holders in treated (experiencing a change in repayments) and untreated states (not experiencing a repayment change). However, fixed rate mortgage holders have unchanged mortgage repayments and can be used to construct a counterfactual. This motivates the difference-in-difference (DiD) estimate

$$\delta_{t_0\to t_1} = \mathbb{E}_i\left[c_{i,t_1} - c_{i,t_0}\middle|\, D=\mathrm{V}\right] - \mathbb{E}_i\left[c_{i,t_1} - c_{i,t_0}\middle|\, D=\mathrm{F}\right], \tag{7}$$

where t_0 is the period before the increase in required repayments and t_1 where required repayments unexpectedly increase; $D = \text{F}$ denotes fixed rate mortgages that expire and become adjustable rate mortgages at some time $t > t_1$. Expressing Equation (7) in terms of the underlying potential outcomes gives

$$\delta_{t_0 \to t_1} = \mathbb{E}_i \left[c_{i,t_1} \left(M + \Delta, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \right], B_{t_1} \right) - c_{i,t_0} \left(M, \mathbb{E}_{t_0} \left[\{M_s\}_{s>t_0} \right], B_{t_0} \right) \middle| D = \text{V} \right] - \mathbb{E}_i \left[c_{i,t_1} \left(M, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \right], B_{t_1} \right) - c_{i,t_0} \left(M, \mathbb{E}_{t_0} \left[\{M_s\}_{s>t_1} \right], B_{t_0} \right) \middle| D = \text{F} \right], \tag{8}$$

using the fact that fixed-rate mortgagors have unchanged repayments. Under the assumptions of (i) parallel trends for untreated outcomes and; (ii) no anticipation, $\delta_{t_0 \to t_1}$ is an unbiased estimate of $dC_t(\Delta)$:

$$\begin{aligned}\delta_{t_0 \to t_1} = & \underbrace{\mathbb{E}_i \left[c_{i,t_1} \left(M + \Delta, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \right], B_{t_1} \right) - c_{i,t_1} \left(M, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \middle| \Delta = 0 \right], B_{t_1} \right) \middle| D = \text{V} \right]}_{\text{required mortgage repayments channel: } \mathrm{d}C_t(\Delta)} + \\ & \underbrace{\begin{aligned} & \mathbb{E}_i \left[c_{i,t_1} \left(M, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \middle| \Delta = 0 \right], B_{t_1} \right) - c_{i,t_0} \left(M, \mathbb{E}_{t_0} \left[\{M_s\}_{s>t_0} \right], B_{t_0} \right) \middle| D = \text{V} \right] \\ & - \mathbb{E}_i \left[c_{i,t_1} \left(M, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \middle| \Delta = 0 \right], B_{t_1} \right) - c_{i,t_0} \left(M, \mathbb{E}_{t_0} \left[\{M_s\}_{s>t_1} \right], B_{t_0} \right) \middle| D = \text{F} \right] \end{aligned}}_{\text{non-parallel trends bias}} - \\ & \underbrace{\mathbb{E}_i \left[c_{i,t_1} \left(M, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \right], B_{t_1} \right) - c_{i,t_1} \left(M, \mathbb{E}_{t_1} \left[\{M_s\}_{s>t_1} \middle| \Delta = 0 \right], B_{t_1} \right) \middle| D = \text{F} \right]}_{\text{anticipation bias: fixed}}. \end{aligned} \tag{9}$$

The parallel trends assumption requires consumption of adjustable and fixed rate mortgage holders to move together absent any change in required repayments for either group. It also requires that fixed and adjustable rate mortgage holders had the same expectations about future repayments before the shock to repayments. The no anticipation assumption requires fixed-rate mortgage holders to not respond in anticipation of changes in repayments.

3.2 Threats to identification

There are three key threats to identification: anticipatory behavior by fixed rate mortgagors, sample attrition and selection effects. We discuss each in turn.

Anticipation The no anticipation assumption is violated if fixed rate mortgagors adjust their spending in advance of changes in required repayments to smooth consumption. Anticipatory behavior for fixed-rate borrowers will bias δ_t downward. We address this threat in a supplementary analysis in Section 4.5 that uses non-mortgage holders as an alternative control group.

Attrition Some of the fixed rate mortgages expire over the analysis period and become adjustable-rate mortgages. There are two ways this could bias our results. First, the characteristics of the fixed rate group could change over time if fixed rate loans that expire later are different from those that expire earlier. We can address this concern by controlling for observable loan characteristics, such as mortgage balance. Second, some mortgages in the adjustable-rate group could

Table 1: Difference between Adjustable and Fixed Rate Mortgage Holders

	Transactions data		HILDA	
	Adjustable	Fixed	Adjustable	Fixed
Income	10,951	10,734	12,789	11,307
Mortgage balance	390,601	451,780	349,959	428,926
Mortgage balance (frac. income)	2.97	3.51	2.28	3.16
Repayments	2,173	1,970	2,305	2,114
Repayments (frac. income)	0.20	0.18	0.18	0.19
Spending	7,651	7,017		
Spending (frac. income)	0.70	0.65		
Supermarket spending	1,388	1,227	1,164	1,024
Supermarket spending (frac. income)	0.13	0.11	0.09	0.09

Notes: This table shows summary statistics for adjustable and fixed-rate mortgagors from our bank transactions sample and from the nationally representative HILDA survey. Statistics for the bank transactions sample are calculated from November 2020 to April 2022, prior to the first increase in the cash rate.

Summary: Fixed-rate mortgagors have a higher mortgage debt to income ratio relative to adjustable-rate mortgagors.

be expired fixed-rate mortgages. To minimize this possibility, we exclude from the sample all loans for which we observe an expiry. However, we do not observe all expiries. Relatively few fixed-rate mortgages, less than 25 per cent, expired prior to 2023 (Lovic et al., 2023), implying that any adjustable rate mortgage observed before the end of 2022 is unlikely to have been an expired fixed rate loan. In a robustness check we restrict the sample of adjustable rate mortgages to those observed at least since the end of 2022.

Selection The characteristics of fixed and adjustable mortgage holders can differ because households self-select into mortgage type. This could cause violations of the parallel trends assumption. Table 1 shows summary statistics for fixed and adjustable-rate mortgagors in our dataset. Fixed-rate mortgagors have more mortgage debt and higher debt-to-income ratios.

A range of economic factors affecting mortgage choice have been identified in the literature (Andersen et al., 2023). The literature has studied the typical situation in which the interest rate on new fixed rate mortgages exceeds that on adjustable rate mortgages; adjustable rate borrowers accept risk in exchange for a lower current interest rate. The first factor identified by the literature is the value of a lower initial interest rate on adjustable rate mortgages to ease constraints on either current consumption or borrowing. The second factor is beliefs: households that expect interest rates to fall will prefer an adjustable rate mortgage and those expecting interest rates to rise will prefer a fixed rate mortgage. The third factor is expected housing tenure. Households expecting to move in the near future will prefer adjustable rate mortgages because the value of insurance against distant interest rate rises is less.

The 2020-2021 period in Australia, when mortgage choice decisions of households in our sample were made, was atypical in two important respects. First, the interest rate on fixed rate mortgages was *below* that on adjustable rate mortgages. This implies constrained households prefer fixed rather than adjustable rate mortgages. Second, policy interest rates were at the effective lower bound. Lower initial interest rates on fixed rate borrowing and the inability of adjustable interest rates to fall implies borrowing costs were certain to be lower for fixed rate mortgages. Considerations about moving in the near future are less relevant in Australia because fixed rate mortgages are mostly for short 2 to 3 year periods. Hence, none of the main factors identified by the literature provide a rationale for adjustable over fixed rate mortgages over the 2020-2021 period in Australia.

A consideration not emphasized in the literature is the ability to make additional voluntary repayments on an adjustable rate mortgage to reduce interest payments on outstanding debt. Appendix C provides a model that shows that the debt-to-income ratio is a significant predictor of mortgage choice in Australia. It shows that households with a lower debt to income ratio are more likely to have an adjustable-rate mortgage. This is consistent with what we observe in our dataset; the debt to income ratio is lower for adjustable-rate mortgagors (Table 1).[5]

However, selection may also depend on unobservables. The inclusion of mortgage-type fixed effects controls for additive time-invariant unobservable determinants of selection. Ghanem, Sant'Anna and Wüthrich (2022) show that selection on time-varying unobservables is compatible with parallel trends if the unobservables follow a martingale property. They prove that imperfect foresight over the determinants of selection is a sufficient condition for unobservables to follow a martingale. This is plausible in our setting because selection into mortgage type occurred when the central bank policy rate was at its lower bound and widely expected to remain so. The martingale assumption on unobservables implies, for example, that households know (and can select on) their permanent income but do not know future realizations of transitory income when selecting into mortgage type.

3.3 Data

Analysis sample To identify the effect of an increase in required repayments on the spending of mortgagors we use a large dataset of consented and de-identified bank transactions. The data are collected by a third-party data provider during routine consumer finance applications (as a result of, for example, applications for a mortgage, credit card, buy-now-pay-later services, personal finance management apps and a change of utility providers). This bank holds approximately 25 per cent of the value of deposits and housing loans in the banking system and maintains branches throughout Australia. The third-party data provider collect a history of transactions which captures all account

[5]We empirically validate that debt to income is a predictor of mortgage choice by estimating the linear probability model:

$$fixed_{i,t} = \alpha_s + \delta_t + \beta DTI_{i,t} + \epsilon_t \tag{10}$$

for mortgages observed prior to the first increase in the cash rate, where $fixed_{i,t}$ is an indicator equal to 1 if mortgagor i had a fixed rate mortgage at time t, α_s are state fixed effects, δ_t are time fixed effects and $DTI_{i,t}$ is the debt to income ratio of mortgagor i at time t. The goodness-of-fit plot of Equation (10) shows that the debt to income ratio is able to predict the probability that an individual has a fixed-rate mortgage well across all deciles of the fixed-rate mortgage propensity (Figure A2). We include the debt to income ratio as a control to account for selection in our analysis.

flows including spending, income, welfare payments, and balances on savings and debt accounts, including mortgage accounts. The average available transaction history for each individual in our sample is 5 months. Our unit of observation is defined as all accounts from the large bank that were captured in the same data collection event within a given month. We refer to each such grouped set of accounts as an 'individual' in our analysis.

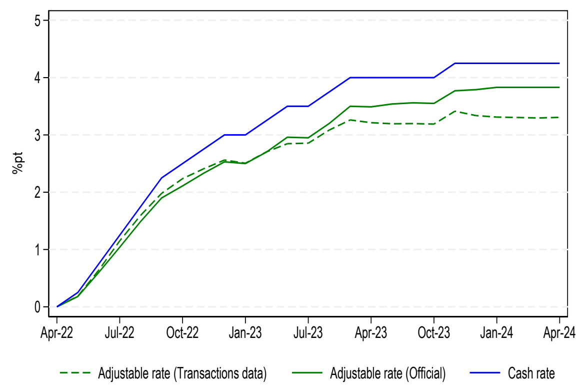
We identify individuals with a mortgage from the presence of mortgage repayments outflows from a transaction (equivalent to a checking account in the United States) or savings account and mortgage repayments inflows into a home loan account. To ensure we are capturing the primary bank accounts of an individual we restrict our sample to accounts where we can match the size and date of all mortgage repayments outflows from their transaction accounts to repayments inflows into their mortgage account. In addition, we also impose the following restrictions on the data. First, we restrict our analysis to individuals with at least five monthly outflows from their transaction accounts following Ganong and Noel (2019). An outflow is any debit from a transaction account including a cash withdrawal, an electronic payment, a debit payment or credit card payment. Second, we require that an individual has positive income inflows into their transaction or savings account in a given month. We also exclude the top and bottom one percent of values in terms of mortgage balances, repayments, spending and income and the top one percent of values for ATM withdrawals and incoming and outgoing external bank account transfers (these are bank account transfers to or from unobserved accounts). Overall, our sample consists of 83,321 individuals over the period from November 2020 to April 2024.

We are unable to see if an account belongs to an individual or a couple and would miss transactions for couples who maintain separate bank accounts. However, this issue is likely to be mitigated by the fact that 80 per cent of couples in Australia have a joint bank account (Huang, Perales and Western, 2019).

We provide a comprehensive description of our data in Appendix B and a summary here.

Mortgage variables The balance, total repayments, interest payments and the stock of excess payments can be observed for each mortgage account. This information is used to calculate the interest rate on each mortgage which is then used to classify whether a mortgage is adjustable or fixed. To capture fixed rate loans originated during the forward guidance period, a loan is classified as fixed if the interest rate on the loan is unchanged and below 2.4 per cent. The minimum interest rate for an adjustable rate loan is 2.7 per cent and it increases in months when the cash rate increases. Some mortgage accounts can have fixed and adjustable rate components and these accounts are separately identified. We exclude the expiry of fixed-rate loans in our main analysis. Prior to the first increase in the cash rate, combination, fixed and adjustable rate mortgages accounted for 10, 12 and 78 per cent of mortgages respectively. We are able to match the increase in interest rates on adjustable-rate home loans in the data (Figure 5) and the bimodal distribution in interest rates between adjustable and fixed-rate borrowers (Figure 2).

Figure 5: Mean Interest Rates



Notes: This figure shows the cumulative change in the RBA cash rate, the average mortgage interest rate from official data and the average interest rate from the transactions data since the commencement of interest rate increases in May 2022. Mortgage interest rates rose by a little less than the cash rate because competition among lenders reduced lending margins.

Summary: Interest rate changes on loans in the transactions data are representative of the population.

Spending Spending is measured from debit and credit card transactions, cash withdrawals, and other electronic transactions. We classify spending into two categories. Measured spending is spending where we know both the merchant and date of spending. It accounts for 68 per cent of spending. Uncategorised spending is spending associated with credit card repayments or cash withdrawals. These transactions likely reflect spending but we do not know the precise timing of spending. Our aggregrate measure of spending – the sum of spending by mortgagors and non mortgagors – lines up well with official statistics; the correlation between monthly changes in our measure and that from the Australian Bureau of Statistics Household Spending Indicator is 0.8.

Income, account balances and other flows We calculate disposable income as the sum of wages, social security payments, rental income and other income inflows and subtract net tax payments. We group all other net inflows, besides disposable income, spending and mortgage repayments into a category called "all other net inflows". The largest component of all other net inflows is transfers to or from external bank accounts. We observe the dollar value of bank accounts for an individual on the date of data collection, including redraw accounts where excess mortgage repayments are stored. We calculate the change in savings in a given month by subtracting the sum of all bank account outflows from the sum of all bank account inflows.

Representativeness To assess the representativeness of our sample we compare it to mortgagors from the Household Income and Labour Dynamics in Australia (HILDA) survey, a nationally representative survey (Table 2). Individuals in our sample have lower incomes and higher mortgage debt and hence higher debt to income ratios than those from HILDA. This suggests our sample somewhat over represents younger mortgagors, who are more likely to experience a larger increase

Table 2: Representativeness of the Bank Transactions Sample

	Median		Mean	
	Transactions data	HILDA	Transactions data	HILDA
Income	8,980	11,589	10,102	13,007
Mortgage balance	355,527	308,000	418,566	363,920
Mortgage balance (frac. income)	3.22	2.39	3.45	2.33
Repayments	1,961	2,100	2,381	2,399
Repayments (frac. income)	0.22	0.19	0.24	0.18
Supermarket spending	1,210	1,000	1,325	1,061
Supermarket spending (frac. income)	0.13	0.09	0.13	0.08
Non-durable spending	2,237	1,653	2,509	1,769
Non-durable spending (frac. income)	0.25	0.15	0.25	0.14

Notes: This table compares mortgagors from the bank transactions sample to mortgagors from the nationally representative HILDA survey. Statistics are calculated from August 2022 to February 2023, the period in which HILDA interviews were conducted.

Summary: Mortgagors in the transactions sample have modestly higher mortgage debt and lower income than mortgagors in HILDA but are otherwise representative.

in repayments in response to an increase in mortgage interest rates. The one measure of spending we can compare across both data sources is supermarket spending. Supermarket spending and mortgage repayments as a share of income are slightly higher in our sample.

4 Estimation and Results

4.1 Empirical specification

We use a linear event study framework to study the effect of increases in the central bank policy rate on household spending. In the baseline specification we estimate:

$$y_{i,t} = \alpha_j + \theta_t + \sum_{k=-1}^{k=-T^{\text{pre}}} \delta_k \left(D_{i,T_0+k} - D_{i,T_0}\right) + \sum_{k=1}^{k=T^{\text{post}}} \gamma_k D_{i,T_0+k} + X_{i,t} + \varepsilon_{i,t} \tag{11}$$

where $y_{i,t}$ is the variable of interest for mortgagor i at time t; α_j is a mortgage-type fixed effect with $j \in \{\text{fixed, adjustable}\}$; θ_t are time fixed effects; D_{i,T_0+k} is an event-time indicator variable taking the value one for adjustable rate mortgagor i at time k quarters after the beginning of required repayment increases in $T_0 =$ August 2022 and zero otherwise; $X_{i,t}$ are control variables, and; $\varepsilon_{i,t}$ is an error term. The regression specification restricts the sum of the pre-event coefficients δ_k to be equal to zero while the post event coefficients γ_k measure the estimated treatment effect relative to the pre-period average of zero. Estimation is at monthly frequency but the event-time coefficients are quarterly (to remove noise) with quarters centered on the commencement of interest rate increases in May-July 2022.

The variables of interest are mortgage repayments, measured and uncategorised spending, income, all other net inflows and the change in savings. In all regressions we include controls for the number of data collection events an individual experiences, the change in the number of bank accounts observed and the number of pay periods for that individual in a month. In some specification we include additional controls to capture differences in characteristics between fixed and adjustable-mortgagors and control for region specific effects. These include, lagged income, mortgage debt, the debt to income ratio and house prices and state $\times$ time fixed effects. Standard errors are clustered at an individual level.

Section 3 outlined the identification approach in a two-period difference-in-difference setting whereas the empirical model has multiple time periods. However, the event study coefficients γ_k are equivalent to a two-period difference-in-difference estimate relative to the pre-period:

$$\gamma_k = \left[\bar{y}_{T_0+k} - \bar{y}_{T_0^-}|D = V\right] - \left[\bar{y}_{T_0+k} - \bar{y}_{T_0^-}|D = F\right], \tag{12}$$

where T_0^- denotes the pre-period T^{pre} to T_0. The coefficient γ_k measures the dynamic effect of the cumulative increase in required repayments that have occurred between T_0 and $T_0 + k$. The no-anticipation assumption and parallel trends assumptions stated earlier (Equation 9) apply to all $t_1 = t' > t_0$ for the empirical model.

The baseline specification includes mortgagors with only fixed or adjustable rate loans. However, some mortgagors hold both fixed and adjustable rate loans. To include these combination mortgagors in the analysis, we modify Equation (11) by measuring the degree of treatment as the fraction of total debt held in adjustable rate loans $f_i \in [0,\ 1]$:

$$y_{i,t} = \alpha_j + \theta_t + \sum_{k=-1}^{k=-T^{pre}} \delta_k \left((D_{i,T_0+k} - D_{i,T_0}) \times f_i\right) + \sum_{k=1}^{k=T^{post}} \gamma_k \left(D_{i,T_0+k} \times f_i\right) + X_{i,t} + \varepsilon_{i,t}. \tag{13}$$

All other terms are unchanged.

4.2 Baseline results

We start with the simplest specification which includes only fixed and adjustable-rate mortgagors and no additional controls. Figure 6 shows the estimated γ_k coefficients from Equation (11). Mortgage repayments for adjustable-rate mortgagors move in line with mortgage repayments for fixed-rate borrowers prior to the initial increase in required repayments in August 2022. Note that while interest rates on adjustable-rate mortgages increased in May 2022, the same month that the RBA first raised the cash rate, banks did not pass this increase onto higher required mortgage repayments until three months later in August 2022. We find that adjustable rate mortgagors did not increase their repayments until after banks raised required mortgage repayments.[6] After this pe-

[6]The CDF of the change in the mortgage repayments during the three month period in which interest rates increased but repayments were unchanged looks similar to that prior to the first increase in interest rates. This shows that mortgagors do not adjust repayments until minimum required repayments increased. Following the increase in required repayments which started in August 2022, we see a larger fraction of adjustable rate mortgagors increase their mortgage repayment (Figure A3).

riod, we see a sustained increase in repayments for adjustable-rate mortgagors relative to fixed-rate mortgagors.

Despite this increase in repayments, there is little difference in either measure of spending between adjustable and fixed-rate mortgagors before and after the increase in required mortgage repayments. We can also decompose spending into durable and non-durable goods and services spending. Again we find little difference in spending between fixed and adjustable rate mortgagors (Figure 7). Adjustable-rate mortgagors financed the majority of the increase in required mortgage repayments through running down their savings. The bottom right panel of Figure 6 shows the cumulative change in the bank account balances of adjustable-rate mortgagors relative to fixed-rate mortgagors. Prior to the increase in required mortgage repayments, there was little difference between fixed and adjustable-rate mortgagors. After the increase in required mortgage repayments we see a large fall in the bank account balances of adjustable-rate mortgagors relative to fixed-rate mortgagors. Adjustable rate mortgagors also financed a smaller fraction of the increase in repayments through higher other net inflows in the last two quarters of the sample. This indicates that adjustable-rate mortgagors brought in funds from external sources to partially fund higher repayments. This is consistent with the results from Baugh et al. (2021), who find that households transfer in funds from external sources to smooth consumption when making anticipated tax payments. There is little difference in the incomes of adjustable and fixed-rate mortgagors before and after the change in required repayments.

Column 1 of Table 3 summarizes the cumulative difference in our dependent variables between adjustable and fixed-rate mortgagors after the increase in required mortgage repayments from August 2022 to April 2024. Over this period, adjustable-mortgagors experienced a \$13,884 increase in mortgage repayments relative to fixed-rate mortgagors. There was little difference in the spending and incomes between fixed and adjustable-rate mortgagors. We find that 70 per cent of the increase in mortgage repayments was paid for by individual's drawing down on their savings and 26 per cent by individuals bringing in funds from external sources.

Our point estimates indicate a negligible MPC from the increase in required repayments. Even at the one-sided 90th percent confidence interval the MPC is 0.15, which is lower than the range found in the literature discussed in Section 1.

4.3 Alternate specifications

Here we address the threats to identification outlined in Section 3.2. Columns 2 to 5 of Table 3 show results from the alternate specifications embedded in Equation (13).

Column 2 includes individuals with combination mortgages. Column 3 includes additional controls to account for selection into mortgage type and region specific shocks.

Column 4 controls for attrition. Some mortgages which we classify as adjustable could have been a fixed rate mortgage in the past when we did not observe them. To reduce the possibility of including an adjustable-rate mortgage that might have been fixed in the past, we restrict our sample of adjustable-rate mortgages to those first observed prior to 2023 when there are relatively few fixed

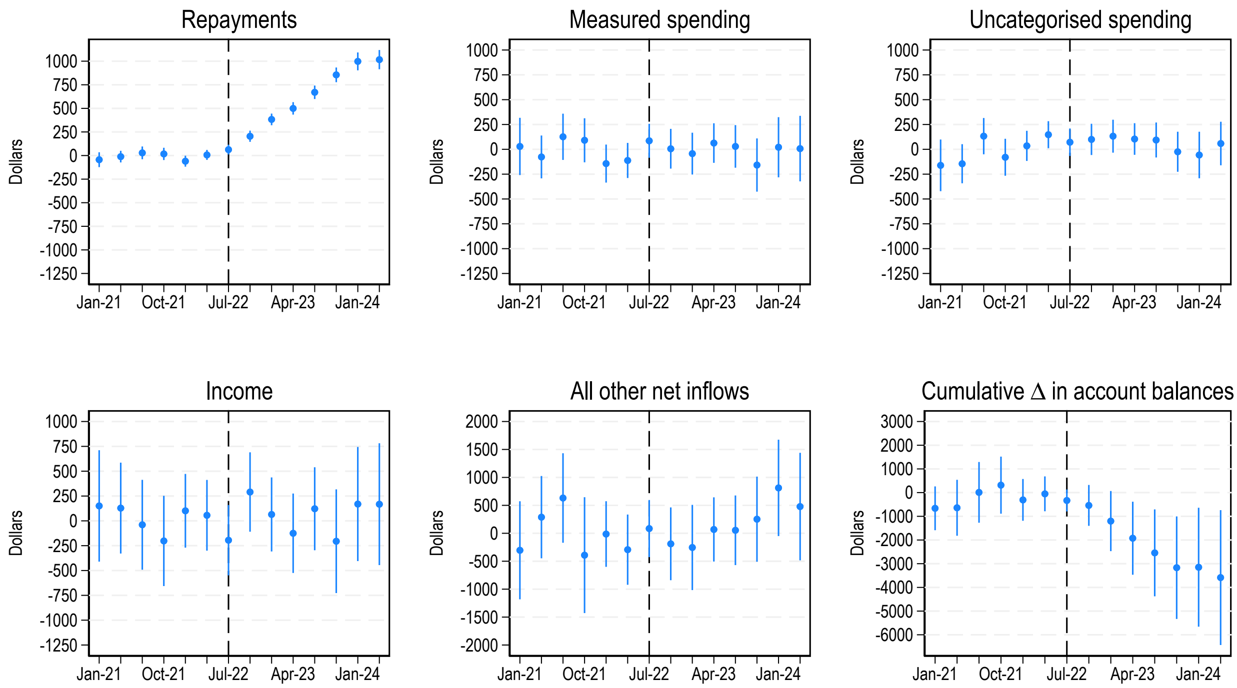
Table 3: Cumulative Difference Between Adjustable and Fixed-rate Mortgagors: August 2022 to April 2024

	(1)	(2)	(3)	(4)	(5)
Repayments	13,884	12,245	10,417	11,053	10,230
	(520)	(526)	(409)	(442)	(408)
Measured spending	-226	768	748	496	–155
	(1,670)	(1,434)	(1,677)	(1,896)	(1,644)
Uncategorised spending	1,220	1,118	890	1,733	255
	(1,315)	(1,134)	(1,309)	(1,440)	(1,248)
Income	1,452	744	-38	855	1,060
	(3,283)	(2,796)	(2,685)	(3,039)	(2,753)
Residual	3,664	6,496	3,342	2,573	-1,582
	(4,604)	(3,755)	(4,601)	(5,065)	(4,657)
Δ account balances	-9,762	-6,892	-8,851	-9,854	-10,852
	(3,983)	(3,258)	(4,085)	(4,462)	(4,238)
Proportion of increased repayments paid by:					
Δ account balances	0.70	0.56	0.85	0.89	1.06
All other new inflows	0.26	0.53	0.31	0.23	-0.15
Combination mortgages		X	X	X	X
Controls			X	X	X
Ex obs post Dec-2022				X	
Excl. large incoming transfers					X

Notes: This table reports the estimated cumulative change in *repayments*, *spending*, *income* and *residual* account flows for the period August 2022 (the commencement of increases in required mortgage payments) to April 2024. *Residual* is the net inflow of all account flows other than repayments, spending and income. The sum of income and residual flows less repayments and spending equals the implied change in account balance. Column (1) shows cumulative changes for the baseline model. Column (2) includes combination mortgagors. Column (3) addresses the selection of mortgagors into fixed and adjustable-rate mortgages by including the covariates: lagged mortgage balance; lagged income; lagged mortgage balance-to-income ratio, and; state × time fixed effects. Column (4) addresses the issue that some of the adjustable-rate mortgagors might have been fixed-rate mortgagors in the past by excluding adjustable rate mortgagors entering the data after December 2022. Column (5) excludes the mortgagors in the top 5 percent of incoming transfers. All specifications include controls for the number of data collection events; changes in the number of visible accounts, and changes in the number of income payments. Standard errors, clustered at the person level, are reported in parentheses.

Summary: Cumulative spending and income flows were broadly unchanged over the 21-month period following the commencement of interest rate increases. The estimates indicate that 80 percent of the increase in repayments was financed by a draw down in account balances and the remainder by other net inflows coming into an individual's bank account.

Figure 6: Event Study: Adjustable vs. Fixed Rate Mortgagors



Notes: This figure shows estimated coefficients δ_k (pre-event) and γ_k (post-event) from Equation (11). All flows shown are at monthly rates. *Cumulative change in account balance* is the sum of *income* and *all other net inflows* less the sum of *repayments* and *spending*. *Measured spending* is the sum of non-durable, durable and services (including rent) spending categorized by the data provider; *unmeasured spending* is the sum of other spending-related outflows (ATM withdrawals, miscellaneous card payments, credit card repayments and gambling). Measured spending account for around 68 percent of total spending. Standard errors are clustered at the person level and two standard error bands are shown

Summary: Mean monthly mortgage repayments rose by around $1,000 for adjustable relative to fixed rate mortgagors between mid-2022 and the start of 2024. However, there was little change in spending between the two groups.

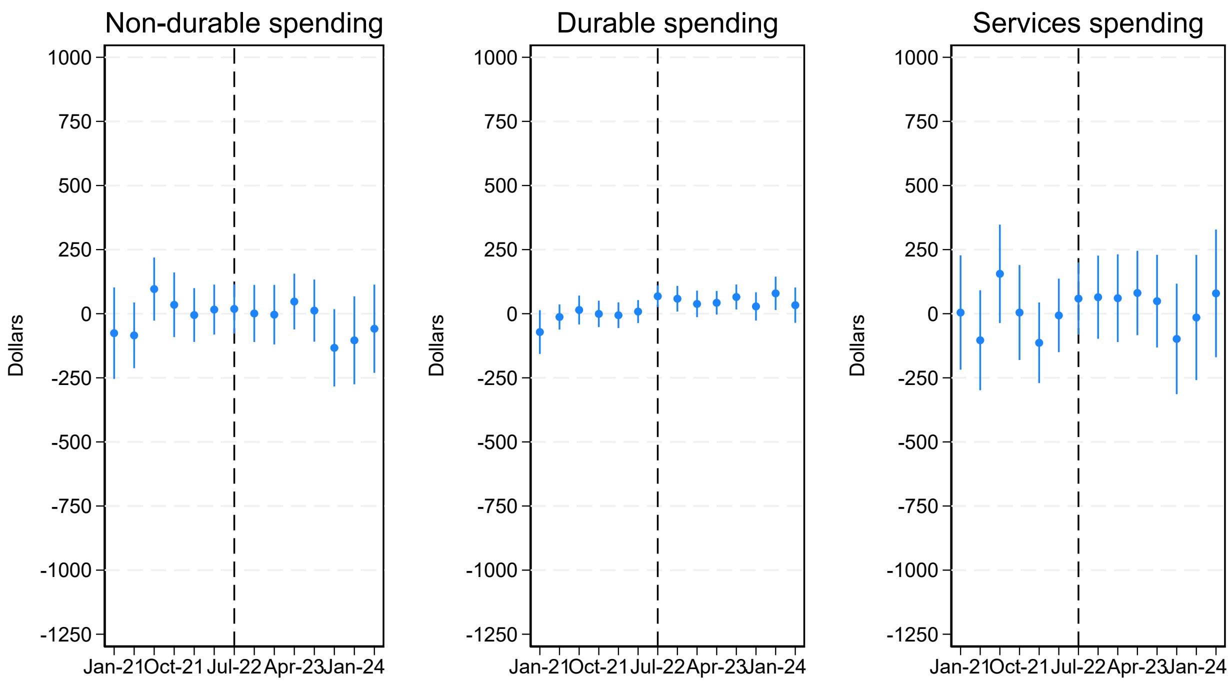
rate expiries.

In column 5, we address concerns that we might not be observing a full picture of an individual's bank account given that we find that adjustable rate mortgagors financed a fraction of higher repayments through external sources. We exclude observations where net incoming transfers from an external bank account are above the 95th percentile.

Across all specifications, we see a notable rise in the repayments of adjustable-rate mortgages relative to fixed rate mortgages. There is little difference in spending between fixed and adjustable-rate mortgagors. We find that on average across all specifications around 80 per cent of the rise in repayments was financed by adjustable rate mortgagors drawing down on their bank account balances, with the remainder accounted for all net other inflows. In the specification where we exclude individuals with large net incoming transfers virtually all of the increase in repayments is paid for by adjustable-rate mortgagors reducing their bank account balances.

Overall we find that adjustable-rate mortgagors financed the majority of higher mortgage repay-

Figure 7: Event Study: Adjustable vs. Fixed Rate Mortgagors
Components of Categorized Spending



Notes: This figure shows estimates for the components of spending in Figure 6. Measured spending is categorized by the data provider. Uncategorised spending is then apportioned to each of these categories using information from the RBA Consumer Payments Survey.

Summary: There was little change in non-durable, durable and services spending for adjustable relative to fixed rate mortgagors.

ments by drawing down on their liquid assets, leaving spending little changed. This is consistent with the predictions of a model where mortgagors have access to sufficient redraw balances and a weak intertemporal elasticity of substitution.

4.4 Evidence on liquid assets

We provide evidence that adjustable-rate mortgagors had a sufficient level of savings to draw down.

Evidence from bank transactions data For each individual in our sample, we observe the balance on their bank accounts at the date of the data collection event. Table 4 shows mean bank account balances for adjustable and fixed-rate mortgagors six months prior to the commencement of the RBA tightening cycle and in the last six months of our sample after mortgage repayments had increased. The bank account balances of adjustable rate mortgagors includes excess mortgage

Table 4: Account Balances

	Prior to rate rise	Last 6 months
	Adjustable rate mortgagors	
Account balances	36,743	24,795
	Fixed rate mortgagors	
Account balances	24,188	21,096

Notes: This table reports the mean bank account balances for the period prior to the commencement of policy rate increases in April 2022 and in the last 6 months of our data (November 2023 to April 2024). Bank account balance are the total of all visible transaction, saving and redraw accounts.

Summary: Savings declined by $8,856 for adjustable-rate mortgagors relative to fixed rate mortgagors, accounting for the bulk of the increase in required repayments for adjustable-rate mortgagors.

payments. It fell by around $12,000 over this period. While fixed rate mortgagors did experience a fall in their bank account balance, it is noticeably smaller, at around $3,000. Taking the difference in the change of account balance between adjustable and fixed-rate mortgagors over this period suggests that the adjustable-rate mortgagor account balances fell by $9,000 relative to fixed-rate mortgagor account balances. This is similar to the estimates from the baseline event study specification (see Table 3).

Adjustable-rate mortgagors can accumulate liquid savings by making excess repayments on their mortgage. Figure 8 shows the CDF of excess mortgage repayments as a percentage of required repayments prior to the commencement of the RBA's tightening cycle in May 2022 and in the last six months of our sample.[7] We find evidence that adjustable-rate mortgagors had accumulated savings in excess repayments buffers prior to the start of interest rate increases. Excess repayments were made on 70 per cent of adjustable-rate mortgagors prior to the first rise in interest rates. Around a quarter of adjustable-rate mortgages had repayments in excess of 40 per cent of required repayments. In the last six months of our sample, the share of adjustable-rate mortgages with excess repayments declined to around 25 per cent. This is consistent with the fall in bank account balances in Table 4.

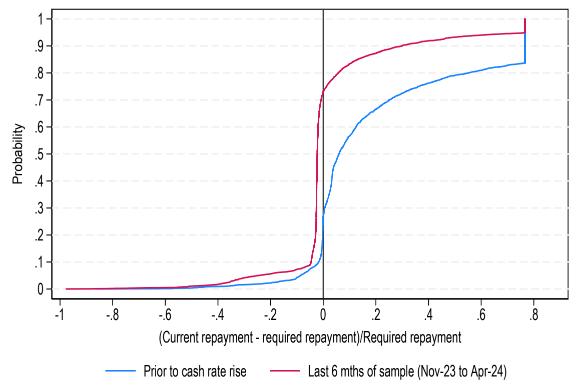
Evidence from aggregate data Why did households have these excess repayment buffers going into the monetary policy tightening cycle? Holding excess funds on mortgages is financially advantageous because it reduces interest charges and mortgage interest rates are higher than deposit interest rates. Furthermore, earnings on deposit accounts are subject to taxation, making excess mortgage repayments tax preferred.[8]

Excess repayment buffers have been substantial for a long period of time. Between 2010 and 2019 excess repayments averaged around one-quarter of required repayments (RBA, 2025). The accumu-

[7] At certain times of year (typically at the end of a calendar or financial year or when interest rates change) the bank in our sample sends individuals a message about what their required repayment will be in three months time. Here we compare an individual's current repayments with what their required repayment will be in three months time.

[8] While households could choose to hold savings in higher return assets, such as certificates of deposits or bonds, these are less liquid.

Figure 8: Excess Mortgage Repayments



Notes: This figure shows the cumulative distribution of excess mortgage repayments (current minus required repayments) as a percentage of required repayments, prior to the commencement of interest rate increases in May 2022 and for the last six months of the sample (November 2023 to April 2024). Note excess repayments above the 90th percentile have been grouped into a singe category.

Summary: Around 70 percent of mortgagors were making excess repayments prior to the commencement of interest rate increases, with around one-quarter making excess repayments of at least 40 percent of required repayments. The share making excess repayments declined to around one-quarter of mortgagors by the end of the sample.

lation of excess repayments was facilitated by a long period of declining interest rates. The RBA's policy rate decreased monotonically from 4.5 percent to 0.1 percent between November 2011 and November 2020. Households could make excess repayments by keeping their repayments unchanged when interest rates declined.

But excess repayment buffers increased sharply during the pandemic, averaging 42 percent of required repayments between 2020 and 2021. This was partly due to mobility restrictions which hindered spending opportunities. The household saving ratio averaged 20 percent over the 2020-2021 pandemic years, compared with 7.7 percent in 2019 (Figure 1a). Disposable income was supported during the pandemic by wage subsidies and increased transfer payments to welfare recipients. A pre-pandemic counterfactual path for consumption implies that around two-thirds of the increase in the household saving in 2020 and 2021 can be explained by pandemic-related forces (Figure A6).

As a consequence, the share of hand-to-mouth households was at a low level at the start of the monetary policy tightening cycle. We use the method in Kaplan, Violante and Weidner (2014) to identify hand-to-mouth households from HILDA, a nationally representative household survey.[9] Less than 7 percent of adjustable-rate mortgagors were hand-to-mouth in the second half of 2022, compared to 13 percent in 2018.

[9] A households is classified as hand-to-mouth if: (i) their liquid wealth balance is positive, but less than half their income each pay period or (ii) their liquid wealth balance is negative, and is less than the difference between half their income each pay period and a credit limit.

4.5 Additional evidence

We present supplementary evidence from alternative identification approaches. First, we compare consumption of mortgagors and non-mortgagors. Next, we study consumption around expiry of fixed-rate mortgages.

Comparison of mortgagors and non-mortgagors Our event-study estimates provide an unbiased estimate of the effect of an increase in required repayments in the absence of anticipatory behavior by fixed-rate mortgagors. A concern is that both adjustable and fixed-rate mortgagors might have responded to higher interest rates by reducing their spending. Adjustable-rate mortgagors reduced spending because of higher actual mortgage repayments, while fixed-rate mortgagors reduced spending in anticipation of higher future mortgage repayments when their fixed-rate loan expires. If this was the case, then our result of little difference in spending could reflect both fixed and adjustable-rate mortgagors reducing their spending. To address this concern, we compare the spending of mortgagors to non-mortgagors who do not experience any increase in mortgage repayments. If both fixed and adjustable-rate mortgagors pulled back on spending at the same time then we would expect the spending of mortgagors to fall relative to non-mortgagors. We do not see this occurring, indicating that both adjustable and fixed-rate mortgagors maintained their previous spending levels following the rise in interest rates.

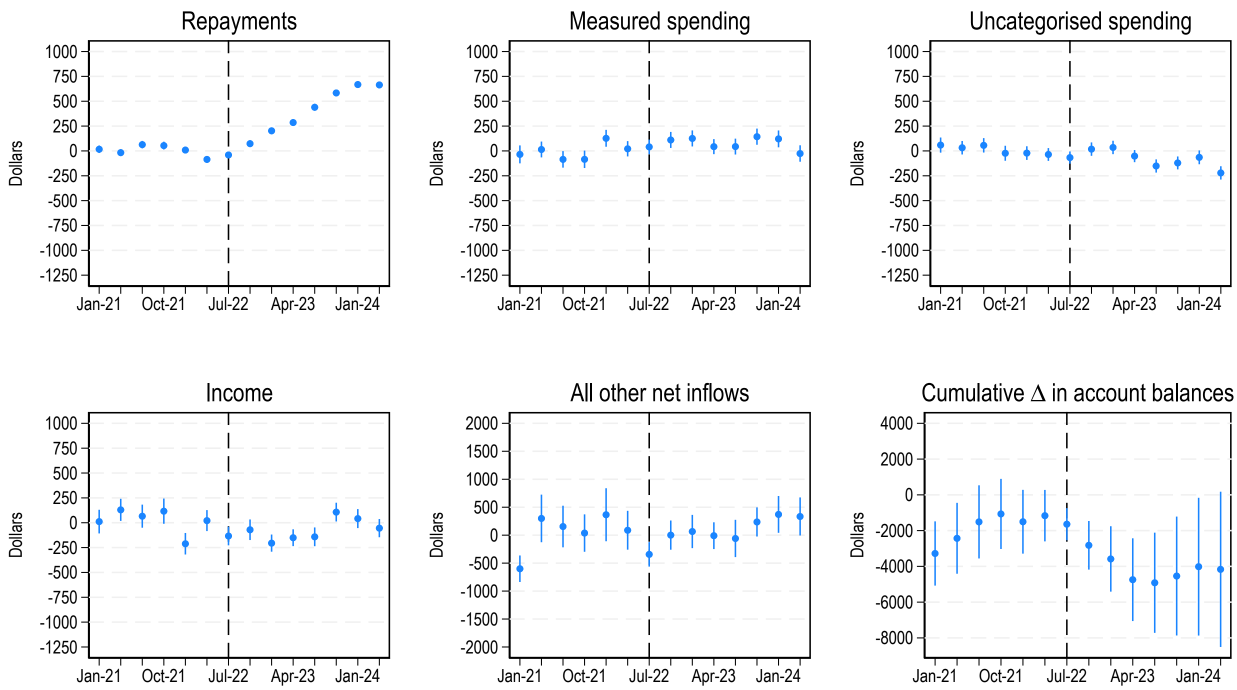
We estimate the equation:

$$y_{i,t} = \alpha_j + \theta_t + \sum_{k=-1}^{k=-T^{\text{pre}}} \delta_k \left(D_{i,T_0+k} - D_{i,T_0}\right) + \sum_{k=1}^{k=T^{\text{post}}} \gamma_k D_{i,T_0+k} + X_{i,t} + \varepsilon_{i,t} \tag{14}$$

where $y_{i,t}$ is the outcome of interest for individual i, α_j is a fixed effect denoting whether individual i is a mortgagor or non-mortgagor and D_{i,T_0+k} is an event-time indicator variable taking the value one if i is a mortgagor at time k quarters after the beginning of required repayment increases in T_0 = August 2022 and zero otherwise. All other terms are as defined for Equation (11). Appendix B contains details of the data used for estimation.

Results with controls are shown in Figure 9. Following the increase in required mortgage repayments starting in August 2022, mortgagors experience a sustained increase in mortgage repayments relative to non-mortgagors. However we see little difference in spending between mortgagors and non-mortgagors across either spending category. Mortgagors financed around half of increased mortgage repayments by drawing down on their savings, as indicated by the fall in mortgagors relative to non-mortgagors bank account balances (see the bottom right panel of Figure 9). The remaining half of the increase in repayments was financed from other net inflows. When we exclude individuals with large net incoming transfers, around 85 per cent of the increase in repayments are financed by mortgagors drawing down on their bank account balances (see Figure A7 in the Online Appendix). Overall we find little evidence that mortgagors reduced their spending relative to non-mortgagors.

Figure 9: Event Study: Mortgagors vs. Non Mortgagors



Notes: This figure shows estimated coefficients δ_k (pre-event) and γ_k (post-event) from Equation (14). All flows shown are at monthly rates. *Cumulative change in account balance* is the sum of *income* and *all other net inflows* less the sum of *repayments* and *spending*. *Measured spending* is the sum of non-durable, durable and services (including rent) spending categorized by the third-party data provider; *unmeasured spending* is the sum of other spending-related outflows (ATM withdrawals, miscellaneous card payments, credit card repayments and gambling). Standard errors are clustered at the person level and two standard error bands are shown.

Summary: Mean monthly mortgage repayments rose by around \$750 for mortgagors relative to non-mortgagors between mid-2022 and the start of 2024. However, there was little change in spending between the two groups.

Expiry of fixed rate mortgages A subset of low-interest fixed-rate mortgages originated before mid-2021 in our sample are observed to expire and reset to adjustable-rate loans with substantially higher interest rates. This setting provides a quasi-experimental setting to examine the consumption response to the anticipated increase in mortgage repayments at the time of expiry.

We compare the outcomes of mortgagors whose fixed-rate loans have expired to those whose loans have yet to expire, using an event-study framework centered around the expiry date. Mortgagors with unexpired loans provide a valid control group if the timing of expiry is quasi-exogenous. This is plausible because the low-rate fixed rate loans we study were originated during a period when interest rate were expected to remain low until 2024, as signaled by the RBA. This research design has been used by Di Maggio et al. (2017) and Kartashova and Zhou (2023), among others. A strength of the approach is this it compares a relatively homogeneous group of borrowers.

For fixed rate loans in our sample expiring between July 2022 and March 2024, the mean increase in interest rate at expiry was 3 percentage points and the mean increase in monthly repayments was around \$600 (Figures A8a and A8b). The rise in interest rate occurs almost immediately but it takes around 4 months for the full increase in repayments to occur, due to notification periods. For at least a year prior to expiry, adjustable interest rates were above the interest rate on fixed rate loans. Thus, higher repayments should have been anticipated by households.

Despite the large increase in repayments, we find no evidence of a drop in consumption around expiry (Figures A8c and A8d). This provides evidence that fixed rate mortgagors smoothed consumption in response to higher repayments. Consistent with the behavior of adjustable rate mortgage holders in the main analysis, Figure A8f suggests they did this by drawing down savings.

These findings are consistent with Kartashova and Zhou (2023), who find no response of durable spending (proxied by new auto and installment loans) to increased repayments at expiry of fixed rate mortgages in Canada for the 2017-2019 period. However, like Di Maggio et al. (2017), they find that durable spending rose when required repayments fell for expiries occurring earlier in their sample. Our findings build on their work by using a more comprehensive consumption measure in response to a larger shock. However, some caveats apply to our analysis. The limited panel dimension of our data means we observe only around 4,000 expiries and the sample size declines with time relative to expiry. The full details of this analysis are reported in Appendix D.

Other evidence Other evidence corroborates our finding that access to liquidity allowed adjustable-rate mortgagors to absorb increased required repayments. First, in February 2025 – nearly three years after the tightening cycle studied in this paper – the RBA cut in interest rates. Following this cut, data from three of the four major banks that dominate the mortgage market in Australia indicate that around 90 per cent of adjustable rate mortgagors chose to keep their mortgage repayments unchanged, rather than reduce their repayments (Commonwealth Bank of Australia, 2025; National Australia Bank, 2025; Knight, 2025). The fact that household kept repayments unchanged, following a period in which there was a sustained increase in rates, indicates that few households were financially constrained, consistent with our results.

Second, data on arrears and non-performing loans is also consistent with few households experiencing severe financial constraints. Both arrears and non-performing loans remained low, at below 1 per cent of total credit outstanding, during the period in which required mortgage repayments increased and were at levels lower than when forward guidance was introduced by the RBA (Figure A9).

5 Macroeconomic Implications

In our empirical analysis, we find no significant difference between the spending response of adjustable-rate mortgagors, compared with either fixed-rate mortgagors or non-mortgagors. But these findings do not tell us about the overall effect of monetary policy on spending for adjustable-rate mortgagors because it is possible that the spending of the two reference groups was changed by the increase in interest rates—a missing intercept. In this section, we first use the model from Section

2 to provide an estimate for part of the missing intercept for the fixed-rate mortgagor and non-mortgagor reference groups. We then evaluate the plausibility of aggregate effects of monetary policy on consumption implied by a standard new Keynesian representative agent model. We compare this to a what our estimated MPC implies for household consumption in absence of a policy tightening by the RBA.

5.1 Common intertemporal substitution effects

In Section 2 we explained that part of the missing intercept is due to a common intertemporal substitution response for both types of households.[10] Accordingly, the elasticity of intertemporal substitution is an important calibration choice because it controls the strength of the intertemporal motive. Best et al. (2020) estimate $\sigma = 0.1$ for mortgagors using interest rate notches at loan-to-value thresholds while Crawley (2025) estimates σ close to zero using structural shocks for identification. We strike a balance between these estimates and a more traditional macro calibration and set $\sigma = 0.25$. The deposit interest rate r^a is set at 3 percent and the after-tax spread between mortgage and deposit interest rates is set equal to 3 percent, based on historical interest rates on certificates of deposits and adjustable rate mortgages. The rate of time-preference is $\rho = 0.026$, such that all household types have an intertemporal motive to save $\left(\rho < r^a < r^d\right)$. In this parameterization, an adjustable-rate mortgagor with $\sigma = 0.25$ would choose to repay their mortgage in 18 years—7 years ahead of schedule.[11]

Guided by the movements in inflation and interest rates in Australia after 2022, we simulate a 4 percentage point increase in inflation that decays with a half-life of $1\frac{1}{2}$ years (Figure 10a). We assume that the central bank raises the real interest rate by one-quarter of a percentage point for each percentage point rise in inflation (a Taylor rule coefficient on inflation of 1.25). Empirically, the adjustable mortgage interest rate increases relative to the after-tax deposit rate when the policy interest rate rises because of stronger pass-through to mortgage interest rates than deposit rates and the fact that interest income on deposits is taxed.

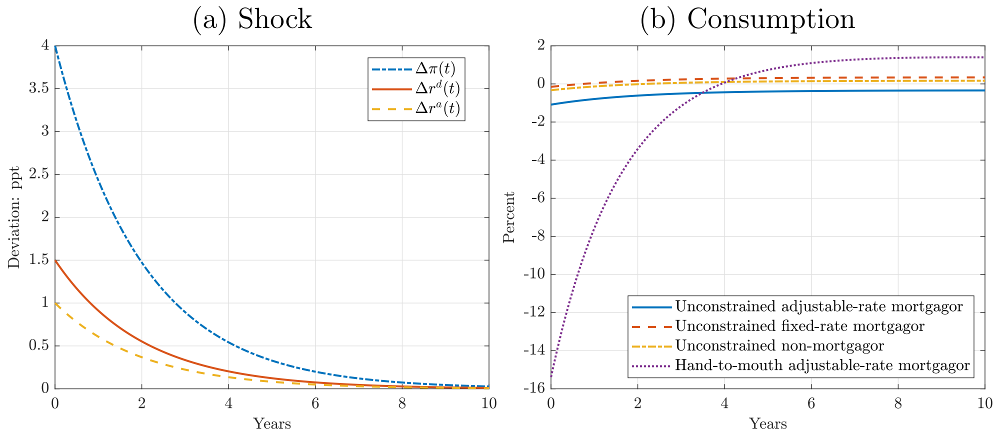
In response to higher interest rates, consumption declines for all households, including those who are not hand-to-mouth. (Figure 10b). The decline is largest for adjustable-rate mortgagors because the rise in the mortgage interest rate relative to the deposit rate induces a larger intertemporal response. The decline is smallest for fixed-rate mortgagors because they experience a positive wealth effect (see Section 2). However, the magnitudes of these drops in consumption are small, and are dwarfed by the implied fall in consumption for hand-to-mouth adjustable-rate mortgagors.

So while there is indeed a missing intercept, since consumption falls for fixed-rate mortgagors

[10] There may also be general equilibrium effects on income that affect both groups. The model we use is partial equilibrium and so cannot be used quantify general equilibrium responses. If there are general equilibrium effects, our estimate of the missing intercept is a lower bound.

[11] There is a relatively small range of values for the intertemporal elasticity of substitution σ in which both adjustable-rate and fixed-rate mortgagors are unconstrained and the desired mortgage repayment time is plausible for adjustable-rate mortgagors. When the discount rate is calibrated to target plausible repayment times for adjustable-rate mortgagors, fixed-rate mortgagors are constrained for larger values of σ. Accordingly, we do not consider larger values of σ given our goal of quantifying intertemporal substitution responses for both groups.

Figure 10: Response of Spending to an Interest Rate Shock



Notes: Panel (a) shows the shock to inflation π, the deposit rate r^a and the adjustable-rate mortgage interest rate r^d. Inflation rises by 4 percentage points, roughly in line with the experience in Australia over the period studied, and decays with a half-life of about 1.5 years. The real deposit rate rises by 1 percentage point, as would be the case if the central bank followed a Taylor rule with an inflation response of 1.25. The real mortgage interest rate rises by more than the deposit rate, reflecting higher pass through of central bank interest rate changes to mortgage rates and difference in tax treatment. Panel (b) shows the impulse response of consumption (percentage deviation from steady-state level) to the shocks in Panel (a) for unconstrained adjustable and fixed-rate mortgagors, unconstrained non-mortgagors and hand-to-mouth adjustable-rate mortgagors. The steady-state parameter values of the model are: real deposit account interest rate $r^a = 0.03$, real mortgage interest rate $r^d = 0.06$, inflation $\pi = 0.025$, rate of time preference $\rho = 0.026$, elasticity of intertemporal substitution $\sigma = 0.25$, initial debt-to-income ratio $d_0/y = 3$ for mortgagors and initial assets $a_0/y = 1$ for non-mortgagors, and real income growth $g_y = -0.005$. The shock is assumed to hit 5 years after commencement of a loan with a 25-year contractual length.

Summary: The decline in consumption for fixed-rate mortgagors and non-mortgagors—the missing intercept—is small.

and non-mortgagors, we estimate it to be less than one-half of a percent of consumption (Figure 10b). Moreover, the simulations suggest that the empirical strategy has substantial power to detect the cashflow effect for hand-to-mouth adjustable-rate mortgagors, for which we do not find evidence.

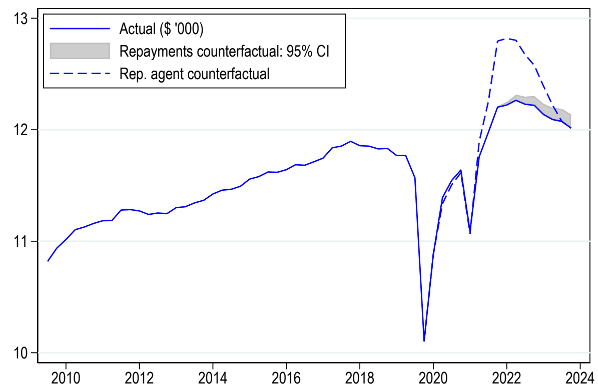
5.2 Macroeconomic counterfactuals

What do our findings imply about the potency of monetary policy for household consumption? We address this question by constructing counterfactual paths for aggregate consumption absent the monetary policy tightening beginning in May 2022. This exercise is a monetary policy analogue to Orchard, Ramey and Wieland (2025) for fiscal policy.

Our first counterfactual is consumption assuming aggregate nominal required mortgage repayments had remained at their level prior to the commencement of policy rate increases in 2022Q1 (Figure 11). It is constructed by multiplying the estimated MPC from our preferred estimation (Specification 1 in Table 3) by the difference between actual required repayments and their 2022Q1 level. A range is shown using the one-sided 95 percent confidence interval (truncated at zero) for the MPC.

Our second counterfactual is the path of consumption implied by a standard representative agent model had the policy rate remained at its effective lower bound until 2024Q1, as signaled but

Figure 11: Actual and Counterfactual Consumption



Notes: This figure shows quarterly real per capita Household Final Consumption Expenditure (from the national accounts) together with two counterfactuals. *Repayments counterfactual* is consumption assuming aggregate required mortgage repayments had remained at their level prior to the commencement of policy rate increases in 2022Q1. It is constructed by multiplying the estimated MPC from our preferred estimation (Specification 1 in Table 3) by the difference between actual required repayments and their 2022Q1 level. A range is shown using the one-sided 95 percent confidence interval (truncated at zero) for the MPC. *Rep. agent counterfactual* is the level of consumption implied by a representative agent model with an intertemporal elasticity of substitution equal to one if the policy rate remained at its lower bound until 2024Q1. *Sources:* ABS, RBA.

Summary: The required repayments channel of monetary policy can account for no more than one-fifth of the consumption response implied by a standard representative-agent model.

subsequently abandoned by the RBA. To construct this counterfactual we begin by log-linearizing the consumption Euler equation for a representative household and iterating forward. Doing so, the percentage deviation in consumption from its observed level at time t is

$$\widetilde{C}_t = -\frac{1}{\sigma}\sum_{s=t}^{\infty}\widetilde{r}_s \tag{15}$$

where $\widetilde{r}_s$ is the difference between the actual and counterfactual $s-t$ period ahead expected real interest rate and σ is the intertemporal elasticity of substitution (IES). We conduct a partial-equilibrium exercise that assumes no change in inflation between the actual and counterfactual scenarios.[12] This implies

$$\widetilde{C}_t = -\frac{1}{\sigma}\sum_{s=t}^{2024\text{Q1}}\left[\mathbb{E}_{2020\text{Q1}}\left[i_s\right] - \mathbb{E}_t\left[i_s\right]\right], \tag{16}$$

for t between 2022Q1 and 2024Q1, where i_s is the nominal interest rate in period s. Using Equation (16), and assuming a standard IES of one, counterfactual consumption is shown in Figure 11. At the peak, counterfactual consumption would have been 5 percent higher under the counterfactual than the actual path.

These counterfactuals imply the mortgage repayments channel accounts for no more than one-fifth of the overall effect of monetary policy in the representative agent model. How plausible is

[12]This would understate the counterfactual increase in consumption if a more accommodative monetary policy led to higher inflation, which in turn lowered the real interest rate.

it that other channels of monetary policy transmission account for the remainder? Intertemporal substitution is the only transmission mechanism in the representative agent model, but is best conceptualized as a proxy for other channels omitted from the model. The evidence indicates that direct intertemporal substitution is minimal (Crawley, 2025), including specifically for mortgagors (Best et al., 2020).

Other potential channels affecting consumption, which are captured by the IES, are indirect effects operating through wealth, labor demand, and the exchange rate. Wealth effects are small except for constrained households (Cooper, 2013), who are relatively few in our sample. The unemployment rate was 3.9 percent at the commencement of monetary policy tightening in May 2022—its lowest level since the 1970s—and has remained below 4.2 percent until the end of our sample. This suggests limited capacity for the labor market to be substantially tighter with more accommodative monetary policy. Although (real) wage growth could have been higher. The effect of the exchange rate was likely to have been limited; the real exchange rate appreciated modestly over the period and the pass-through to consumer prices is estimated to be modest (Chung, Kohler and Lewis, 2011). Taken together, the evidence suggests monetary policy tightening had a modest effect on consumption in this episode.

6 Conclusion

We have studied the effects of the large increase in required mortgage repayments due to Australia's post-pandemic monetary policy tightening on household spending. Despite monthly repayments on the typical adjustable rate mortgage rising by $13,800, the effect on spending was small for up to two years following the commencement of interest rate increases. Households smoothed consumption in response to higher required repayments by drawing down on accumulated savings, much of which was held as excess repayments on mortgages.

Our findings demonstrate that mortgagors' spending may not be sensitive to central bank policy rates, even when the share of adjustable-rate mortgages is large and pass-through of interest rate changes to mortgage interest rates is rapid and complete. The main reason is that adjustable rate mortgagors in Australia can and do make voluntary excess repayments that can be withdrawn at their discretion. These features make mortgages a high-return but liquid asset. The lack of sensitivity of mortgagors' consumption to increases in required repayments may seems to contradict convention wisdom but it is not surprising in light of economic theory. Consumption is sensitive to disposable income when high return assets are illiquid, which is not the case for Australian mortgages.

We contribute to a growing literature on the mortgage debt transmission channel of monetary policy. Most of the literature has found greater sensitivity of mortgagors spending to required repayments than we do. These different findings can be explained by structural and episodic factors. In Australia, adjustable rate mortgagors can withdraw excess mortgage repayments. The pool of savings accumulated during the pandemic facilitated smoothing of consumption by mortgagors, implying that the strength of the mortgage debt transmission channel is state dependent. More broadly, our findings contribute new findings to a literature studying how mortgage market structure and design affects monetary policy transmission.

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Online Appendix

(Not for Publication)

A Mortgagor's decision problem

This appendix solves the analytical model of the mortgagor's decision problem described in Section 2.

A.1 Adjustable rate mortgagor

Real required repayments The adjustable rate mortgage contract is described in Section 2. Required repayments can be expressed in real terms making use of the price level

$$P(s) = P(t)\, e^{\int_t^s \pi(u)du}, \quad s \geq t$$

where $\pi(s) = \dot{P}(s)/P(s)$. Doing so,

$$m(s) = \frac{M_t}{P(s)}, \quad t \leq s \leq t + N_t.$$

The problem that follows is expressed in real terms.

Problem setup A household chooses consumption c and mortgage repayments x to solve

$$\max_{\{c(s),x(s)\}_{s\geq t}} \int_t^\infty e^{-\rho(s-t)} u(c(s))\, ds$$

subject to

$$\begin{aligned}
\dot{a}(s) &= r^a(s)\, a(s) + y(s) - x(s) - c(s), \quad s \geq t \\
\dot{d}(s) &= r^d(s)\, d(s) - x(s), \quad s \geq t \\
a(s) &\geq 0 \\
d^{sch}(s) &\geq d(s) \geq 0
\end{aligned}$$

where

$$\begin{aligned}
\dot{d}^{sch}(s) &= r^d(s)\, d^{sch}(s) - m(s) \\
d^{sch}(t) &\text{ given} \\
m(s) &\text{ given} \\
a(t) &\text{ given} \\
r^d(s) &> r^a(s)
\end{aligned}$$

The Hamiltonian for the maximisation problem is

$$\begin{aligned}
\mathcal{H} = u\left(c\left(s\right)\right) &+ \lambda^{a}\left(s\right)\left[r^{a}\left(s\right)a\left(s\right)+y\left(s\right)-x\left(s\right)-c\left(s\right)\right]\\
&+\lambda^{d}\left(s\right)\left[r^{d}\left(s\right)d\left(s\right)-x\left(s\right)\right]\\
&+\mu^{a}\left(s\right)a\left(s\right)\\
&+\mu^{d}\left(s\right)d\left(s\right)\\
&+\mu^{R}\left(s\right)\left[d^{sch}\left(s\right)-d\left(s\right)\right]\\
&\text{with}\\
&\mu^{a}\left(s\right)\geq 0,\quad a\left(s\right)\geq 0,\quad \mu^{a}\left(s\right)a\left(s\right)=0\\
&\mu^{d}\left(s\right)\geq 0,\quad d\left(s\right)\geq 0,\quad \mu^{d}\left(s\right)d\left(s\right)=0\\
&\mu^{R}\left(s\right)\geq 0,\quad d^{sch}\left(s\right)\geq d\left(s\right)\quad \mu^{R}\left(s\right)\left[d^{sch}\left(s\right)-d\left(s\right)\right]=0
\end{aligned}$$

The first-order conditions are

$$\frac{\partial\mathcal{H}}{\partial c\left(s\right)} = u'\left(c\left(s\right)\right)-\lambda^{a}\left(s\right)=0$$

$$\frac{\partial\mathcal{H}}{\partial x\left(s\right)} = \begin{cases} -\lambda^{a}\left(s\right)-\lambda^{d}\left(s\right)\geq 0 & a\geq 0 \text{ binds}\\ -\lambda^{a}\left(s\right)-\lambda^{d}\left(s\right)=0 & \text{interior}\\ -\lambda^{a}\left(s\right)-\lambda^{d}\left(s\right)\leq 0 & d=d^{sch} \text{ binds}\end{cases}$$

and the co-state conditions are

$$\begin{aligned}
\dot{\lambda}^{a}\left(s\right) &= \left(\rho-r^{a}\left(s\right)\right)\lambda^{a}\left(s\right)-\mu^{a}\left(s\right)\\
\dot{\lambda}^{d}\left(s\right) &= \left(\rho-r^{d}\left(s\right)\right)\lambda^{d}\left(s\right)-\mu^{d}\left(s\right)+\mu^{R}\left(s\right)
\end{aligned}$$

Income is assumed to grow at g^{y} such that

$$y\left(s\right)=y\left(t\right)e^{g^{y}\left(s-t\right)},\quad s\geq t. \tag{A.1}$$

Patient household Suppose the household is patient and pays down debt ahead of schedule then accumulates assets in the checking account after repaying the mortgage ahead of schedule. Assume: $\rho\leq r^{a}\left(s\right)<r^{d}\left(s\right)$ and $d^{sch}\left(s\right)>d\left(s\right)$ for all $s\geq t\Rightarrow$ unconstrained. There are two regimes: prior to paying off the mortgage and post-mortgage. Let N^{*} be the endogenous remaining time on the mortgage.

Prior to paying off mortgage: $t\leq s<t+N_{t}^{*}$ $\quad d^{sch}\left(s\right)>d\left(s\right)$ and $d\left(s\right)>0$, implying

$$\begin{aligned}
\mu^{R}\left(s\right)&=0\\
a\left(s\right)=0,&\quad \mu^{a}\left(s\right)>0\\
\mu^{d}\left(s\right)&=0.
\end{aligned}$$

The condition $\mu^a(s) > 0$ implies $\dot{a}(s) = 0 \Rightarrow \Delta c(s) = -\Delta x(s)$ from the deposit account law of motion. Optimality requires that along this feasible path

$$D\mathcal{H}_t = \left(u'(c(s)) - \lambda^a(s)\right)\Delta c + \left(-\lambda^a(s) - \lambda^d(s)\right)\Delta x = \left(u'(c(s)) + \lambda^d(s)\right)\Delta c = 0.$$

Hence, $u'(c(s)) = -\lambda^d(s)$ and consumption growth is determined by the co-state equation for the mortgage account:

$$\frac{\dot{c}(s)}{c(s)} = \sigma\left(r^d(s) - \rho\right) = g^d(s)$$

where σ is the intertemporal elasticity of substitution assuming $u(c)$ has CRRA form. This implies

$$c(s) = c(t)\, e^{\int_t^s g^d(u)du} \quad \text{for} \quad t \leq s < t + N^*. \tag{A.2}$$

For the special case where $r^d(s)$ is constant we have

$$c(s) = c(t)\, e^{g_d(s-t)} = c(t)\, e^{\sigma\left(r^d-\rho\right)(s-t)} \quad \text{for} \quad t \leq s < t + N_t^*. \tag{A.3}$$

Now integrate the budget constraint for the mortgage account forward from $s = t$ to $s = t + N^*$. Define the integrating factor

$$\gamma^d(s) = e^{-\int_t^s r^d(u)du},$$

so that

$$\frac{d}{ds}\left[\gamma^d(s)\, d(s)\right] = \dot{\gamma}^d(s)\, d(s) + \gamma^d(s)\, \dot{d}(s) = \gamma^d(s)\left[\dot{d}(s) - r^d(s)\, d(s)\right] = -\gamma^d(s)\, x(s)$$

$$\Rightarrow \quad \gamma^d(t + N_t^*)\, d(t + N_t^*) - \gamma^d(t)\, d(t) = -\int_t^{t+N_t^*} \gamma^d(s)\, x(s)\, ds$$

We have $\gamma^d(t) = 1$ and at $s = t + N_t^*$ the debt is repaid so $d(t + N_t^*) = 0$. When $d^{sch}(s) > d(s)$ we have $a(s) = 0 \Rightarrow x(s) = y(s) - c(s)$. Hence,

$$d(t) = \int_t^{t+N_t^*} e^{-\int_t^s r^d(u)du}\left[y(s) - c(s)\right] ds \tag{A.4}$$

For the special case where $r^d(s)$ is constant, $\gamma^d(s) = e^{-r^d(s-t)}$ and

$$\begin{aligned} d(t) &= \int_t^{t+N_t^*} e^{-r^d s}\left[y(s) - c(s)\right] ds \\ &= y(t)\int_t^{t+N_t^*} e^{-\left(r^d-g^y\right)s} ds - c(t)\int_t^{t+N_t^*} e^{-\left(r^d-g^d\right)s} ds \end{aligned} \tag{A.5}$$

Computing the integrals and re-arranging gives

$$c(t) = \underbrace{\left(r^d - g^d\right)}_{\text{slope}} \cdot \underbrace{\left(\frac{\frac{y(t)}{\left(r^d-g^y\right)}\left(1 - e^{-\left(r^d-g^y\right)(t+N_t^*)}\right) - d(t)}{1 - e^{-\left(r^d-g^d\right)(t+N_t^*)}}\right)}_{\text{wealth}}. \tag{A.6}$$

After paying off the mortgage: $s \geq t + N_t^*$

$$d(s) = 0$$
$$\mu^a(t) = 0$$
$$\mu^d(t) > 0$$
$$\mu^x(t) > 0$$

Consumption growth is determined by the co-state equation for the deposit account:

$$\frac{\dot{c}(s)}{c(s)} = \sigma\left(r^a(s) - \rho\right) = g^a(s), \quad s \geq t + N_t^*$$

implying

$$c(s) = c\left(t + N_t^*\right) e^{\int_{t+N_t^*}^{s} g^a(u)du} \quad \text{for} \quad s \geq t + N_t^* \tag{A.7}$$

For the special case where $r^a(s)$ is constant we have

$$c(s) = c\left(t + N_t^*\right) e^{g^a\left(s-\left(t+N_t^*\right)\right)} \quad \text{for} \quad s \geq t + N_t^*$$

For $s \geq t + N_t^*$ the evolution of assets is governed by the deposit account. Define the integrating factor

$$\gamma^a(s) = e^{-\int_{t+N_t^*}^{s} r^a(u)du},$$

so that

$$\frac{d}{ds}\left[\gamma^a(s)\, a(s)\right] = \dot{\gamma}^a(s)\, a(s) + \gamma^a(s)\, \dot{a}(s) = \gamma^a(s)\left[\dot{a}(s) - r^a(s)\, a(s)\right] = \gamma^a(s)\left[y(s) - c(s)\right].$$

Integrating from $t + N_t^*$ to $s' > t + N_t^*$

$$\Rightarrow \quad \gamma^a\left(s'\right) a\left(s'\right) - \gamma^a\left(t + N_t^*\right) a\left(t + N_t^*\right) = \int_{t+N_t^*}^{s'} \gamma^a(s)\left[y(s) - c(s)\right] ds.$$

Letting $s' \to \infty$ and using $a\left(t + N_t^*\right) = 0$ implies

$$0 = \int_{t+N_t^*}^{\infty} e^{-\int_{t+N_t^*}^{s} r^a(u)du}\left[y(s) - c(s)\right] ds. \tag{A.8}$$

For the special case where $r^a(s)$ is constant, $\gamma^a(s) = e^{-r^a\left(s-\left(t+N_t^*\right)\right)}$ and

$$\begin{aligned}\int_{t+N_t^*}^{\infty} e^{-r^a\left(s-\left(t+N_t^*\right)\right)} y(s)\, ds = y\left(t + N_t^*\right) \int_{t+N_t^*}^{\infty} e^{-\left(r^a-g^y\right)\left(s-\left(t+N_t^*\right)\right)} ds \\ = \int_{t+N_t^*}^{\infty} e^{-r^a\left(s-\left(t+N_t^*\right)\right)} c(s)\, ds \\ = c\left(t + N_t^*\right) \int_{t+N_t^*}^{\infty} e^{-\left(r^a-g^a\right)\left(s-\left(t+N_t^*\right)\right)} ds.\end{aligned}$$

Computing integrals gives

$$c\left(t + N_t^*\right) = \underbrace{\left(r^a - g^a\right)}_{\text{slope}} \cdot \underbrace{\left(\frac{y\left(t + N_t^*\right)}{r^a - g^y}\right)}_{\text{wealth}} \tag{A.9}$$

By definition, $t+N_t^*$ is the time at which the mortgage is repaid and assets are equal to zero. At $t+N_t^*$, the consumer solves an infinite horizon consumption-saving problem beginning with zero assets, facing interest rate $r^a(s)$ and receiving certain income y.

If $r^a(s)$ is constant and $g^y=0$ then regardless of when $t+N_t^*$ occurs, the consumer solves the same problem (the problem is stationary) and $c(t+N_t^*)$ does not depend on what happens beforehand. However, the time at which $t+N_t^*$ occurs does.

Finding $c(t)$ as a function of $t+N_t^*$ An optimal solution requires no jumps in consumption:

$$\lim_{s\to t+N_{t-}^*} c(s) = \lim_{t\to t+N_{t+}^*} c(s).$$

Otherwise, it would be optimal to smooth consumption to eliminate the jump. From Equation (A.2),

$$\lim_{s\to t+N_{t-}^*} c(s) = \lim_{s\to t+N_{t-}^*} c(t)\, e^{\int_t^s g^d(u)du}$$

and from Equation (A.7)

$$\lim_{s\to t+N_{t+}^*} c(s) = \lim_{s\to t+N_{t+}^*} c(t+N^*)\, e^{\int_{t+N_t^*}^s g^a(u)du}$$

Hence,

$$c(t)\, e^{\int_t^{t+N_t^*} g^d(u)du} = c(t+N_t^*) \Leftrightarrow c(t) = c(t+N_t^*)\, e^{-\int_t^{t+N_t^*} g^d(u)du}. \tag{A.10}$$

For the special case where $r^a(s)$ is constant, substituting this back into Equation (A.3) allows us to express consumption before the mortgage is repaid in terms of parameters and $t+N_t^*$:

$$c(s) = c(t)\, e^{g^d(s-t)} = c(t+N_t^*)\, e^{g^d(s-(t+N_t^*))} \text{ for } t\le s< t+N_t^*. \tag{A.11}$$

Steady-state comparative statics with respect to r^d: patient household Assume now that r^a and r^d are constant. We want to know how $c(t)$ changes when the mortgage interest rate changes. Taking logs and differentiating Equation (A.10) with respect to r^d gives

$$\begin{aligned}
\log c(t) &= \log c(t+N_t^*) - \sigma\left(r^d-\rho\right)N_t^* \\
\frac{d\log c(t)}{dr^d} &= g^y\frac{dN_t^*}{dr^d} - \sigma\left(N_t^* + \left(r^d-\rho\right)\frac{dN_t^*}{dr^d}\right) \\
&= -\sigma N_t^* - \left[\sigma\left(r^d-\rho\right) - g^y\right]\frac{dN_t^*}{dr^d},
\end{aligned}$$

where we have used that r^d is constant and $c(t+N_t^*)$ depend on r^d only through N_t^* (see Equation A.9). We now need to consider how N_t^* changes with r^d. Treating N_t^* as a function of r^d and differentiating Equation (A.5) implicitly with respect to r^d gives

$$0 = e^{-r^d(t+N_t^*)}\left(y(t+N_t^*) - c(t+N_t^*)\right)\frac{dN_t^*}{dr^d} - \int_t^{t+N_t^*} s e^{-r^d s}\left(y(s)-c(s)\right)ds - \int_t^{t+N_t^*} e^{-r^d s}\left(\frac{\partial c(s)}{\partial r^d} + \frac{\partial c(s)}{\partial N_t^*}\frac{dN_t^*}{dr^d}\right)ds$$

Re-arranging gives

$$\frac{dN_t^*}{dr^d} = \frac{\int_t^{t+N_t^*} s e^{-r^d s}\left(y(s)-c(s)\right)ds + \int_t^{t+N_t^*} e^{-r^d s}\frac{\partial c(s)}{\partial r^d}ds}{\left(y(t+N_t^*) - c(t+N_t^*)\right)e^{-r^d(t+N_t^*)} - \int_t^{t+N_t^*} e^{-r^d s}\frac{\partial c(s)}{\partial N_t^*}ds}$$

The numerator is the change in the value of mortgage debt when r^d rises. The first term is the time-weighted present-value of mortgage repayments, akin to the duration of a bond. It is the change in the value of mortgage debt absent any change in consumption or income. The second term in the numerator captures the effect on the debt burden of any change in consumption in response to an increase in r^d. The denominator is the change in resources available for mortgage repayments when the length of the mortgage increases. The first term in the denominator is repayments at $t = t + N_t^*$. It is the additional repayments when N_t^* rises absent any change in consumption. The second term in the denominator is the change in resources available for repayment due to adjustment in consumption in response to an increase in mortgage length.

Numerical solution for transitory change in interest rates Solving for the path of consumption in response to a transitory change in interest rates requires substituing the expressions for consumption as a function of $c\left(t+N_t^*\right)$ (Equations A.11 and A.7) and income (Equation A.1) into Equations (A.4) and (A.8) a solving jointly for $t+N_t^*$ and $c\left(t+N_t^*\right)$. Given N_t^* and $c\left(t+N_t^*\right)$, the level of consumption at any time can be computed using Equations (A.11) and (A.7).

A.2 Non-mortgagor

Problem setup A household chooses consumption c to maximize

$$\max_{\{c(s)\}_{s\geq t}} \int_t^\infty e^{-\rho(s-t)} u\left(c\left(s\right)\right) ds$$

subject to

$$\begin{aligned}
&\dot{a}\left(s\right) = r^a\left(s\right) a\left(s\right) + y\left(s\right) - c\left(s\right), \quad s \geq t \\
&a\left(s\right) \geq 0 \\
&\lim_{s\to\infty} e^{-\int_t^s r^a(u)\,du} a\left(s\right) = 0 \\
&a\left(t\right) \text{ given}
\end{aligned}$$

The Hamiltonian for the maximisation problem is

$$\begin{aligned}
\mathcal{H} = u\left(c\left(s\right)\right) + \lambda^a\left(s\right)&\left[r^a\left(s\right) a\left(s\right) + y\left(s\right) - c\left(s\right)\right] \\
&+ \mu^a\left(s\right) a\left(s\right) \\
&\text{with} \\
&\mu^a\left(s\right) \geq 0, \quad a\left(s\right) \geq 0, \quad \mu^a\left(s\right) a\left(s\right) = 0
\end{aligned}$$

The first-order conditions are

$$\frac{\partial \mathcal{H}}{\partial c\left(s\right)} = u'\left(c\left(s\right)\right) - \lambda^a\left(s\right) = 0$$

and the co-state condition is

$$\dot{\lambda}^a\left(s\right) = \left(\rho - r^a\left(s\right)\right) \lambda^a\left(s\right) - \mu^a\left(s\right)$$

Income is assumed to grow at g^y such that

$$y(s) = y(t)\, e^{g^y (s-t)}.$$

Unconstrained household An unconstrained household has $\mu^a(s) = 0$ for all $s \geq t$. Consumption growth is determined by the co-state equation

$$\frac{\dot{c}(s)}{c(s)} = \sigma \left(r^a(s) - \rho \right) = g^a(s)$$

implying

$$c(s) = c(t)\, e^{\int_t^s g^a(u) du} \quad \text{for} \quad s \geq t \tag{A.12}$$

Define the integrating factor

$$\gamma^a(s) = e^{-\int_t^s r^a(u) du},$$

so that

$$\frac{d}{ds}\left[\gamma^a(s)\, a(s)\right] = \dot{\gamma}^a(s)\, a(s) + \gamma^a(s)\, \dot{a}(s) = \gamma^a(s)\left[\dot{a}(s) - r^a(s)\, a(s)\right] = \gamma^a(s)\left[y(s) - c(s)\right].$$

Integrating from t to s'

$$\Rightarrow \quad \gamma^a(s')\, a(s') - \gamma^a(t)\, a(t) = \int_t^{s'} \gamma^a(s)\left[y(s) - c(s)\right] ds.$$

Letting $s' \to \infty$ implies

$$\begin{aligned} -a(t) &= \int_t^{\infty} e^{-\int_t^s r^a(u) du}\left[y(s) - c(s)\right] ds. \\ &= \int_t^{\infty} e^{-\int_t^s r^a(u) du}\left[y(t)\, e^{g^y(s-t)} - c(t)\, e^{\int_t^s g^a(u) du}\right] ds \\ &= y(t) \int_t^{\infty} e^{-\int_t^s (r^a(u) - g^y) du} ds - c(t) \int_t^{\infty} e^{-\int_t^s (r^a(u) - g^a(u)) du} ds \end{aligned} \tag{A.13}$$

Under the special case that r^a is constant,

$$c(t) = \underbrace{(r^a - g^a)}_{\text{slope}} \cdot \left[\underbrace{\left(\frac{y(t)}{r^a - g^y}\right)}_{\text{PDV labor income}} + \underbrace{a(t)}_{\text{initial wealth}} \right]$$

Numerical solution for transitory change in interest rates Solving for the path of consumption in response to a transitory change in interest rates requires solving (A.13) for $c(t)$ and then using Equation (A.12) to find the level of consumption at time $s \geq t$.

A.3 Fixed rate mortgagor

Consider a household with a fixed 25 year mortgage. Let N_t be the remaining loan term at time t. The mortgage does not permit prepayment. Nominal required repayments is given by Equation (2). The (scheduled) nominal mortgage balance evolves according to

$$\dot{D}(s) = i \cdot D(s) - M_t, \quad s \geq t \quad \text{with} \quad D(t + N_t) = 0,$$

where i is the nominal interest rate on the fixed rate mortgage.

Real required repayments is given by

$$m(s) = \begin{cases} \frac{M_t}{P(s)} = M_t \cdot e^{-\int_t^s \pi(u)du} & t \leq s \leq t + N_t \\ 0 & s > t + N_t \end{cases}$$

where $\pi(s)$ is the inflation rate at time s. The real mortgage balance evolves according to

$$\dot{d}(s) = (i - \pi(s))\, d(s) - m(s) \quad s \geq t \quad \text{with} \quad d(t + N_t) = 0$$

The household can save in a deposit account a earning return $r^a(s)$.

Problem setup A household chooses consumption c to maximize

$$\max_{\{c(s)\}_{s \geq t}} \int_t^\infty e^{-\rho(s-t)} u(c(s))\, ds$$

subject to

$$\dot{a}(s) = r^a(s)\, a(s) + y(s) - c(s) - m(s) \quad s \geq t$$

$$a(s) \geq 0$$

$$\dot{d}(s) = (i - \pi(s))\, d(s) - m(s) \quad s \geq t$$

$$a(t) \text{and } d(t) \text{ given}$$

$$\lim_{s \to \infty} e^{-\int_t^s r^a(u)\, du} a(s)\, ds = 0$$

where $m(s)$ is real required mortgage repayments.

The Hamiltonian for the maximisation problem is

$$\mathcal{H} = u(c(s)) + \lambda^a(s)\left[r^a(s)\, a(s) + y(s) - c(s) - m(s)\right] + \mu^a(s)\, a(s)$$

with

$$\mu^a(s) \geq 0, \quad a(s) \geq 0, \quad \mu^a(s)\, a(s) = 0 \quad \text{s} \geq t$$

The first-order conditions are

$$\frac{\partial \mathcal{H}}{\partial c(s)} = u'(c(s)) - \lambda^a(s) = 0$$

and the co-state condition is

$$\dot{\lambda}^a(s) = (\rho - r^a(s))\, \lambda^a(s) - \mu^a(s)$$

Income is assumed to grow at g^y such that

$$y(s) = y(t)\, e^{g^y(s-t)}.$$

Unconstrained fixed rate mortgagor An unconstrained household has $\mu^a(s) = 0$. Consumption growth is determined by the co-state equation

$$\frac{\dot{c}(s)}{c(s)} = \sigma(r^a(s) - \rho) = g^a(s)$$

implying

$$c(s) = c(t)\, e^{\int_t^s g^a(u)du} \quad \text{for} \quad s \geq t \tag{A.14}$$

Define the integrating factor

$$\gamma^a(s) = e^{-\int_t^s r^a(u)du},$$

so that

$$\frac{d}{ds}[\gamma^a(s)\, a(s)] = \dot{\gamma}^a(s)\, a(s) + \gamma^a(s)\, \dot{a}(s) = \gamma^a(s)[\dot{a}(s) - r^a(s)\, a(s)] = \gamma^a(s)[y(s) - c(s) - m(s)].$$

Integrating from t to s'

$$\Rightarrow \quad \gamma^a(s')\, a(s') - \gamma^a(t)\, a(t) = \int_t^{s'} \gamma^a(s)[y(s) - c(s) - m(s)]\, ds.$$

Letting $s' \to \infty$ implies

$$\begin{aligned} -a(t) &= \int_t^{\infty} e^{-\int_t^{s'} r^a(u)du}[y(s) - c(s) - m(s)]\, ds. \\ &= \int_t^{\infty} e^{-\int_t^s r^a(u)du}\left[y(t)\, e^{g^y(s-t)} - c(t)\, e^{\int_t^s g^a(u)du}\right] ds - M_t \int_t^{t+N_t} e^{-\int_t^s (r^a(u)+\pi(u))du} ds \\ &= y(t)\int_t^{\infty} e^{-\int_t^s (r^a(u)-g^y)du} ds - c(t)\int_t^{\infty} e^{-\int_t^s (r^a(u)-g^a(u))du} ds - M_t \int_t^{t+N_t} e^{-\int_t^s (r^a(u)+\pi(u))du} ds \end{aligned} \tag{A.15}$$

Under the special case that r^a is constant,

$$c(t) = \underbrace{(r^a - g^a)}_{\text{slope}} \cdot \left(\underbrace{\left(\frac{y(t)}{r^a - g^y}\right)}_{\text{PDV labor income}} + \underbrace{a(t)}_{\text{initial wealth}} - \underbrace{\frac{M_t}{i}\left(1 - e^{-iN_t}\right)}_{\text{PDV repayments}} \right)$$

Numerical solution for transitory change in interest rates Solving for the path of consumption in response to a transitory change in interest rates requires solving (A.15) for $c(t)$ and then using Equation (A.14) to find the level of consumption at time $s \geq t$.

B Data Construction

We outline the procedure used to construct our sample of mortgagors and non mortgagors.

B.1 Bank transaction data

The dataset is an administrative collection of digitized bank transactions (at the account-statement level) maintained by a large Australian data provider. It contains information on Australian residents who consented to share their bank records when applying for various financial services with the provider's client institutions. Each such application triggers a data collection event in which the data provider obtains a recent transaction history (around 90 days of records, on average) from the accounts the individual has chosen to include.

B.1.1 Sample restrictions: Mortgagors

The sample is based on the serviced mortgage accounts of Australian residents at a large Australian bank that are observed between November 2020 and April 2024. We remove individuals who are self employed (as indicated by wages paid out to themselves) or applicants for commercial loans.

We impose additional restrictions to ensure we are capturing primary bank accounts.Firstly, we remove any individual where we observe less than 81 days of information as the data collection event should include at least 90 days of transactions data. Fewer days indicates an individual has: (i) submitted an account that is not use regularly, or (ii) recently opened this bank account. Seconly, we ensure that every mortgage repayment on the home loan has a corresponding direct debit from an observed transaction account. This ensures that we can fully account for the changes in each household's cash flows associated with any changes in interest rates. Thirdly following Ganong and Noel (2019), we remove individuals who do not have at least five outflows from their accounts and zero income inflows in the account every month. These restrictions remove around 50% of the sample.

In addition, we also exclude the top and bottom one percent of values in terms of mortgage balances, repayments, spending and income and the top one percent of values for ATM withdrawals and incoming and outgoing external bank account transfers (these are bank account transfers to or from unobserved accounts).

We use the data provider's categorization of transactions to aggregate transactions into broad categories of inflows and outflows (Table A1) .

B.2 Mortgage data

This section outlines the transformation of the bank transaction dataset into a dataset of households servicing a mortgage which we use in our analysis.

B.2.1 Mortgage rate imputation

For indivdiuals with a mortgage we observe their outstanding mortgage balance, mortgage repayments, interest payments and their stock of excess repayments. We do not observe if an individual has an adjustable or fixed-rate mortage. We infer mortgage type from account information. In particular, we calculate the a monthly mortgage interest rate, which we refer to as the 'balance-weighted interest rate' (BWIR).

Let $B_t < 0$ be the mortgage balance at time t when the monthly interest $I_t < 0$ is charged by the bank. Let $t + d$ be the date when interest is charged in the next month, d days later (which will vary by the number of days in a month). Suppose that two repayments ($R_A > 0$ and $R_B > 0$) are made at times $t + d_1$ and $t + d_2$. Then the BWIR is computed as:

$$r = \frac{365 \times I_{t+d}}{B_t \times d + R_{t+d_2} \times (d - d_2) + R_{t+d_3}(d - d_3)} \tag{B.1}$$

Using the fact that: $B_{t+d} = B_t + (R_{t+d_2} + R_{t+d_3}) + I_{t+d}$. Throughout the paper, the BWIR is used as the mortgage rate.

There are two situations where the BWIR will not equate to the actual mortgage interest rate faced by an individual. Firstly when the mortgage rate changed within a period. Here the BWIR is a weighted average of the new and old mortgage rates. Secondly, when individuals have large offset balances. Interest is accumulate on the balance net of the offset. However, we only observe the outstanding balance on the home loan, which will result in a downward bias on the BWIR for loans associated with large offset balances. But we think these errors are likely to be small.

We assess the quality of the imputed BWIR using two sources of information:

1. Mortgagors in our sample occassionally receive a message from their bank which contains the interest rate on their mortgage. This typically occurs for adjustable rate mortgagors during periods where the cash rate is changing, where the bank reports the new mortgage rate and the date the higher rate becomes effective. Using information from these messages we find that more than two-thirds of BWIR values are within 10 basis points of the actual mortgage rate.

2. The average outstanding mortgage rate (across both fixed and variable loans) for customers at large financial institutions, reported by the Reserve Bank of Australia (Figure A11). We find that our imputed BWIR co-moves closely with official statistics, and is similar in levels (the means differ by 12 bps on average).

B.2.2 Rule for assigning mortgage as fixed or variable

We infer mortgage type using several pieces of information:

- Whether the interest rates on the mortgage changed in the month where the cash rate moved or whether any information messages are received which refer to changes in the mortgage rate in months when the cash rate moved.

- Whether there are references to institutional features that only adjustable-rate mortgages can access, such as offset accounts.

As the majority of this information relies on periods where the cash rate is changing, we divide home loans into two sub-samples, depending on whether the last month observed for the loan is before or after May-2022 (the month of the first cash rate increase).

Pre-tightening sample For the pre-tightening sample, we use the facts that:

- Between the start of 2020 to the start of 2022 interest rates on new fixed rate loan were lower than 2.44% (Lovic et al., 2023)
- Prior to first rise in the cash rate the minimum interest rate on an adjustable rate mortgage was 2.7% (Lovic et al., 2023)
- There were four decreases in the cash rate in June, July and October 2019 and March 2020

Therefore, we applied the following rule to assign mortgages:

1. If an information message referring to a new interest rate below 2.44% $\implies$ **Fixed rate mortgage**.
2. If an information message referring to a change in the mortgage rate was received on the date that the bank publicly announced pass through for the cash rate declines in late 2019/early 2020 $\implies$ **Adjustable rate mortgage**
3. For the average BWIR imputed between April 2020 and April 2022, where there were no cash rate changes during this period which were passed onto mortgage rates, if:
   - The average BWIR is $> 1.8\%$ and $\leq 2.44\%$ $\implies$ **Fixed rate mortgage** as this was the range of fixed rate mortgage interest rates during this period.
   - The average BWIR is $> 2.7\%$ $\implies$ **Adjustable rate mortgage**.

Post-tightening sample For the post-tightening sample the following rule was used:

1. If a reference to the presence of an offset account was made in an information message (such as *"Interest rate applied to that part of the loan equal to the offset account balance(s) - 0% per annum"*) $\implies$ **Adjustable rate mortgage**
2. If a home loan received an information message referring to a change in their mortgage rate which occurred on the date that the bank passed through a change in the cash rate (such as *"Change in interest rate on 12/08/22 to 4.7% per annum"*) $\implies$ **Adjustable rate mortgage**.
3. In any month where the cash rate changed after May 2022, we use the change in the BWIR relative to the size of the cash rate change:

- If the BWIR changed by less than 5 bps, $\implies$ **Fixed rate mortgage**.
- If the BWIR increased within 15 basis points of the size of the cash rate change (for a 50 bps cash rate increase, then a corresponding BWIR increase of between 35 bps and 65 bps), $\implies$ **Adjustable rate mortgage**.

4. For mortgages observed when there were no changes in the cash rate:

- If the imputed BWIR $> 4\%$ $\implies$ **Adjustable rate mortgage**
- If the imputed BWIR $> 1.8\%$ and $\leq 2.4\%$ $\implies$ **Fixed rate mortgage**

For both the pre and post-tightening samples, any months where the mortgage type has not been assigned, we fill using the closest future month where it was assigned. Our assignment rules allow us to classify over 95% of mortgages.

Identifying the expiry of fixed rate mortgages Mortgage rates on home loans can only be fixed for a relatively short period in Australia. Beginning mostly in 2023, a number of fixed rate loans originated during the COVID-19 pandemic began to expire and move onto variable rates (Ung, 2024). For loans initially classified as fixed, we identify expiries using two criteria: (i) messages from the mortgagors' bank notifying them of an expiry or loan status change; and (ii) if the increase in the BWIR on the loan is 50bps larger than the corresponding change in the cash rate over the same period. From that month onwards, the loan is classified as variable-rate. Applying these criteria, we identify approximately 4,000 mortgages expiries. The number of expiries is relatively low due to the short panel dimension of the dataset. However, the profile of the expiry of fixed-rate mortgages in our data (plotted in Figure A12), replicates the trend observed in Graph 2 of Lovic et al. (2023) from the RBA.

Aggregating across multiple mortgages For individuals that hold a combination of fixed and adjustable rate mortgages, we are able to observe both the fixed rate and adjustable rate portions of the mortgage separately. In these cases we aggregate over the individual to see what fraction of their mortgage balance is accounted for by an adjustable-rate home loan. Prior to the first increase in the cash rate, combination, fixed and adjustable rate mortgages accounted for 10, 12 and 78 per cent of mortgages respectively.

B.2.3 Evaluating the assignment rule

To assess the accuracy of the assignment rule, we asess how our sample of assigned mortgages compares to the distribution of fixed and variable mortgages in the population. We use data on average outstanding mortgage rates reported by the RBA, and the evolution of the stock of fixed and variable mortgages on the bank's loan balance which we collect from it's biannual financial reporting documents.

The imputed BWIR is similar in levels and co-moves closely with the average outstanding mortgage rate at large financial institutions reported by the RBA (Figure A13). Comparing the ratio of fixed and variable loans to the share reported on the bank's balance sheet also provides further confidence to our assignment. Across all months the share of fixed-rate mortgages in our sample is within 8 percentage points of that reported by the bank.

B.3 Spending data

We use the data provider's categorisation of transactions into broad classes of expenditure types to aggregate transactions into broad categories of flows, which are shown in Table A1.

Spending is measured from debit and credit card transactions, cash withdrawals, and other electronic transactions captured through an individual's bank account. We exclude loan repayments and transfers to other accounts. We classify spending into two categories: (i) measured spending and (ii) uncategorized spending. Measured spending refers to spending where we know both the merchant and date of spending. For these transactions we are confident spending took place. Measured spending accounts for 68 per cent of spending. Uncategorised spending refers to spending associated with credit card repayments or cash withdrawals. These transactions likely reflect spending but we do not know the precise timing or merchant associated with the spending.

We also classify spending into durable goods, non-durable goods and services spending. For measured spending items, the data provider classifies spending based on the merchant at which the transaction took place using a methodology similar to Ganong and Noel (2019) (for example supermarket spending is classified as groceries). We allocate each of these spending categories into durable, non-durable and services spending using the taxonomy from the national income and product accounts. We allocate uncategorised spending into each of these three spending categories using information from the RBA Consumer Payments Survey in 2022 and the 2022/23 annual national accounts. For each category of spending, the RBA Consumer Payments survey indicates what fraction is paid for by cash and credit card. Using this information we allocate cash purchases and credit card repayments to non-durable, durable and services spending.[13]

We can generate an aggregate measure of spending by summing the spending of mortgagors and non mortgagors in our dataset. Our measure of aggreage spending lines up well with official aggregate statistics. The correlation between monthly changes in our measure of spending and that from the Australian Bureau of Statistics's Household Spending Indicator is 0.8.

B.4 Account balances

We observe the dollar balance of bank accounts for an individual on the date of the data collection event. This includes redraw accounts where excess mortgage repayments are stored. We calculate

[13] We allocate 6.75, 40.68 and 52.57 per cent of cash spending to durable goods, non-durable goods and services spending respectively. For credit card transactions, 10.17, 45.15 and 44.69 per cent of the value of transactions are allocated to durable goods, non-durable goods and services spending. For other miscellaneous card payments, 9.83, 47.71 and 42.46 per cent of the value of transactions are allocated to durable goods, non-durable goods and services spending.

the change in an individual's bank account balance in a given month by subtracting the sum of all bank account outflows from the sum of all bank account inflows. We refer to this as the change in savings.

B.5 The non mortgagor sample

We define a non-mortgagor as in individual who does not make mortgage repayments. We exclude renters and social security recipients from our sample of non-mortgagors. Renters are excluded because there was a large increase in rents over the sample period which might have reduced renters' spending on other items. Social security recipients are excluded because these are low income individuals. For symmetry, we also exclude renters and social security recipients from our sample of mortgagors in this analysis.[14]

[14] Around 20 and 25 per cent of our sample of mortgagors are observed to pay rent or receive social security payments. These shares are similar across fixed and adjustable-rate mortgagors.

C Mortgage choice

This Appendix presents a stylized model of fixed versus adjustable mortgage choice in the Australian context. It provides a decomposition of the difference in value to holding a fixed vs. adjustable mortgage and shows that in the Australian institutional setting the capacity to make excess mortgage repayments is a determinant of the fixed vs. adjustable mortgage choice decision. We abstract from the choice of debt level to focus on the mortgage type decision.

The value of an adjustable rate mortgage is given by

$$V_t\left(b, d, y, r_V, \sigma_{r_V}, e\right) = \mathbb{E}_{y,r_V}\left[\underset{\{c,\Delta_e\}}{max}\, u(c) + \beta \mathbb{E}_{y',r'_V} V_{t+1}\left(b', d', y', r'_V, \sigma'_{r_V}, e'\right)\right] \tag{C.1}$$

subject to

$$\begin{aligned} b' &= b\left(1 + r_b\right) + y - R - \Delta_e - c \\ d' &= \left(1 + r_V\right)\left(d + e\right) + R + \Delta_e \\ e' &= e + \Delta_e \\ e' &\geq 0 \\ b &\geq 0 \end{aligned} \tag{C.2}$$

where $b \geq 0$ is the savings account balance, $d \leq 0$ is the mortgage balance, y is income, r_V is the adjustable interest rate on mortgage debt, σ_{r_V} is the volatility of the adjustable mortgage interest rate, $e \geq 0$ is the stock of excess repayments, and Δ_e is the change in excess repayments. Required mortgage repayments R are determined by the lender (as a function of d, r_V and loan term). The savings account earns a lower level of interest r_b than mortgage debt r_V.

Fixed rate mortgages in Australia have a fixed rate period of 2 to 3 years. After this the interest rate becomes adjustable. We model the fixed rate term to be a single period. Accordingly, the value of a fixed rate mortgage is given by

$$F_t\left(b, d, y, r_F\right) = \mathbb{E}_y\left[\underset{c}{max} u(c) + \beta \mathbb{E}_{y',r'_V} V_{t+1}\left(b', d', y', r'_V, \sigma'_{r_V}, e'\right)\right] \tag{C.3}$$

subject to

$$\begin{aligned} b' &= b(1 + r_b) + y - R - e' - c \\ d' &= (1 + r_F)d + R \\ e' &\geq 0 \\ b &\geq 0 \end{aligned}$$

A household refinancing from adjustable to fixed with excess payments buffer e can keep a fraction α of the payments buffer in their savings account and allocate the remained to reduced debt outstanding. It is optimal for a household with redraw balance e to refinance from adjustable to fixed if

$$\underset{\alpha}{max}\ F_t\left(b + \alpha e, d + (1 - \alpha)\, e, y, r_F\right) - V_t\left(b, d, y, r_V, \sigma_{r_V}, e\right) > \phi \tag{C.4}$$

where ϕ is the cost of refinancing. Condition (C.4) can be decomposed into components of difference: i) current interest rate; ii) reduced consumption smoothing; iii) cost of holding a liquid buffer in the low return saving account, and; iv) interest rate uncertainty:

$$\begin{aligned} & F_t\left(b+\alpha^* e, d+\left(1-\alpha^*\right) e, y, r_F\right)-V_t\left(b, d, y, r_V, \sigma_{r_V}, e\right) \\ & \quad=\underbrace{\left\{F_t\left(b+\alpha^* e, d+\left(1-\alpha^*\right) e, y, r_F\right)-F_t\left(b+\alpha^* e, d+\left(1-\alpha^*\right) e, y, r_V\right)\right\}}_{\text{value of difference in current interest rate}} \\ & \quad+\underbrace{\left\{F_t\left(b+\alpha^* e, d+\left(1-\alpha^*\right) e, y, r_V\right)-F_t\left(b+e, d, y, r_V\right)\right\}}_{\text{reduced consumption smoothing buffer}} \\ & \quad+\underbrace{\left\{F_t\left(b+e, d, y, r_V\right)-V_t\left(b, d, y, r_V, 0, e\right)\right\}}_{\text{increased cost of holding liquid saving buffer}} \\ & \quad-\underbrace{\left\{V_t\left(b, d, y, r_V, \sigma_{r_V}, e\right)-V_t\left(b, d, y, r_V, 0, e\right)\right\}}_{\text{insurance value}}>\phi \end{aligned} \tag{C.5}$$

A special case is where there is no interest rate uncertainty ($\sigma_{r_V} = 0$) and the household refinances from adjustable to fixed and retains all the excess payments buffer in the saving account ($\alpha = 1$). Under these assumptions, the envelope theorem implies the approximation to Equation (C.5)

$$F_t - V_t \simeq \beta \mathbb{E}_{y', r'_V}\left[\frac{\partial V_{t+1}}{\partial d}\left(\underbrace{\left(r_F-r_V\right) d}_{\text{current interest rate}} - \underbrace{\left(r_V-r_b\right) e}_{\text{value of excess repayments}}\right)\right] > \phi \tag{C.6}$$

Switching from fixed to adjustable is optimal only if the interest saving on mortgage debt d is large relative to the interest cost of keeping excess funds e is a deposit account rather than offsetting the mortgage:

$$\left(r_F-r_V\right) d>\left(r_V-r_b\right) e+\phi. \tag{C.7}$$

Hence, we should expect adjustable rate borrowers to have excess payment buffers.

D Expiry of fixed rate mortgages

This Appendix provides evidence on the response of spending around expiry for fixed rate loans that reset to adjustable rate loans with higher required repayments. This research design exploits variation in the timing of expiry of fixed rate mortgages, comparing outcomes for expired fixed rate mortgages to those for yet-to-expire fixed rate mortgages. Late-expiring mortgagors are likely to be a good comparison group for early-expiring mortgagors because it was widely expected that interest rates would remain low at the time all the fixed rate loans in our analysis sample were originated.

We collaspe loan level fixed-rate expiry data to the person level, aggregating across loans where more than one is present.[15]

Our goal is to estimate the causal effect of increased required repayments on spending. Unexpired fixed-rate loans provide a suitable comparison group, whereas previously expired fixed-rate loans do not, since treatment effects may vary across expiry cohorts. To address this, we use the Sun and Abraham (2021) estimator, which relies only on the first valid comparisons, unlike the standard two-way fixed effects estimator. This method estimates a treatment effect for each expiry cohort, using fixed-rate loans with at least a certain time to expiry as the control group. The overall treatment effect is a weighted average across cohorts.

Formally, we estimate the expiry cohort-specific event study coefficients δ_k from the regression

$$y_{i,t} = \alpha_i + \gamma_t + \sum_{k=-6,k\neq-1}^{5,6-12} \delta_k^g \text{Event}_{i,t+k} + \varepsilon_{i,t} \tag{D.1}$$

where y is the variable of interest for person i at time t, α_i is an individual fixed effect, γ_t is a time fixed effect, g is the expiry cohort; $\text{Event}_{i,t+k}$ is an event-time indicator taking the value one if person i had a fixed rate loan that expired k periods after calendar time t, and $\varepsilon_{i,t}$ is an error term. The data are an unbalanced panel. The coefficients of interest are a weighted average across cohorts:

$$\delta_k = \sum_{g=1}^{g=T} w_k^g \delta_k^g \tag{D.2}$$

using weights w_g, with $\sum_{g=1}^{g=T} w_k^g = 1$ for all k. The first expiring cohort is g_1 = 2022m7 and the final expiring cohort is g_T = 2024m3. Observations outside the window of 6 months prior and 12 months post expiry are dropped. The estimation is conducted at a monthly frequency, with a pooled estimate for months 6–12 after expiry due to the decreasing sample size over time.

Ideally, the control cohort would use only loans with at least 6 months to expiry—the length of the pre-event window. However, due to the short panel dimension of our dataset few mortgagors are observed for at least 6 months before expiry. Instead, we use loans observed to have at least three months to expiry as the control cohort. Aggregate data (Ung, 2024, Graph 2) suggest an expiry rate of approximately 5 percent per month in 2023 (lower in 2022 and 2024). This implies that, probabilistically, at least 85 percent of loans in our control group remain unexpired for at least six months.

[15] This occurs primarily where an individual had a combination loan, which appears as separate fixed and adjustable loans. We drop a small number of individuals who had multiple loans expire at different times.

Figure A8 presents the results. At expiry, the interest rate rises sharply by $3\frac{1}{2}$ percentage points (Figure A8a), leading to an increase in repayments of approximately $600 (Figure A8b). However, the increase in repayments is delayed by 2–3 months due to the notification period before higher repayments take effect. Despite the substantial increase in required repayments, there is no evidence of a decline in categorized or uncategorized spending (Figures A8c-d). The absence of temporal variation in spending for at least the 6 months around expiry support using fixed rate mortgagors as a control group in the main analysis.

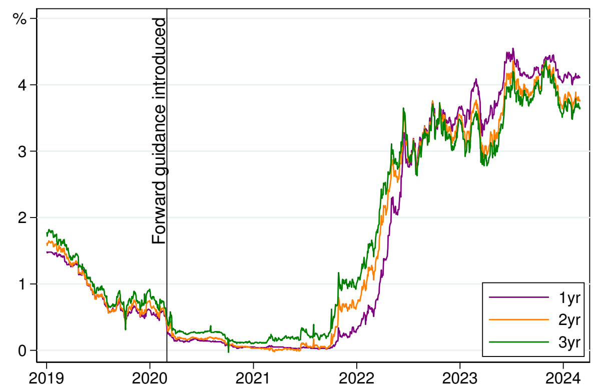
Although account flows are noisy, the results indicate no change in net inflows to the account (Figure A8e). One possibility is that fixed-rate mortgagors begun reducing consumption in anticipation of higher repayments earlier than our 6 month pre-event window. The other possibility is that they maintained spending by drawing down on account balances after expiry. Consistent with this, the point estimates suggest that account balances decline over time (Figure A8f). This supports the no-anticipation assumption made in the main analysis (see Section 3).

Table A1: Categorization of Transactions

Category	Subcategories aggregated from
Durables	Retail, Department Stores, Pet Care, Children's Retail
Non-durables	Groceries, Automotive
Services	Dining Out, Online Retail and Subscription Services, Telecommunications, Health, Insurance, Government and Council Services, Home Improvement, Travel, Transport, Utilities, Education, Personal Care, Gyms and other memberships, Entertainment, Subscription TV, Financial Services
Misc Card Expenditure	Third Party Payment Providers, EFTPOS Terminals
Expenditure	Services, Non Durables, Durables, Misc Card Expenditure, ATM withdrawals, Rent, Credit Card Repayments, Gambling
Income	Wages, Social Security Payments, Other Income, Taxes
Other net inflows	Net of incoming and outgoing transfers Small amount credit contracts, debt management services
Net flows	Sum of all transactions which change the account balance

Notes: This table shows the categorization of bank account transactions into different measures of spending, income and other flows.

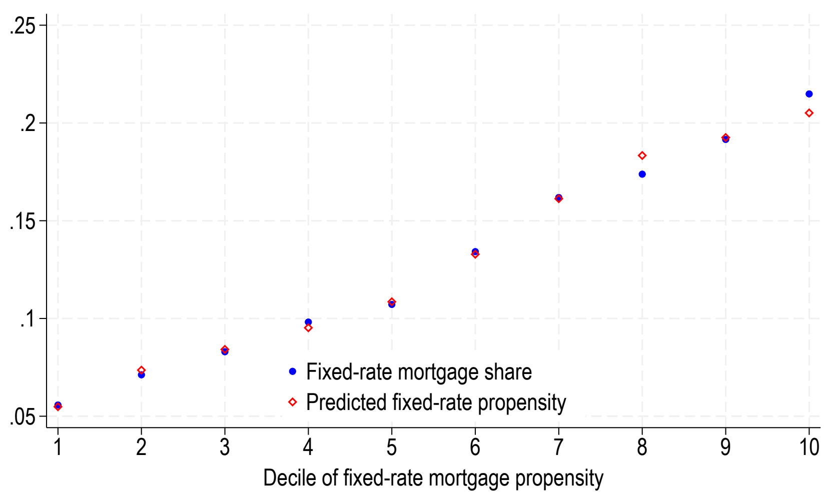
Figure A1: Yields on Zero-Coupon Government Bonds



Notes: Yields on one, two and three year zero-coupon government bonds. *Source*: RBA.

Summary: Between 2020 and October 2021, yields on government bonds indicated that interest rates would remain low in the future.

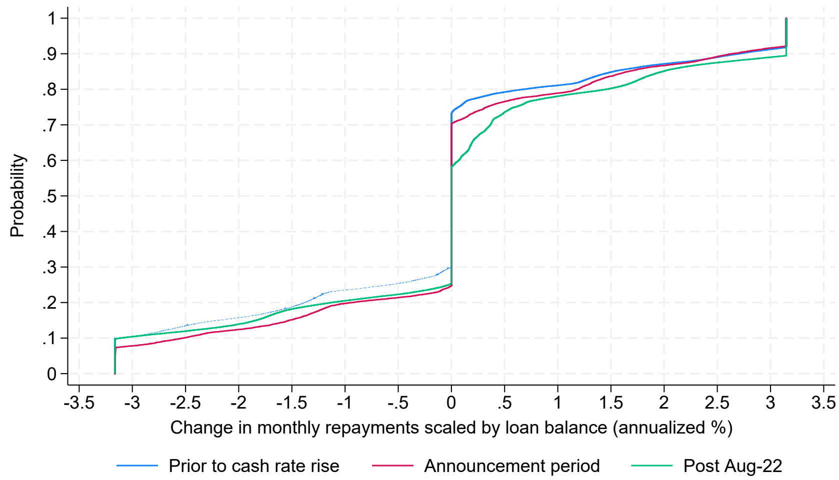
Figure A2: Goodness of Fit: Fixed-Rate Mortgage Propensity



Notes: This figure shows the mean fixed-rate mortgage propensity and mean share of mortgages that are fixed-rate, by decile of the fixed-rate mortgage propensity, prior to the first increase in the cash rate in May 2022.

Summary: The fixed-rate mortgage propensity variable has substantial predictive ability for the probability that an individual has a fixed-rate mortgage. It has excellent fit across the distribution of fixed-rate mortgage propensity.

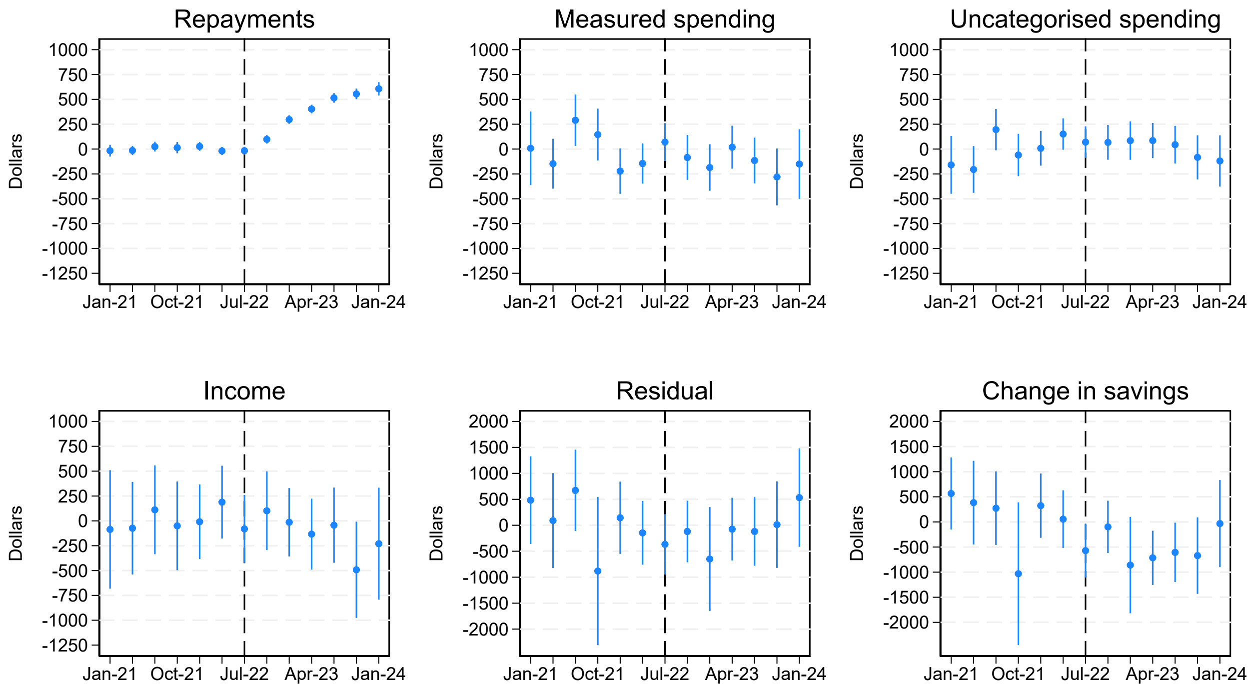
Figure A3: Monthly Change in Mortgage Repayments:
Cumulative Distribution Function



Notes: This figure shows the CDF of the monthly change in mortage repayments for adjustable-rate mortgagors over three periods: (i) prior to the first rise in the cash rate, (ii) during the three-month period when interest rates increased but required repayments were unchanged and (iii) after repayments first increased.

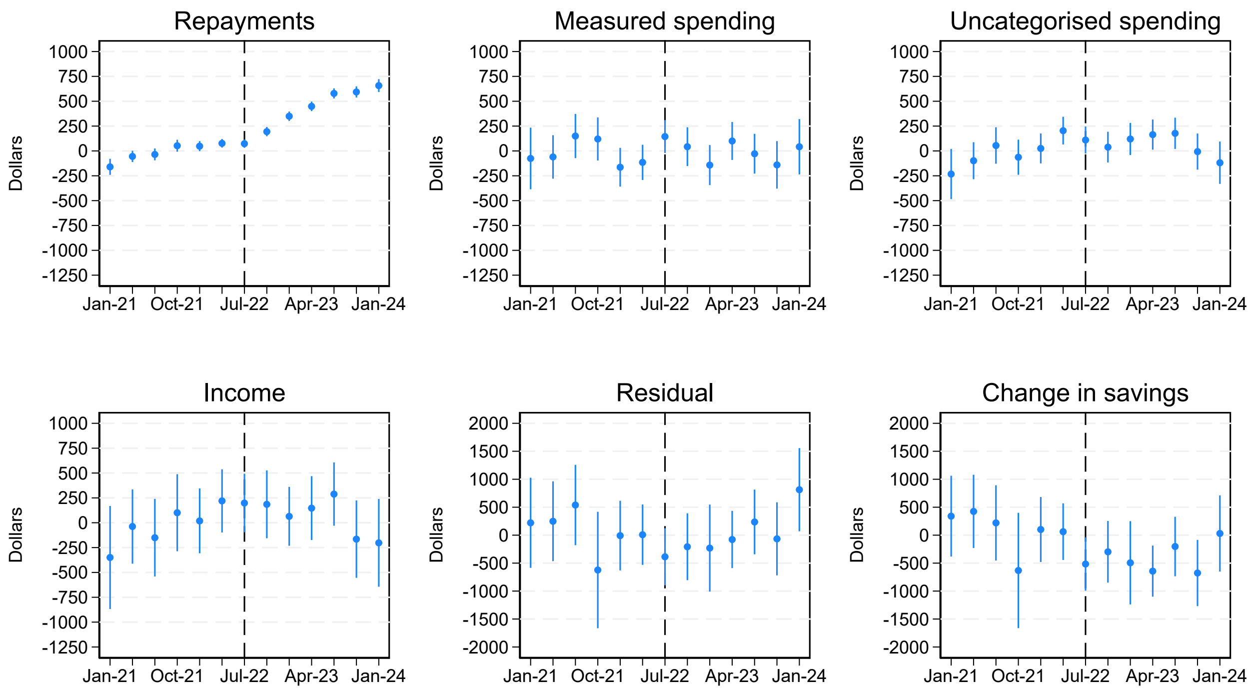
Summary: Adjustable-rate mortgagors do not adjust repayments until minimum required repayments increased.

Figure A4: Event Study: Adjustable vs. Fixed Rate Mortgagors: Including Control Variables



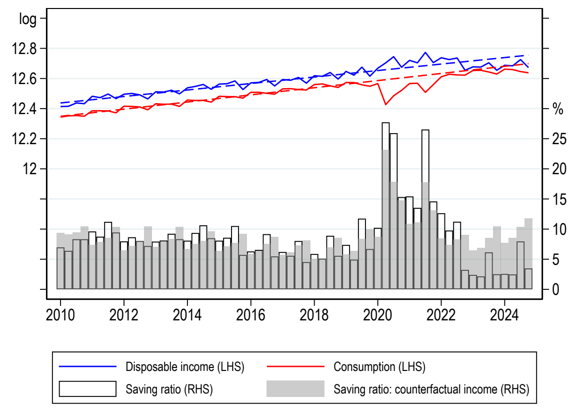
Notes: This figure reports results analogous to Figure 6 including the following control variables: lagged mortgage balance, lagged income, lagged debt-to-income ratio, interest-only loan status and state × time fixed effects.
Summary: Results including control variables are broadly similar to the baseline results in Figure 6.

Figure A5: Event Study: Adjustable, Combination and Fixed Rate Mortgagors



Notes: This figure report results analgous to Figure 6 where the data are augmented to include combination (split fixed and adjustable rate) borrowers. It shows coefficients δ_k (pre-event) and γ_k (post-event) from Equation (13). The event study coefficient can be interpreted as the change in variable y between the average over the pre-period $t \leq T_0$ and time $T_0 + k$ for a mortgagor with only adjustable rate loans compared to a mortgagor with only fixed rate loans. *Summary:* Results including combination mortgagors are broadly similar to the baseline results in Figure 6.

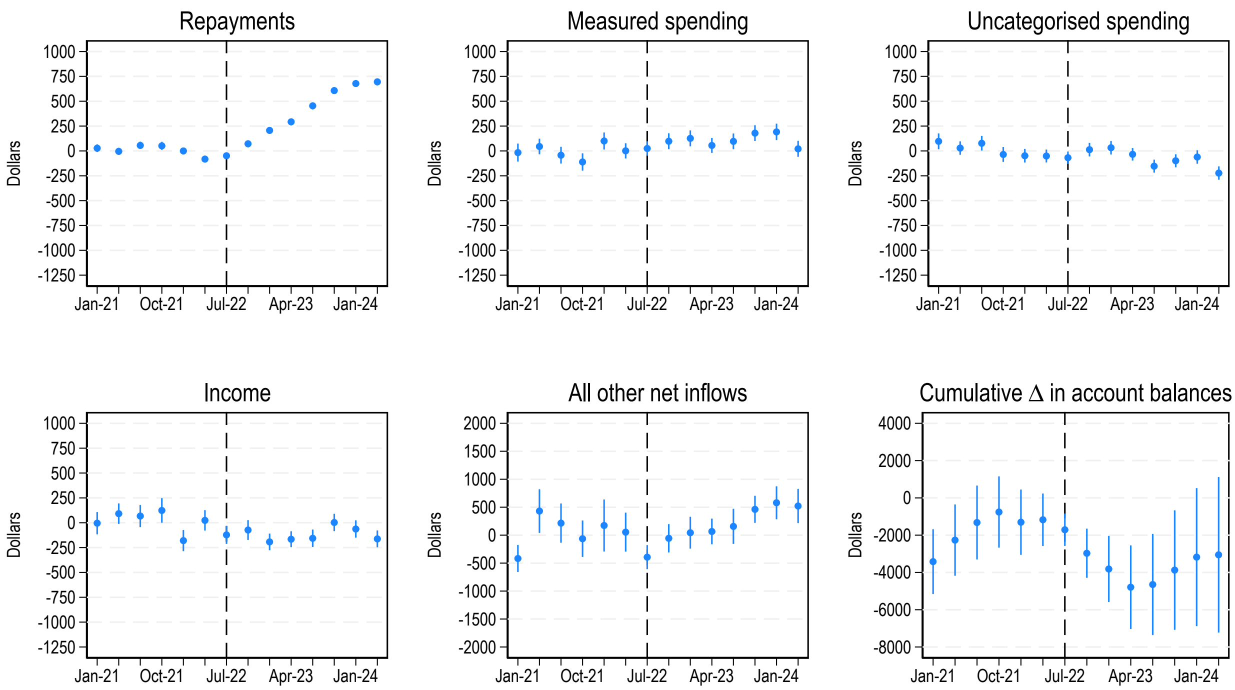
Figure A6: Household Consumption, Disposable Income and Saving



Notes: The figure shows log real household final consumption expenditure, log real household disposable income and the household saving ratio from the National Accounts (ABS Cat. 5206). Household disposable income is net of interest payments. Data are quarterly and seasonally adjusted. Counterfactual trends for consumption and disposable income assume a log-linear trend from 2010-2019. Grey bars show the saving ratio using actual consumption and counterfactual disposable income.

Summary: Lower consumption during the pandemic accounts for 63 percent of the increase in the household saving ratio in 2020-2021 relative to 2019.

Figure A7: Event Study: Mortgagors vs. Non Mortgagors

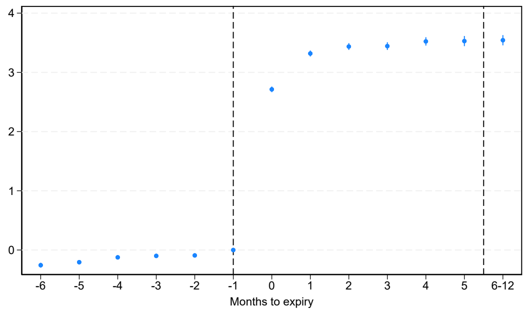


Notes: This figure shows estimated coefficients δ_k (pre-event) and γ_k (post-event) from Equation (14) excluding individuals whose average net incoming transfers are above the 95th percentile. All flows shown are at monthly rates. *Cumulative change in account balance* is the sum of *income* and *all other net inflows* less the sum of *repayments* and *spending*. *Measured spending* is the sum of non-durable, durable and services (including rent) spending categorized by the data provider; *unmeasured spending* is the sum of other spending-related outflows (ATM withdrawals, miscellaneous card payments, credit card repayments and gambling). Measured spending account for around 60 percent of total spending. Standard errors are clustered at the person level and two standard error bands are shown.

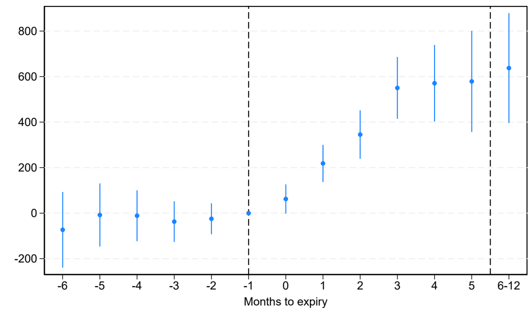
Summary: After excluding individuals with large net incoming transfers, 85 per cent of the increase in repayments were financed by mortgagors reducing their bank account balances.

Figure A8: Event Study: Fixed Rate Mortgage Expiries

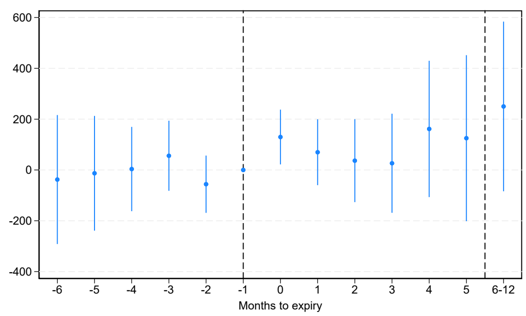
(a) Interest rate



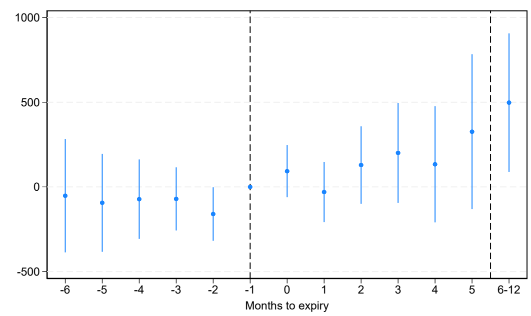
(b) Repayments



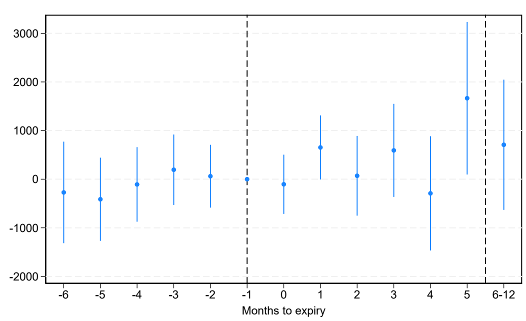
(c) Categorized Spending



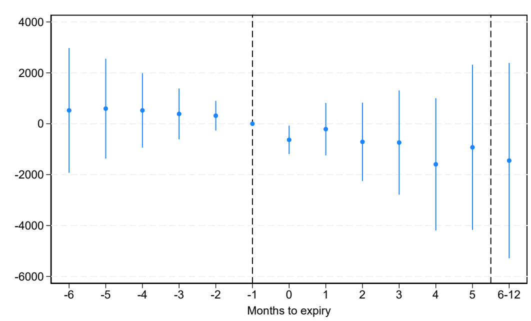
(d) Uncategorized Spending



(e) Inflows



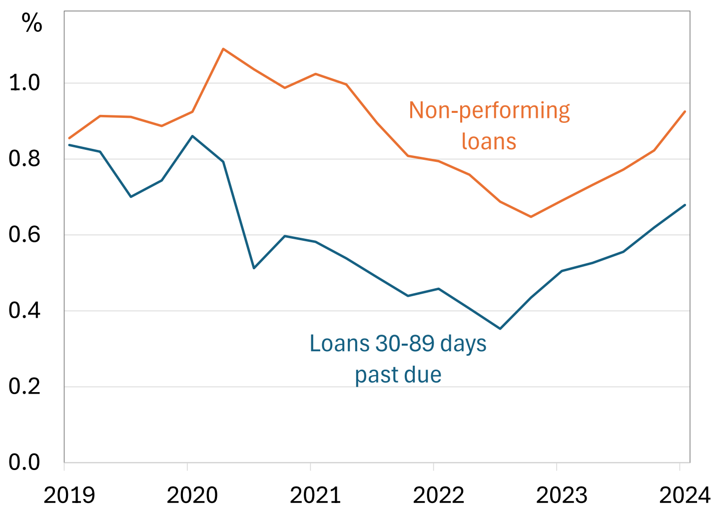
(f) Change in Savings



Notes: Each panel reports expiry cohort-averaged event study coefficients from the Sun and Abraham cohort-specific event study model. The control cohort is unexpired fixed rate loans observed to have at least three months to expiry. Estimation is at a monthly frequency and a pooled estimate for the period 6-12 months ahead is used because the sample size decreases with time. The first expiring cohort is July 2022 and the final expiring cohort is March 2024. Observations outside the period 6 months prior and 12 months post expiry are dropped. Panel (a) shows the the interest rate on the expiring fixed rate loan; Panel (b) shows repayments on all mortgages held by an individual with an expiring fixed rate loan; Panel (c) shows the sum of non-durable, durable and services spending categorized by the data provider; Panel (d) shows other spending-related outflows (ATM withdrawals, rental payments, miscellaneous card payments, credit card repayments); Panel (e) shows the sum of income and all other net inflows, and; Panel (f) shows the cumulative change in bank account balances. Standard errors are clustered at the person level.

Summary: For the average expiring fixed rate loan that reset to adjustable rate status, the interest rate rose by about 3 percentage points and repayments rose by about $600. There is little evidence of a change in spending.

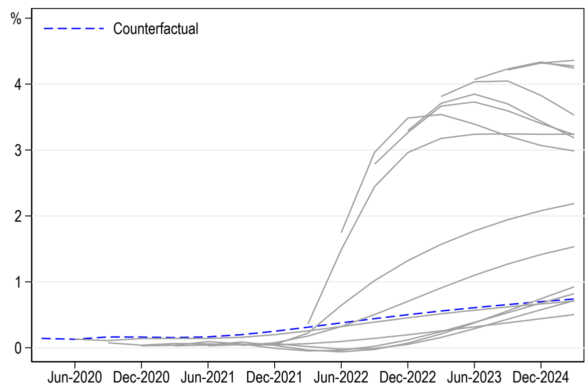
Figure A9: Arrears and Non-Performing Mortgages
Share of Total Credit Outstanding



Notes: Non-performing loans are loans that have been recognised as either impaired or 90 days past due. Loans 30-89 days past-due but not impaired are loans that are at least 30 days past-due but less than 90 days past-due, whether or not the loan is well secured or impaired . *Source*: APRA.

Summary: Arrears and non-performing loans accounted for less than 1 per cent of outstanding credit during the period in which required repayments on adjustable-rate loans increased.

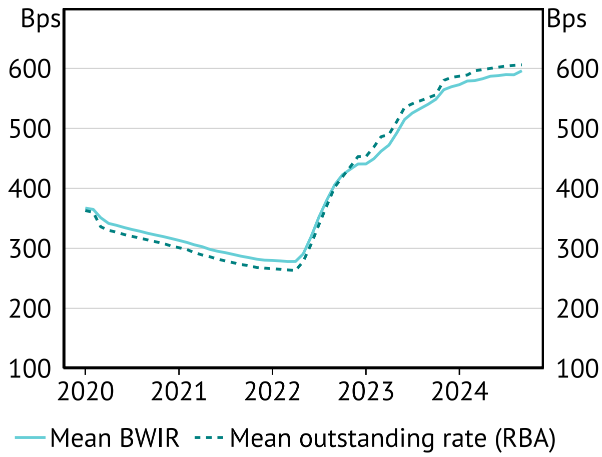
Figure A10: Actual and Counterfactual Monetary Policy



Notes: The figure shows the expected path of nominal interest rates at each date and the counterfactual path. Data are forward rates from RBA Statistical Table F17. The counterfactual path assumes interest rates remained at the values expected in 2020Q2, until 2024Q1. After 2024Q1, the counterfactual path is equal to the actual path at all dates.

Summary: Market interest rate expectations began to rise relative to the counterfactual path in late 2021.

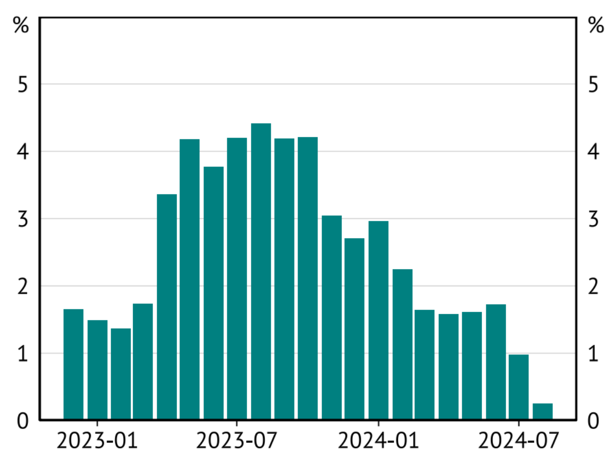
Figure A11: Mortgage Interest Rates



Notes: The figure shows the average outstanding mortgage rate from the transactions sample of mortgagors and that reported in official statistics by the RBA.

Summary: Our imputed BWIR moves closely with official statistics.

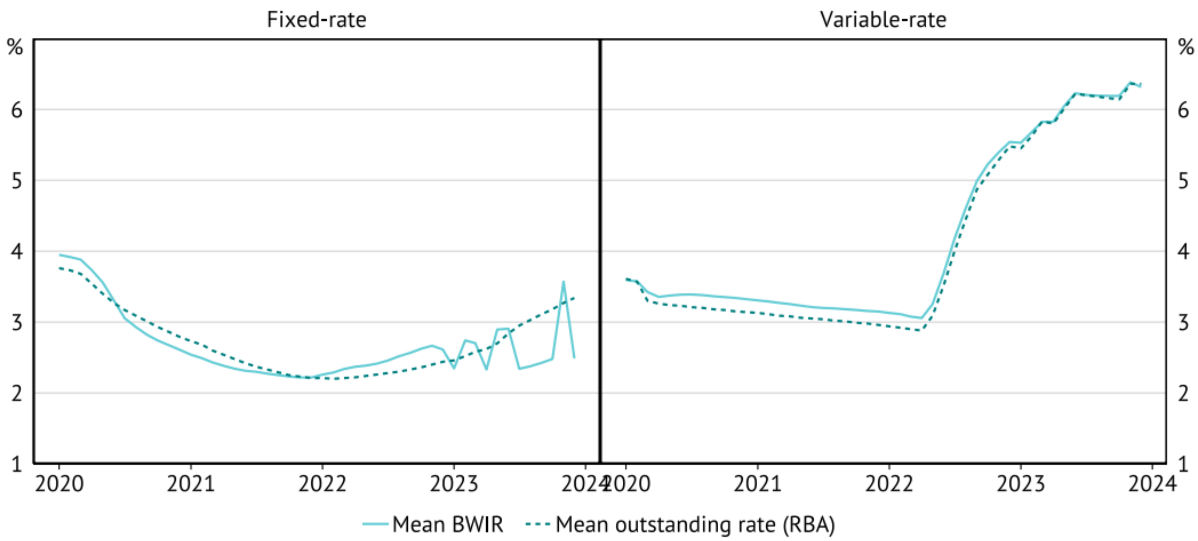
Figure A12: Percentage of Fixed-Rate Loan Expiries by Month
Share of the stock of outstanding fixed-rate loans



Notes: This figure shows the percentage of fixed-rate loans in our dataset that expire each month.

Summary: The profile of expiry of fixed rate mortgages in our data matches the trend from Graph 2 of Lovic et al. (2023) from the RBA.

Figure A13: Interest Rate by Mortgage Type



Notes: This figure shows estimates interest rates on fixed and adjustable-rate loans in our sample compared to that from the RBA.

Summary: The imputed BWIR is similar in levels and co-moves closely with the average outstanding mortgage rate at large financial institutions reported by the RBA.