# How Does Monetary Policy Affect Consumption? The Indebted Demand Channel*

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**Abstract**

This paper studies over six million natural experiments in the UK created by staggered mortgage refinancing schedules. Using administrative data on consumption transactions and mortgage borrowing, we show that monetary policy has a large effect on consumption through the *indebted demand channel*. Interest rate cuts boost consumption by lowering mortgage payments and increasing equity extraction via higher collateral values. A 1 pp rate cut raises annual consumption by 0.5% of GDP through the indebted demand channel. Using households that experience interest rate shocks multiple times, we find that the increase in debt from past rate cuts makes households more sensitive to rates in the future.

*We thank Verónica Bäcker-Peral and Alexander Prior for excellent research assistance and Huw Pill for comments. UK residential mortgage data are taken from the Product Sales Database (PSD) provided by the UK Financial Conduct Authority. The FCA Product Sales Data include regulated mortgage contracts only, and therefore exclude other regulated home finance products such as home purchase plans and home reversions, and unregulated products such as second charge lending and buy-to-let mortgages. This paper contains the views of the authors and not necessarily those of the Bank of England, the MPC, the FPC, or the PRC. Preliminary draft: Please do not quote without the permission of the authors

# 1 Introduction

When central banks cut interest rates, does consumption rise—and if so, why? Textbook accounts emphasize the intertemporal substitution channel (e.g., Galí, 2015): lower rates reduce saving and boost consumption. More recent work highlights an income channel (e.g., Kaplan, Moll and Violante, 2018): rate cuts raise aggregate income, increasing household consumption. This paper instead studies what we term the "indebted demand" channel of monetary policy. When the central bank cuts rates, house values rise, and indebted consumers increase consumption due to lower debt payments and increased borrowing against housing collateral.

Our paper focusses on a natural experiment that identifies how monetary policy affects consumption via indebted demand. In the UK, households typically choose mortgage deals that last for 2, 3 or 5 years. The interest rate is typically fixed over the length of the deal at a low "teaser rate", which is determined by macroeconomic conditions at the start of the deal. When the deal expires, households have strong financial incentives to start a new deal, at a new interest rate. Households can extract equity at no additional cost when a new deal starts—that is, they do not pay penalties to borrow or save using their mortgage. However while a deal is in effect, there are large costs to extracting equity. Taking these features together, households experience a sudden interest rate change, plus an opportunity to extract equity at pre-determined and staggered times—as originally observed by Cloyne, Huber, Ilzetzki and Kleven (2019).[1]

We combine the natural experiment with household level information on mortgages and consumption for 2015-2024. First, we use administrative data collected by the UK's mortgage regulator. The dataset contains the universe of mortgages in the UK between 2015 and 2024, with details such as the length of deals, the mortgage interest rate, the size of the mortgage and the size of equity extraction at refinancing. Second, we use a consumption dataset. The source is two personal finance apps, namely Money Dashboard (for 2015-2021) and ClearScore (for 2018-2024), with 700 000 individuals across the two apps. In both cases, users sign up with the app in order to link bank accounts and observe their finances in one place. The apps contain transaction level data, which we aggregate into measures of durable and non-durable consumption for each household. We also observe additional financial variables such as credit card debt, personal loan repayment and liquid assets. The consumption data are non-representative, being people who selected into using the app. However the data are close to representative based on observable characteristics. Consumption measured in the

[1] Cloyne et al. (2019) use the natural experiment to study the effect of house prices on borrowing—we instead study how interest rates affect consumption.

app is similar to household consumption in survey data. Therefore apps do not seem miss a portion of households' consumption, which could happen if households fail to link all of their spending to the app. We merge the data, meaning a combined dataset with information on both mortgages and consumption at the household level. In total we observe around 7 million mortgage deals that experience a refinancing episode during our sample period in the full dataset of mortgages, and around 70 000 deals in the merged mortgage and consumption data.

Combining the natural experiment and the data on mortgage and consumption, we estimate how monetary policy affects consumption via indebted demand. To isolate the indebted demand channel, we use an identification strategy that holds fixed households' income and intertemporal substitution outside the mortgage market.[2] Our main regression compares households with long and short mortgage deals. For instance, consider a household with a 2 year deal, and a second household with a 5 year deal, both expiring at the same time. If the aggregate interest rate has been falling over time, the second household has a larger interest rate cut than the first when their deals expire. We ask to what extent the second household enjoys a larger fall in mortgage payments, or extracts more equity. That is, we study the extent to which "cash on hand"—summing across mortgage payments and equity extraction—rises by more for the second household than the first. We also test whether the higher cash on hand leads to higher consumption. Our identification assumption is that, absent their expiring deals, the 2- and 5-year households would have had similar consumption growth. Our research design exploits that with British mortgages, the opportunity to refinance is pre-determined. In countries such as the United States, households choose when to refinance—meaning refinancing may depend on potentially endogenous shocks affecting consumption.

Our approach has an additional benefit: we estimate how interest rates affect consumption using cross sectional variation. We identify the effect of interest rates by comparing two households at a single point in time. In total, we observe millions of households with expiring deals during 2015-2024. As a result, there is powerful cross sectional variation with which to estimate the effects of interest rates. Moreover, we observe over two million households who experience several expiring deals earlier and later on. These households experience multiple interest rate shocks—allowing us to separate indebted demand from fixed household characteristics. Finally, households experience both interest rate cuts and hikes during the sample period, enabling us to estimate monetary policy effects over both easing

[2]Applied to the same dataset of British mortgages, past work finds that the intertemporal elasticity of substitution is small (Best, Cloyne, Ilzetzki and Kleven, 2020). That is, holding fixed mortgage payments and collateral, changes in interest rates have small effects on consumption—consistent with our view that instead increased cash-on-hand via equity extraction and mortgage payments are important.

and tightening episodes.

Our main result is that the indebted demand channel is large. We show that a 1 percentage point cut raises cash on hand—the sum of equity extraction and mortgage payments—by around 4000 pounds after 1 year (i.e. approximately 5200 US dollars in 2015). Consumption rises by roughly half as much, i.e. 2000 pounds after 1 year. Combining the two estimates, the marginal propensity to consume out of cash on hand is around 0.5. We also find that the consumption response is concentrated in non-durables, although spending on home improvements is also responsive. Summing these effects across indebted homeowners, we find that a 1 percentage point cut raises consumption for borrowers by 4%, equivalent to 0.5% of UK GDP.

We probe the robustness of our main result. Our identification assumption is that households with long and short mortgage deals do not face different shocks to consumption, other than through their mortgage. We provide support for this assumption. There are no pre-trends—before their deals expire, households with long and short deals have similar consumption growth. Households are balanced according to various household characteristics. In a placebo test, the income of households with long and short deals evolves similarly as their deals expire. Our results are also similar if we include fixed effects for deal length, absorbing fixed characteristics of households that choose different deals.

Most stringently, the estimates are similar if we add household fixed effects, and study the response of consumption for the *same* household at different points in time as they receive different interest rate shocks. As such, we exploit a unique feature of our setting, whereby we can identify consumption behavior from multiple interest rate shocks to the same household. We also find similar results when we instrument for interest rate changes with high frequency monetary policy shocks (Braun, Miranda-Agrippino and Saha, 2025). Finally, we show that selection into the consumption data, drawn from personal finance apps, is unlikely to explain our results—the cash on hand response to interest rates is similar for households with and without the personal finance app.

We next ask what mechanisms can account for how indebted demand affects consumption. After interest rate cuts, cash on hand can rise either because mortgage payments fall, or because households extract more equity. We decompose the response of cash on hand into its two sources. 50-75% of the response of cash on hand is due to equity extraction. The strong response of equity extraction suggests that interest rate cuts raise consumption in part by raising the value of collateral.

We also explore how the indebted demand effect of monetary policy varies across households. Households with more debt respond more to interest rate shocks. In particular, doubling pre-existing debt doubles the indebted demand effect of a monetary policy shock.

Overall, our results show that debt and leverage are key state variables that determine the strength of the transmission of monetary policy to the real economy.

As noted earlier, a unique feature of our natural experiment setting is that we have over two million households who experience an interest rate shock more than once during our sample period. We can therefore address a question that is otherwise difficult to answer: how does an interest shock today shape a household's response to future monetary policy shocks? This question is particularly relevant in light of the indebted demand effect that we document. Suppose that monetary policy increases consumption by raising debt. One wonders whether the higher debt might hinder the economy in the future, when rates revert to their original level.

We answer this question with an instrumental variables regression. In the first stage, we instrument for a household's future debt position using the interest rate shocks that they experienced in the past. In the second stage, we ask how the household's response to interest rate shocks in the future depends on the past debt increase. We find that if a household's debt doubles due to past interest rate shocks, in the future the household becomes around ten times more sensitive to interest rate changes. As a result, a monetary easing today creates a drag on monetary policy in the future, due to indebted demand.

**Related literature.** There is a large literature studying how interest rates affect consumption at the household level, often emphasizing the importance of mortgages. Using consumption survey data in the US and the UK, Cloyne, Ferreira and Surico (2020) study how consumption responds monetary policy shocks, and detect a strong response among mortgage holders. Using consumption data imputed from tax records, Holm, Paul and Tischbirek (2021) study the response of consumption to monetary policy shocks in Norway. They find that changes in mortgage payments appear to be important. Using quantitative models combined with data on mortgages and proxies for consumption, Beraja, Fuster, Hurst and Vavra (2019), Berger, Milbradt, Tourre and Vavra (2021) and Eichenbaum, Rebelo and Wong (2022) study how mortgage refinancing affects the response of consumption to interest rate changes. Closely related to our paper, Di Maggio, Kermani, Keys, Piskorski, Ramcharan, Seru and Yao (2017) study a natural experiment in the US. Around the Great Recession, certain households experienced abruptly declining mortgage payments as their adjustable-rate mortgages reset, but were unable to extract equity from their mortgages. As a result, they significantly increased car purchases, which proxies for durable consumption.

Our paper extends the past work in two ways. First, our natural experiment allows us to isolate the indebted demand channel. We can study how interest rates affect consumption in a setting in which both mortgage payments and equity extraction can adjust, while holding fixed movements in household income and other factors. As it turns out, equity

extraction is a key reason why consumption responds to interest rates. Second, we are able to observe household level information on both mortgages and a comprehensive measure of consumption, including both durables and non-durables. As such, we can calculate crucial statistics such as the consumption response to increases in cash on hand after interest rate cuts—which pins down the size of the indebted demand channel.[3]

A second literature estimates how monetary policy affects the economy, using time series variation. Seminal papers include, for instance, Romer and Romer (2004) and Gertler and Karadi (2015). The main approach is to find exogenous variation in interest rates in the times series, and then study the response of aggregate variables. We instead study how consumption responds to monetary policy using cross sectional variation. Our cross sectional approach has several advantages. For instance one can estimate the effect of monetary policy with precision, even when the time series is relatively short. Moreover the cross section provides powerful variation with which to estimate state dependence—including how household debt affects the response of consumption to interest rates.

# 2 Data

We now describe the mortgage and consumption datasets.

## 2.1 Mortgage Data

We measure mortgages from the Product Sales Database (PSD), an administrative dataset collected by the United Kingdom's Financial Conduct Authority. This dataset contains snapshots every 6 months of the universe of outstanding mortgages in the United Kingdom, from the start of 2015 until the start of 2024. At any point in time, there are roughly 8 million mortgages.

The PSD measures comprehensive data about mortgages. In particular the PSD measures the initial loan size, the mortgage term, the initial loan interest rate, whether the interest rate is fixed or floating, whether the mortgage is refinanced, how much has been paid back before refinancing, and how much equity is extracted at refinancing. As we will discuss later on in more detail, in the UK mortgages typically have a discounted "deal" period of 2, 3, or 5 years. During the deal interest rates are low. Afterwards, the mortgage interest rate sharply increases, but households can pay a relatively low fee to start a new deal. The PSD measures the length of the deal period and the fee paid at the start of the deal. We also observe the

[3] A large theoretical literature also studies how monetary policy affects consumption via indebted demand (e.g. Iacoviello, 2005, Greenwald, 2018, Auclert, 2019).

full date of birth for borrowers and the full postcode of their property, allowing us to track the same mortgage through time.[4] The PSD records the house price if the mortgage is for a new purchase.

In some exercises, we study a proxy for the house price associated with the mortgage. We use granular data on regional house prices from the UK House Price Index. This series captures changes in the value of residential properties bought both with cash and with a mortgage, and is calculated for 360 Local Authority Districts.[5]

## 2.2 Consumption Data

We use two consumption datasets, from ClearScore and Money Dashboard. Both ClearScore and Money Dashboard are personal finance apps. The apps have a common owner and use essentially the same technology, but serve different customer bases.

The apps collect information about consumers' finances across their various bank accounts. In each case, consumers who wish to simplify their finances can add their bank accounts to the app. The app then scrapes historical information from the consumers' bank accounts in order to form a comprehensive measure of their finances.

Money Dashboard is available from 2015 until mid 2021. Our sample of ClearScore data available from July 2019 to January 2024. Money Dashboard contains around 130 thousand regular users, while ClearScore contains roughly 600 thousand regular users.

We observe each transaction by every household in a bank account that they have linked to the app. The app measures what card type is associated with the transaction (i.e. credit or debit) and tags the transaction with an expenditure category based on the text of the transaction. These tags are detailed, at the level for instance of "gym equipment" or "take-away food". We then aggregate these spending categories into measures of durable, non-durable and services expenditure that follow the standard definition of the Bureau of Economic Analysis, as well as a comprehensive, broad measure of spending which we will refer to as "consumption". We also observe various forms of income paid into accounts associated with the app. The most common is salary or wages, but other forms of income such as investment or rental income are also tracked.

To merge the finance app information to the mortgage dataset, we exploit that in the apps we can observe the sector-level (4 digit) postcode, year and month of birth, mortgage lender, and the monthly mortgage payment amount. In the mortgage dataset, we observe the full (6-digit) postcode, date of birth, mortgage lender, and the monthly mortgage payment amount. We merge on these variables, which selects unique individuals in the PSD in over

[4] In the UK, postcodes typically contain around 15 properties.

[5] For further details see here.

99% of cases. ClearScore merges 150 thousand households to the PSD, whereas Money Dashboard merges 30 thousand households.

We then validate our measures of consumption. Both apps contain by their nature selected samples. An additional concern is that the apps contain only a subset of consumers' spending. Fortunately, neither concern seems too important. Appendix Figure B.1 plots mean monthly expenditure for mortgagors in Money Dashboard and ClearScore, compared to mean annual expenditure among mortgage holders in the Office of National Statistics' Living Costs and Food Survey. Both ClearScore and Money Dashboard have similar expenditure to the official data—suggesting that the apps do not underestimate spending. The regional distributions of mortgagors in Money Dashboard and ClearScore are also broadly similar to official data. Appendix Figure B.6 reports the share of the mortgage population in each of 11 regions in Great Britain. Money Dashboard oversamples and ClearScore undersamples London, but otherwise the regional distributions are similar. Regarding income distributions, Appendix Figure **??** shows that ClearScore overweights poorer mortgagors, and Money Dashboard overweights richer mortgagors, relative to the population. Finally, Appendix Figure **??** shows that both apps are reasonably representative of the age distribution of mortgagors, though they overweight under-40s and underweight over-50s.

# 3 Natural Experiment: Mortgage Deals in the UK

This section introduces our natural experiment: the expiry of mortgage deals in the UK.

## 3.1 Mortgage Deals in the UK

In the United Kingdom, mortgages have a particular structure, which leads to interest rate changes and opportunities to extract equity at pre-determined and staggered times. Approximately 95% of mortgagors choose fixed interest rate mortgages. These mortgages have a term that depends on the borrower's income and preferences, and may be as long as 35 years. However mortgages typically offer a deal length of 2, 3 or 5 years. During the deal, the interest rate is fixed at a relatively low "teaser" rate, determined by macroeconomic conditions at the start of the deal. When the mortgage deal expires, households have a strong incentive to start a new deal. If households remain on the same deal, they must pay a significantly higher penalty rate, with an increase of at least 200 basis points. However they can also pay a fee of 1-2 thousand pounds to start a new deal. Households are typically reminded by banks that their deal will expire, around 3 months beforehand. Households do not face additional costs from extracting equity—that is, borrowing or saving using their

mortgage—when their new deal starts. However extracting equity during a deal incurs large costs. Combining these features, households receive an interest rate change, as well as an opportunities to extract equity, at pre-determined moments.

There are at least two important differences compared to refinancing in other countries such as the United States. First, 30 year fixed rate mortgages are common in the US, with an option to refinance that the borrower can exercise at any time. Therefore refinancing is inherently endogenous to macroeconomic conditions such as interest rates. By contrast, in the UK refinancing is in part exogenously determined by deal expiration. Second, refinancing is common in the UK due to short deal lengths. As such, home equity loans are rare and equity withdrawal typically happens when deals expire—different from the US, where home equity loans are common. As such, we can focus on deal expiration to capture how interest rates affect mortgage payments and equity extraction.

## 3.2 Summary Statistics on Deal Expiration

We will organize our empirical strategy around deal expirations. That is, we will study how households' consumption, equity extraction and mortgage payments adjusts as their deal expires—and then relate these adjustments to interest rate changes. Table 1 reports summary statistics on consumption and borrowing for our main samples. In total, we observe 6.7 million deal expiration events in the mortgages dataset, and 69 000 deal expirations in the merged mortgage and consumption data.

In the first two columns of the table, we report summary statistics about the sample with mortgage information. In the middle two columns we report summary statistics about the sample with both mortgage and consumption information. In the final two columns we report summary statistics for the sample with consumption and mortgage information, after reweighting the sample in order to target the distribution of mortgage holders. We reweight based on quintiles of age, income, loan-to-value, mortgage term and home value, as well as broad region (NUTS1) fixed effects. Comparing the first and last two columns, we can see that after reweighting, most observables are similar in the consumption and mortgage sample, including variables that the reweighting does not explicitly target. In what follows, we will present results both for the full sample with mortgage information ("mortgage sample"), and the sample with consumption information ("consumption sample"). Where possible we will show that results from the two samples agree.

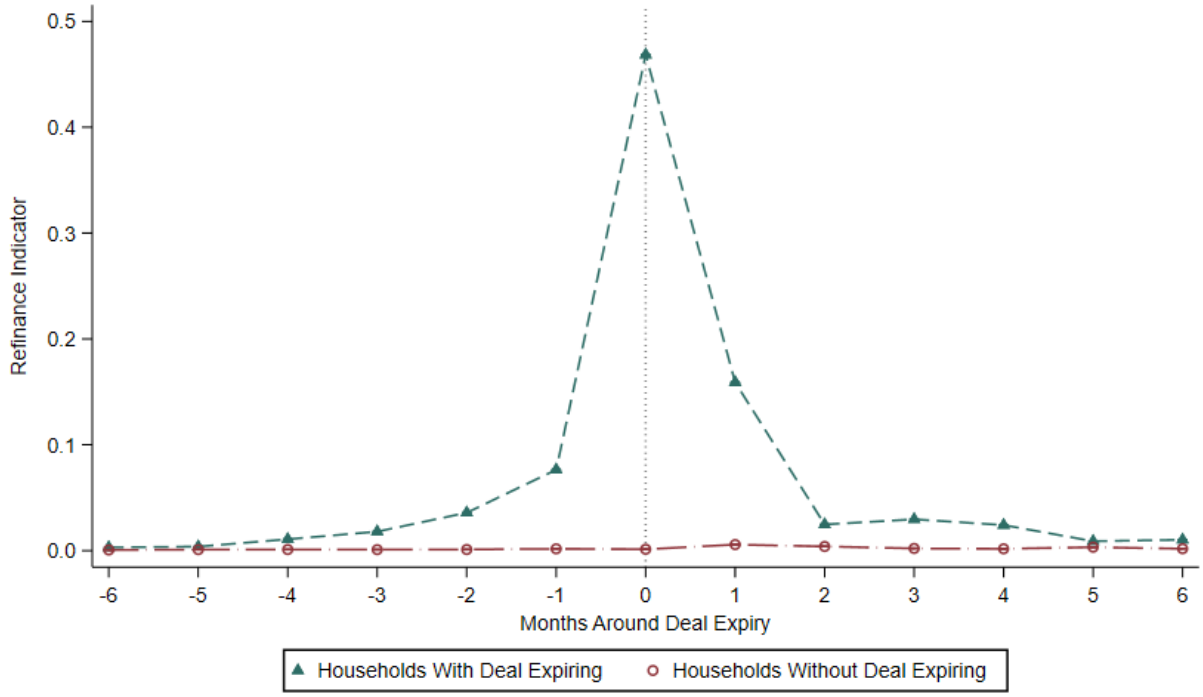



**Figure 1:** Event Study—Deal Expiration and Deal Switching

## 3.3 Event Study Plots of Deal Expiration

We now present unconditional event studies. These event studies show that deal expiry leads households to switch to a new deal. Households also adjust consumption and cash on hand, where we define cash on hand as the sum of how equity extraction and mortgage payments adjust. While our sample period includes both interest rate easing and tightening, the average change in interest rate is negative. Thus the event studies reflect the average response to interest rate shocks at the time of deal expiry. Later on, we will combine these consumption and cash on hand adjustments with information on the magnitude of interest rates change at deal expiry, to estimate the effect of interest rate shocks.

In the event study, we consider households with expiring deals, who have deal lengths of either 2, 3 or 5 years on expiration. In the graph, $t$=0 is the point at which the deal expires in event time, with negative numbers indicating the preceding months and positive numbers the subsequent months relative to the expiry month. Then, in each month relative to the expiry month, we take the mean of various household level outcomes. We also plot outcomes for a comparison group of households. The comparison group is households whose deals do not expire during the 12 month window of the event study.

Figure 1 shows that deal switching is likely when deals expire. The outcome variable is

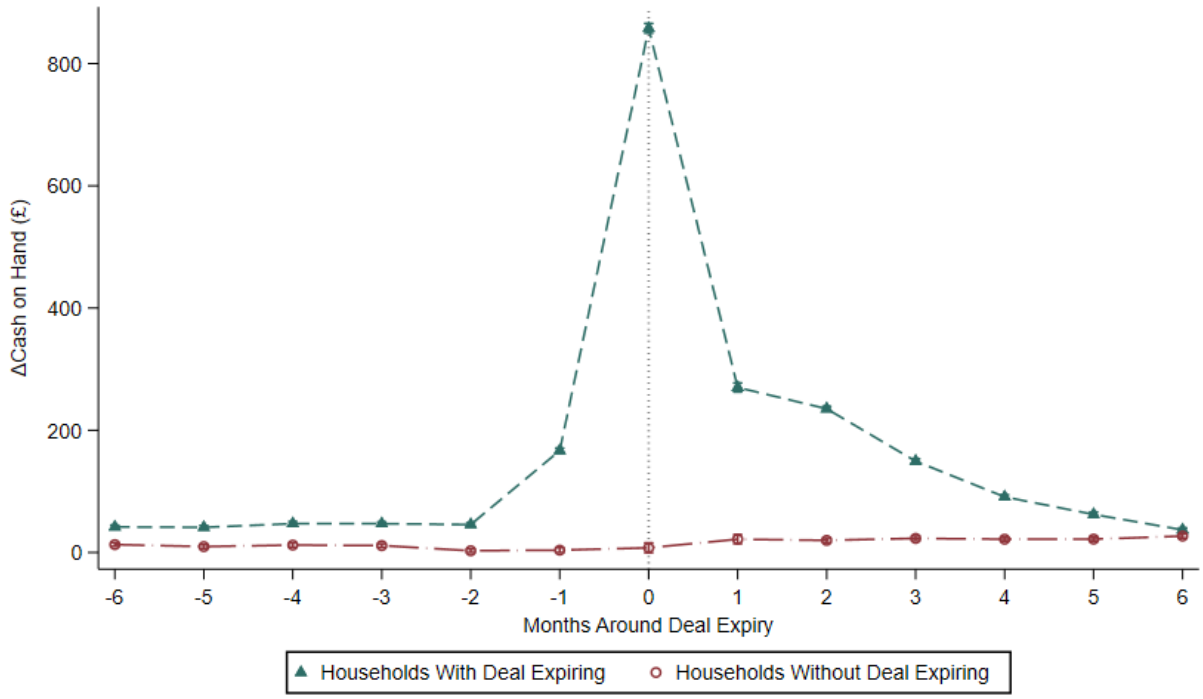



**Figure 2:** Event Study—Deal Expiration and Change in cash on hand

an indicator variable equal to one if the household refinances and zero otherwise. For each month, we calculate the mean of the refinance indicator across households with either a 2, 3 or 5 year mortgage deal length at expiration. We include a comparison group comprised of households with mortgage deals that started at the same time as the households with expiring deals, but whose deals expire at a later date.

For households with expiring deals, their propensity to switch deals becomes positive around 3 months before their deal expires—around the time that banks notify households that their deal will expire soon. The propensity to switch deals peaks in the month that the deal expires, with a monthly propensity to switch deals of 0.5, and remains elevated for several months afterwards. Overall, the cumulative probability to switch to a new deal around refinancing trigger is around 90%.

Figure 2 shows monthly change in cash on hand (measured in 2015 dollars) around deal expiration. The change in cash on hand has two components: (i) the change in debt principal due to equity extraction at refinancing, (ii) the change in mortgage payments (debt service). There are large adjustments in cash on hand as deals expire, peaking at an increase of 800 pounds in the month of expiration.

Figure 3 shows that consumption, i.e. total spending on all goods and services, also adjusts when deals expire. The outcome variable is monthly household consumption in 2015

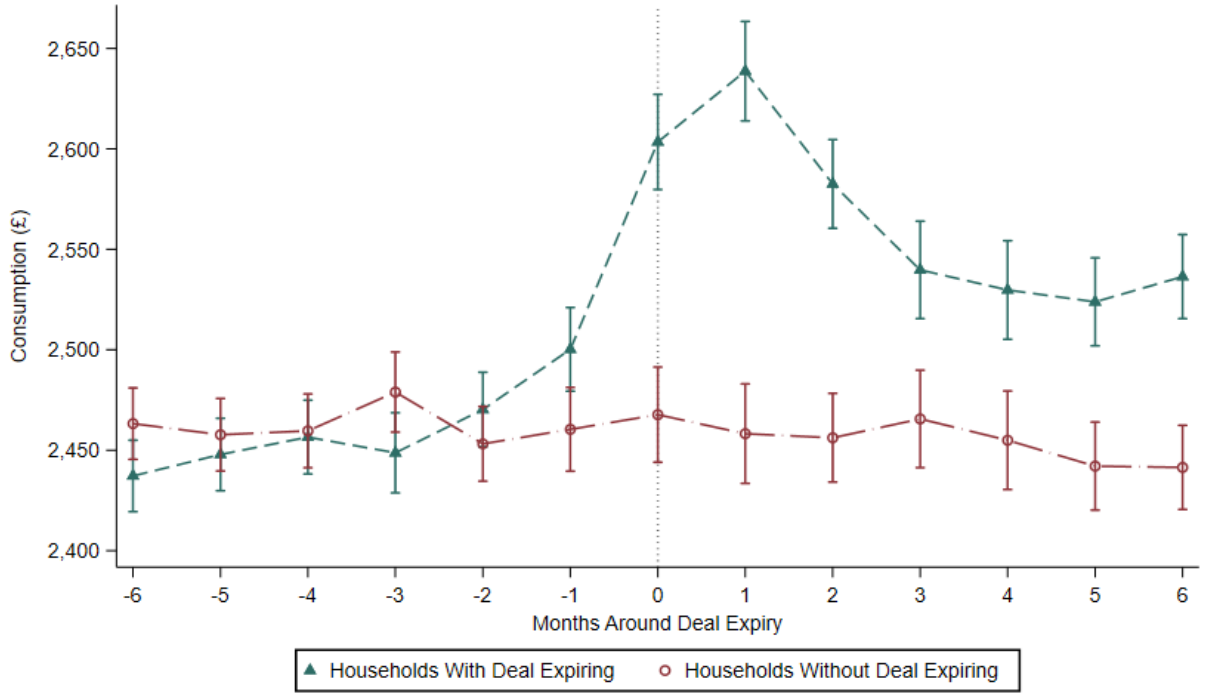



**Figure 3:** Event Study—Deal Expiration and Consumption

pounds. For each month, we calculate the mean consumption across households with either a 2, 3 or 5 year mortgage deal length at expiration. The figure includes a comparison group comprised of households with mortgages that started at the same time as the treatment group but whose mortgage deals expires at a later date. We also include 90% confidence intervals around the means. The means is weighted, using weights based on quintiles of age, income, loan-to-value, mortgage term and home value, as well as broad region (NUTS1) fixed effects; to match the population of mortgage borrowers.

The figure shows that upon expiration, consumption increases rapidly for the expiring deals relative to other deals. On average, consumption and cash on hand rise upon deal switching—likely because during most of our sample, interest rates were falling. What is more relevant is that regardless of the direction, consumption and cash on hand *adjust* when deals expire than at other times. In the coming section, we will relate the cash on hand and consumption adjustments to interest rate changes experienced as the deal expires.

# 4 Simple Conceptual Framework and Specification

This section develops a simple conceptual framework in order to define how monetary policy affects consumption via indebted demand. We also use the framework to derive a regression

specification, which explains how our natural experiment identifies the indebted demand channel.

## 4.1 Simple Conceptual Framework: Defining Indebted Demand

We study a simple framework to define indebted demand. There is a household with consumption $C_t$. For simplicity, we assume that the price of the consumption good is fixed. The household is endowed with a fixed unit of housing $\bar{h}$ with price $P_t$. They can borrow or save using a mortgage, with total mortgage borrowing $B_t$ at interest rate $r_t$. Households can also hold a liquid asset $A_t$, with a rate of return $r_t^a$. The liquid asset has a non-pecuniary benefit to the household, representing liquidity benefits that the mortgage does not provide; the household has concave flow utility $u(C, A)$ over consumption and the liquid asset. Households face a borrowing constraint. Their borrowing must be less than a fixed fraction of the value of their house, $\theta$ (i.e. a loan-to-value ratio). Finally, the household receives income $Y_t$ in each period. Combining these ingredients, the household maximizes utility

$$\max_{\{C_t, A_t, B_t\}_{t\geq 0}} \sum_{t=0}^{\infty} \beta^t u\left(C_t, A_t\right)$$

subject to initial assets $A_0$ and $B_0$, their budget constraint

$$C_t + A_{t+1} - B_{t+1} = Y_t + \left(1 + r_t^a\right) A_t - \left(1 + r_t\right) B_t$$

and their borrowing constraint

$$B_t \leq \theta P_t \bar{h}.$$

We now define the indebted demand channel of monetary policy. Consider shocks $dr, dr^a$ and $dY$, at time $t = 0$, to interest rates on mortgages, liquid assets and income; while assuming that the economy is in steady state prior to time 0. The response of consumption is

$$dC \approx \mathcal{Y} dY + \mathcal{A} dr^a + MPC^{\text{cash}} \left(\frac{\partial B}{\partial r} - B\right) dr \qquad MPC^{\text{cash}} \equiv \frac{dC}{dC + dA}. \tag{1}$$

In this expression, consumption is affected by three terms. The first is how income changes $dY$ affect consumption, with coefficient $\mathcal{Y}$; and the second term is how interest rate changes on assets outside the mortgage market, $dr^a$ affect consumption, with coefficient $\mathcal{A}$.

The third term is the focus of this paper, the "indebted demand" channel. When interest rates on mortgages fall, there are two effects. First, equity extraction may increase. Households might borrow more out of their mortgage, represented by the $(\partial B/\partial r)dr$ term. Second,

mortgage payments might decrease, represented by the $-Bdr$ term. As a result, "cash on hand"—summing across the response of equity extraction and mortgage payments—might rise. The response of consumption to the interest rate-induced rise in cash on hand depends on the marginal propensity to consume out of cash on hand, $MPC^{\text{cash}}$. In turn, the MPC depends on the extent to which households consume more, versus accumulate more of the liquid asset. Fundamentally, the response of consumption and cash on hand depends on the mortgage debt of the household—hence the terminology of indebted demand.

One factor that can raise the strength of the indebted demand channel is a strong response of house prices to interest rates. As a result, the value of collateral rises and households can extract equity when rates fall. Consider a household with a binding borrowing constraint. For this household, equity extraction is given by

$$\frac{\partial B}{\partial r} = \theta \bar{h} \frac{dP}{dr}.$$

Equity extraction responds strongly to interest rates when $dP/dr$ is large, meaning house prices respond to interest rates. If so, then households' borrowing constraints relax after interest rate cuts, because the value of collateral rises.

## 4.2 Specification: Identifying Indebted Demand

We now show how to use our natural experiment—the expiry of mortgage deals—in order to identify the indebted demand channel. To do so, we modify the setup in order to embed the natural experiment in our simple framework, and then derive a regression equation.

We allow an individual household $i$ to have a household-specific interest rate $r_{it}$; going forward an $i$ subscript denotes variables corresponding to this household. Let $r_t$ be the aggregate interest rate. Then with the structure of UK mortgage deals, household $i$'s interest rate equals the aggregate rate $r_t$ if their deal expires at time $t$, and otherwise equals the aggregate interest rate prevailing at the start of their deal. Therefore interest rates satisfy

$$r_{it} = \begin{cases} r_t & \text{if current deal expires} \\ r_{t-n_i} & \text{if un-expired deal started } n_i \text{ periods ago.} \end{cases}$$

Next, equation (1) implies that

$$\Delta C_{it} = \mathcal{I} \Delta Y_{it} + \mathcal{A} \Delta r^a_{it} + MPC^{\text{cash}} \frac{\Delta \text{cash on hand}_{it}}{\Delta r} \times \Delta r_{it}$$

where $\Delta C_{it}$ is the difference of consumption between period 0, and the prior steady state.

Restricting only to households with expiring deals, substituting in the expression for the changing interest rate, and adding a time fixed effect, we have

$$\Delta C_{it} = \alpha_t + MPC^{\text{cash}} \frac{\Delta \text{cash on hand}_{it}}{\Delta r} \times (r_t - r_{t-n_i}) + \varepsilon_{it} \tag{2}$$

where $\alpha_t$ is the time fixed effect. $\varepsilon_{it}$ represents idiosyncratic movements in income, as well as idiosyncratic interest rate changes outside the mortgage market. Beyond the particular setting of our model, $\varepsilon_{it}$ also captures other general equilibrium forces affecting consumption.

Equation (2) is our baseline regression specification. The regression can be estimated in two ways. First, one can regress consumption changes $\Delta C_{it}$ for a household with an expiring deal, on their interest rate change after the deal expires $r_t - r_{t-n_i}$. The coefficient on this regression is the product of $MPC^{\text{cash}}$ and the response of cash on hand to interest rates, $\Delta \text{cash on hand}_{it}/\Delta r$. Second, one can simply regress the consumption change on the change in cash on hand, instrumenting for the change in cash in hand with the interest rate change. In this case, the regression coefficient is $MPC^{\text{cash}}$, the marginal propensity to consume out of cash on hand.

The regression compares households with different deal lengths, who as a result experience different interest rate changes as their deals expire. For example, consider two households, the first with an expiring 2 year deal and the second with an expiring 5 year deal. Suppose also that interest rates have been falling over the past 5 years. As a result, the second household experiences a greater interest rate change than the first. The regression investigates to what extent the second household also experiences a greater consumption change.

The identification assumption is that shocks to income and other general equilibrium objects around the time of deal expiry, $\varepsilon_{it}$, are uncorrelated with interest rate changes over the past deal. We will probe this assumption in various ways. We will show that there are no pre-trends in consumption, differentially across long and short mortgage deals, before the deal expires. We will also study the response of income as a placebo test. Finally we will control in some specifications for the length of the deal, accounting for the fact that households with different characteristics might select into deals with different lengths.

Our natural experiment identifies the indebted demand channel. Provided the identification assumption holds, the time fixed effect "differences out" other forces affecting consumption, such as income and interest rate changes outside the mortgage market. As a result, the regression captures only the effect of interest rates on consumption via equity extraction or lower mortgage payments, mediated by changes in cash on hand.

What is the variation corresponding to the regressor $r_t - r_{t-n_i}$? Figure 4 shows that our estimate of the indebted demand channel comes in large part from cross sectional variation.

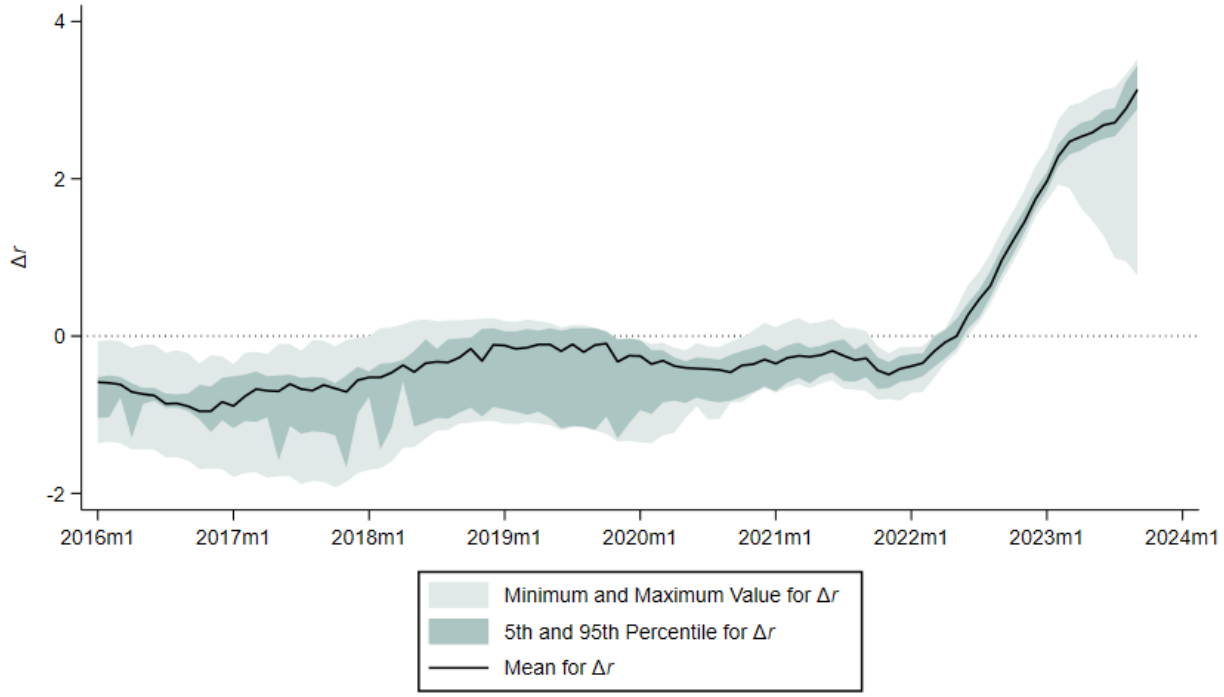



**Figure 4:** Interest Rate Variation Corresponding to Main Regression

*Notes*: The figure plots the time series and cross sectional variation for the change in the interest rate on new mortgage deals.

The black line plots the mean change in the interest rate on new mortgage deals between 2015 and 2024. Mortgage interest rates were declining before 2022, and rising afterwards. As a result our estimates include both interest rate cuts and hikes.

The figure also shows the cross sectional variation in interest rate changes. The light green shaded area illustrates the minimum and maximum interest rate change at a given point in time for expiring mortgages. It also plot the 5th and 95th percentiles of these interest rate changes. The cross sectional variation is generated by deals of different length expiring at the same time. As such, one has a great deal of variation with which to estimate the effects of monetary policy, since we observe many expiring mortgages at a point in time, and over six million in total. Therefore one can estimate the causal effects of monetary policy on consumption—via the indebted demand channel—even with a relatively short time series.

The rate $r_t$ in equation (2) represents the economy-wide interest rate on new mortgage refinances at time $t$. This rate is external to the individual household rate, $r_{it}$, and hence preferable to use as a regressor. $r_t$ is measured using the Bank of England's reported average mortgage rate on all new mortgages issued in month $t$.

There are two differences between the regression specification of equation (2) and the basic

conceptual framework. First, the interest rate change from deal expiration is anticipated, whereas in the model the interest rate shock is realized at time 0. As such, we will also study the consumption response prior to the expiry of the deal, to measure anticipation effects. Second, the interest rate change after deal expiry is persistent, whereas the interest rate change in the simple conceptual framework is purely transitory. As such, one should interpret parameters such as $MPC^{\text{cash}}$ in equation (2) as the marginal propensity to consume out of persistent interest rate shocks.

# 5 Estimates of the Indebted Demand Channel

This section presents estimates of the indebted demand channel. We show how interest rate changes affect cash on hand and consumption, and then estimate the marginal propensity to consume out of cash on hand. The indebted demand channel is large—a 1 pp interest rate cut raises consumption by 0.5% of GDP.

## 5.1 Response of Cash on Hand and Consumption

We first estimate how cash on hand responds to interest rate changes. To do so, we operationalize our regression specification (2), by estimating a cumulative impulse response via a local projection regression. We estimate

$$\sum_{j=-3}^{h} [Y_{i,t+j} - Y_{i,t-4}] = \alpha_{th} + \beta_h (r_t - r_{t-n_i}) + \text{error}_{ith}. \tag{3}$$

In this regression, the outcome variable $\sum_{j=-4}^{h} [Y_{i,t+j} - Y_{i,t-4}]$ is the cumulative change in cash on hand $h$ periods after deal expiry, relative to four months before deal expiry. The cumulative change in cash on hand has two components. First, there is total equity extracted between periods $t-4$ and $t+h$. Second, there is the sum of mortgage payments between periods $t-4$ and $t+h$ in excess of what payments would have been had they remained at their $t-4$ level. Together, these two components sum to the cumulative change in cash on hand—i.e. the cumulative change in pounds available to the household as a result of their new mortgage deal. We regress the cumulative change in cash on hand on the change in the aggregate mortgage rate (averaging across all households) since deal expiry $r_t - r_{t-n_i}$ as well as a month fixed effect. As a result $\beta_h$ measures the effect of a 1 pp increase in interest rates on total cash on hand, $h$ periods after the deal has expired. We estimate this regression using full sample of households with mortgage information, and will later show similar results for households with consumption information.

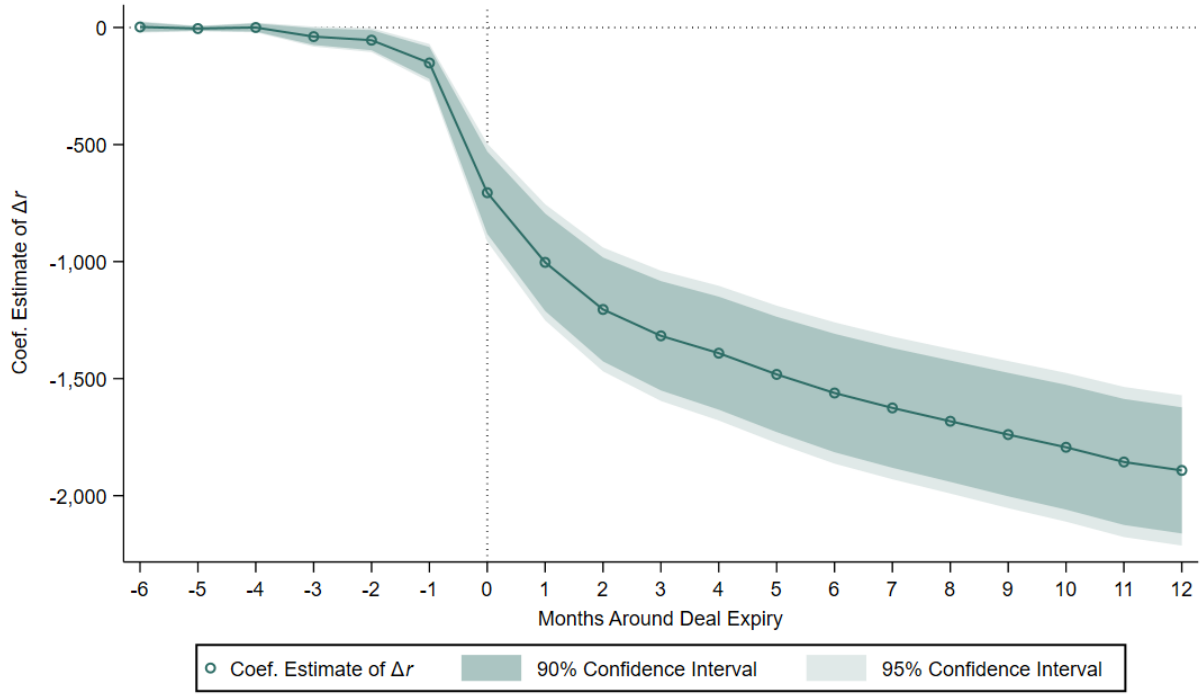
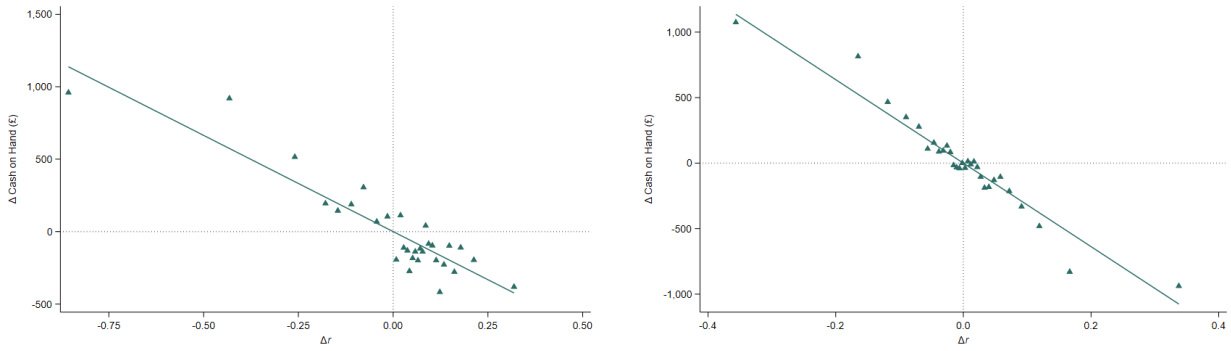



**Figure 5:** Impulse Response of Cash on Hand

Figure 5 presents the result. Specifically, the figure plots estimates of $\beta_h$, the cumulative response of cash on hand to interest rate changes, from 6 months before deal expiry, through to 12 months after expiry. The figure shows that cash on hand starts to respond to interest rate changes around 3 months before the deal expires. The response of cash on hand grows steadily over time. After 12 months, a 1 pp increase in interest rates means that cumulatively, cash on hand is almost 2000 pounds lower. Reassuringly, there are no pre-trends earlier than 3 months before deal expiry. As we saw in Figure 1, households start to switch deals at that time.

We also present versions of the regression underlying the figure in Table 2. The outcome variable is the cumulative response of cash on hand 6 months after deal expiry, i.e. we present estimates of $\beta_6$ from regression (3). In the first column there are no controls. The second column, our main specification, adds time fixed effect. The third column adds deal fixed effects, accounting for the possibility that households with different characteristics might select into deals of different length. The fourth column controls for time and household fixed effects. In this specification, one identifies the indebted demand channel using households who have multiple expiring deals—meaning the regression controls for time-invariant household characteristics that affect consumption growth. With household fixed effects, naturally, the sample is limited to households who refinance a mortgage at least twice during our sample




**(a)** Without HH FE **(b)** With HH FE

**Figure 6:** Binscatter for Cash on Hand

period.

Column (6) instruments for the change in interest rate using the change in interest rate that was not expected at the start of the deal. For instance, we instrument for the change in interest rates over the last 5 years with the current interest rate, minus what the expectation of the current interest rate was, 5 years ago. Rate expectations are measured from the interest rate swap curve. This instrument purges rate changes of their predictable variation, which might correlate with the characteristics of certain households.

Table 2 shows that in our main specification, consistent with the figure, cash on hand cumulatively falls by 1400 pounds after 6 months, in response to a 1 pp interest rate increase. The effect is slightly smaller after controlling for deal fixed effects, and significantly larger after controlling for household fixed effects. Column (5) presents the first stage of our instrument, the unexpected change in interest rates. Column (6) show that the results are similar when we instrument for mortgage interest rates with their unexpected component.

Figures 6 presents binned scatterplots reflecting regressions in columns (2) and (4) of table 2 respectively. The figure graphically represents the variation that is driving identification and generates the coefficient of interest. It also validates that the linear functional form assumption implicit in our regressions and local projections is reasonable.

So far, we have have estimated the response of cash on hand to interest rates using the full population of mortgage deals, numbering 6.7 million in total. However we wish to make statements about consumption, using the smaller sample of 69 000 mortgage deals with information from the personal finance apps. As an intermediate step, we show that cash on hand responds similarly in the full population as in the sample with consumption information. As a result, in the relevant dimensions, households with consumption data seem to respond similarly to interest rates, compared with the population as a whole. We report this regression in Appendix Table A.1. In the table we estimate the response of cash on hand

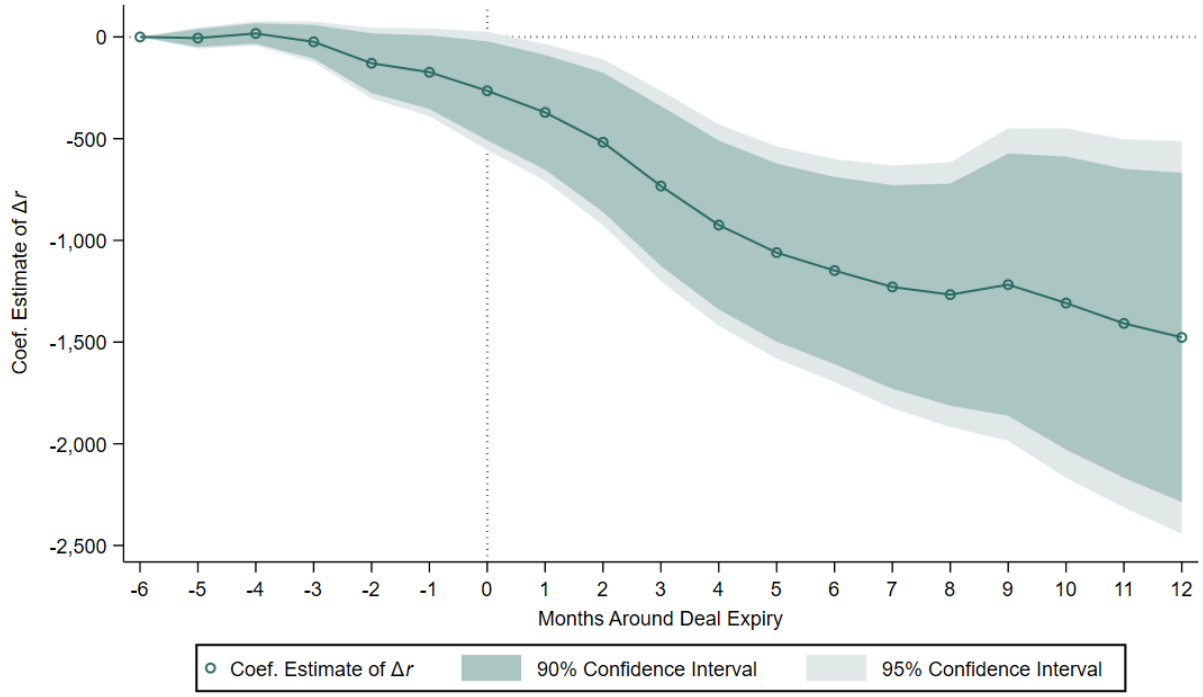



**Figure 7:** Impulse Response of Consumption

separately for households with and without consumption information, by interacting interest rate changes with an indicator for whether the household has consumption information. The estimated response is similar for both samples.

We next present the response of consumption to interest rate shocks by estimating equation (3) with cumulative change in consumption as the dependent variable. Specifically, the outcome variable is $\sum_{j=-3}^{h} [C_{i,t+j} - C_{i,t-4}]$—the cumulative change in consumption, $h$ periods after deal expiry compared with 4 periods before deal expiry. Figure 7 presents the result. In response to an interest rate cut of 1 pp, consumption starts to rise 2-3 periods before deal expiry, and continues to rise afterwards. 12 months after the deal has expired, a 1 pp rise in interest rates leads consumption to fall by 1500 pounds (in 2015 pounds). The regressions in local projection response are weighted, using weights based on quintiles of age, income, loan-to-value, mortgage term and home value, as well as broad region (NUTS1) fixed effects; in order to match the population of mortgage borrowers.

We again study the regressions underlying the consumption impulse response figure. We study the response of average monthly consumption, averaging across the 6 periods after deal expiry; which we regress on changes in the interest rate since the start of the deal. Table 3 reports the results. The response of consumption is similar with and without fixed effects for the deal length, while including time fixed effects (columns 2 and 3). The

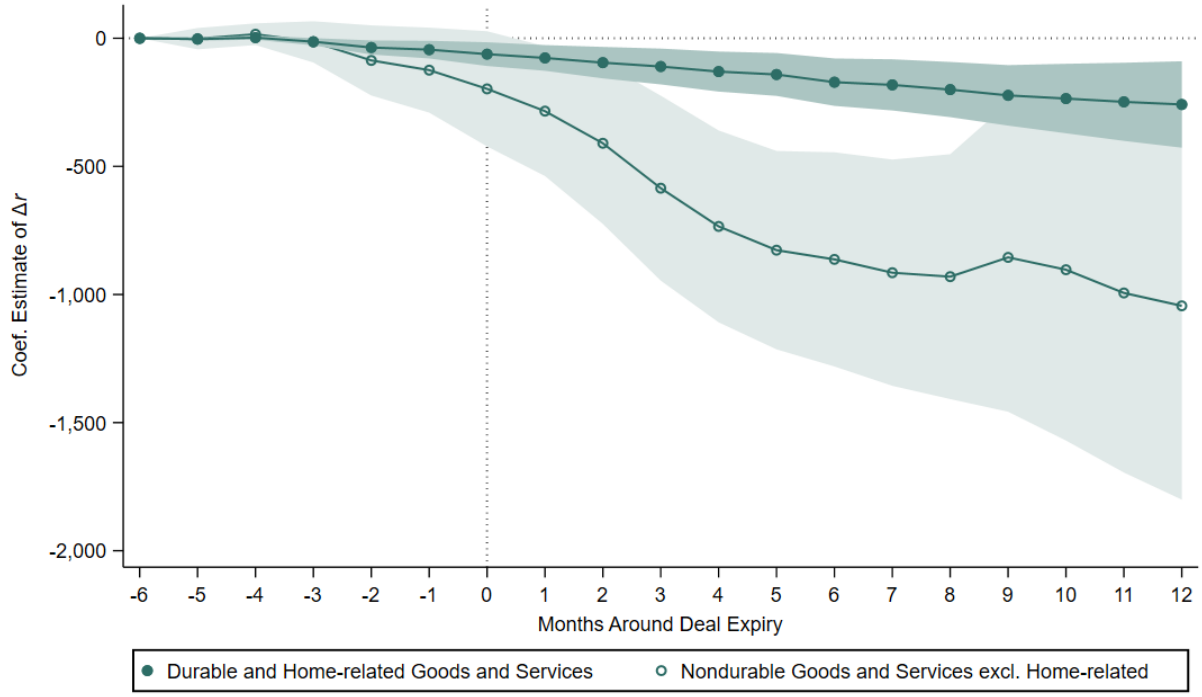



**Figure 8:** Impulse Response of Consumption Components

response is significantly larger with household fixed effects (column 4)—which measures how consumption responds to interest rate shocks, within the same household at different points in time. The estimates are similar when we instrument for interest rates using their unexpected component (column 6).

One principal major advantage of the consumption data is the transaction level information—meaning we can study at the household level how both durable and non-durable consumption respond to interest rate changes. We partition the overall response of consumption into two categories: first, the response of durables and home-related services spending (e.g. spending on builders for renovations); and second, the response of non-durable consumption. We study the response of both categories of consumption, again via local projections.

Figure 8 reports the result and shows that the overall strong response of consumption is mostly due to the response of non-durables and services that are not related to the home. In the figure, after 12 months non-durable spending falls by 1000 pounds after a 1pp interest rate increase. However durables and home-related services respond by only 300 pounds.

We can summarize how interest rate changes jointly affect cash on hand and consumption, by estimating the cumulative marginal propensity to consume out of cash on hand changes, consistent with our simple framework. We operationalize our regression equation (2) in order

to estimate cumulative responses. Specifically, we estimate a regression

$$\sum_{j=-4}^{h} [C_{i,t+j} - C_{i,t-4}] = \gamma_{th} + \delta_{th} \left(\text{cash on hand}_{t+12} - \text{cash on hand}_{t-4}\right) + \text{error}_{ith}$$

and where we instrument for $(\text{cash on hand}_{t+12} - \text{cash on hand}_{t-4})$ with the change in interest rates around deal expiry. In this regression, the outcome variable is the cumulative response of consumption, $h$ periods after the deal expiry compared with 4 periods before. We study how consumption responds to the total increase in cash on hand over the 12 months after the deal expires. Finally the variation in cash on hand is due to interest rate changes at deal expiry—hence the instrument. As a result, $\delta_h$ should be interpreted as the cumulative marginal propensity to consume, at time $h$, out of the total change in cash on hand induced by interest rate changes after the deal expires. In order to maximize sample size, we estimate the cumulative MPC using a two sample two stage least squares procedure (Inoue and Solon, 2010). We estimate the first stage, relating cash on hand to interest rates, using the full sample of households with mortgage information. We estimate the second stage, relating cash on hand to consumption, using the sample of households with consumption information. As such, we estimate both the first and second stage using the maximum sample for which the relevant information is available. This procedure requires that in population, cash on hand responds similarly for the sample with and without consumption information—we provided support for this presumption in Appendix Table A.1.

Figure 9 reports the cumulative marginal propensity to consume. The marginal propensity to consume starts to increase from zero, shortly before the deal expires. Gradually, the consumption response climbs. Finally, after 12 months, cumulatively households have consumed 75 pence for every pound increase in cash on hand due to interest rate cuts. The cumulative marginal propensity to consume that we have estimated, of 0.75, seems large—compared, for instance, to estimates of the marginal propensity to consume out of transitory income shocks (e.g. Boehm, Fize and Jaravel, 2025). However there are several differences: our estimate of the MPC includes both durables and non-durables, the shock is relatively persistent, and also involves interest rate changes. Appendix Table A.2 is a regression table that reports the results underlying this figure, and shows similar results with either household fixed effects or instrumenting for interest rates with their unexpected component.

**Identification Concerns and Robustness.** One question is whether our identification assumption is likely to be satisfied—that is, whether households' consumption would have evolved similarly absent the interest rate change associated with their expiring deals. Already we have seen several results suggesting this identification assumption is reasonable.

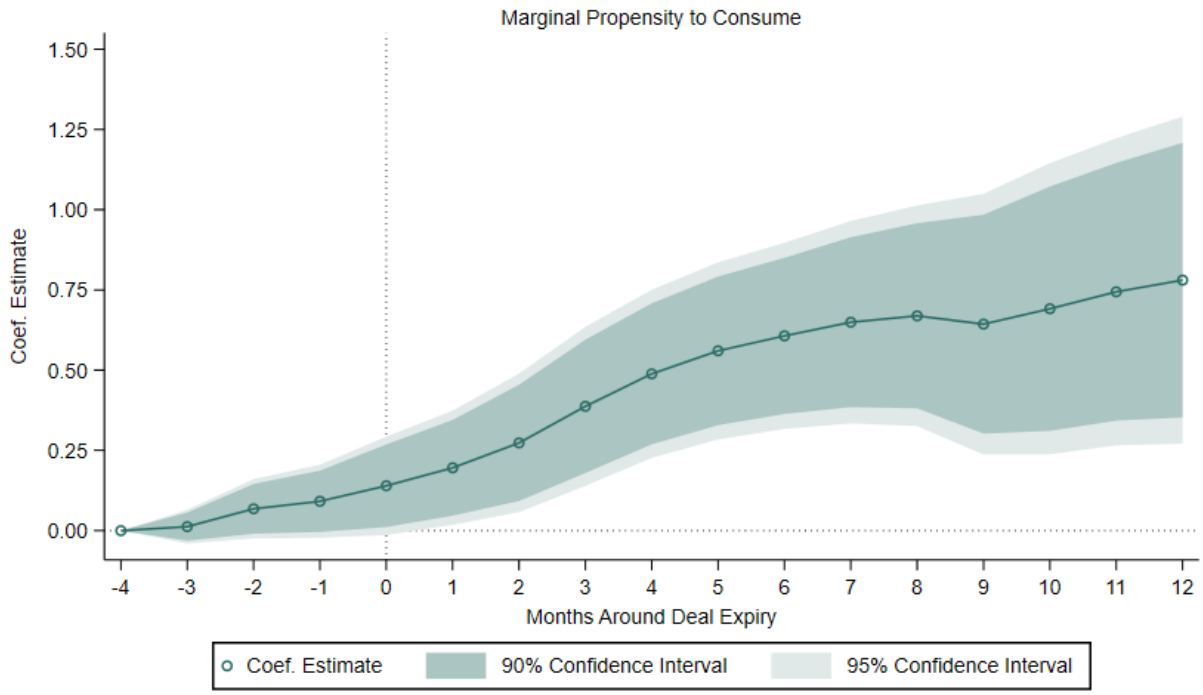



**Figure 9:** Marginal Propensity to Consume out of Cash on Hand

There is no pre-trend earlier than 3 months before the deal expires. As we discussed, at this point households tend to start switching deals in anticipation of the end of the deal. Moreover results are similar adding in either deal or household fixed effects, which absorb characteristics that correlate with households' choice of deal length. In further support of the identification assumption, we now present a placebo test. We show that income is uncorrelated with interest rate changes around deal expiry. Figure B.7 presents the result. Specifically, we present how income responds to interest rate changes, starting from 4 months before deal expiry, and ending 12 months after deal expiry. Income growth is uncorrelated with interest rate changes.

Another concern is that our consumption data might miss portions of household consumption. One reason could be that households do not link all their accounts to the financial app. As a result households might consume after the interest rate cut, without the consumption appearing in our dataset. Already, we have seen some evidence suggesting this concern is not too important. In Appendix Figure B.1, we showed that average household consumption in the app is similar to household consumption in survey data for the UK. As a result, for the typical household, most or all of their consumption appears to be recorded in the app.

We end this section by presenting additional evidence suggesting that our data captures most or all of the consumption response. Specifically, we calculate the "marginal propensity

to expend" out of the interest-rate-induced changes in cash on hand. The marginal propensity to expend includes not only consumption but also changes in non-mortgage savings. Specifically, the marginal propensity to expend is the change in consumption plus paying off credit card debt and personal loans, and accumulating liquid assets. Figure B.8 presents estimates of the marginal propensity to expend, from 6 months before deal expiry to 12 months afterwards. After 12 months, the marginal propensity to expend is 1. That is, households seem to have spent or saved all of the increase in cash on hand associated with their mortgage—as one would expect if we accurately measure the entirety of households' consumption.

## 5.2 Magnitude of the Indebted Demand Channel

How large is the effect of interest rates on consumption via the indebted demand channel? We perform some simple calculations to show that the effects are significant. Figure 7 shows that average consumption for an indebted household falls by 1,500 pounds for a 1pp rise in interest rate in terms of 2015 pounds. The average annual household consumption in our own sample of mortgagors in the UK is around 30 000 pounds (see Table 1). Thus a 1 pp rise in interest rate reduces consumption by around 5% according to this measure. There are about 8 million households in the U.K. with a mortgage, and so 1,500 pound decline in consumption per indebted household translated into 12 billion pounds, or about 0.5% of GDP in 2015 pounds. This calculation of course assumes that the entire population of mortgagors receive the 1pp interest rate shock at the same time.

The implied aggregate indebted demand effect of monetary policy is sizeable. For instance, the effect of interest rates on consumption via intertemporal substitution are much smaller (e.g. Best et al., 2020). However one must bear in mind two caveats when interpreting the size of the indebted demand channel. First, we have estimated the response of consumption to persistent interest rate changes, since the interest rate change at the start of a new deal will prevail until the new deal ends. All else equal, more persistent interest rate changes have stronger effects on consumption. Second, we have estimated the response of consumption to interest rates for borrowers only. The aggregate response of consumption to interest rates includes how savers react. Savers may reduce consumption after an interest rate cut, since resources are redistributed towards borrowers. However this offsetting effect will be small if savers have low marginal propensities to consume relative to borrowers, as some data suggests (e.g. Auclert, 2019). Finally, our aggregate calculation ignores any other general equilibrium feedback effects via changing absolute or relative prices.

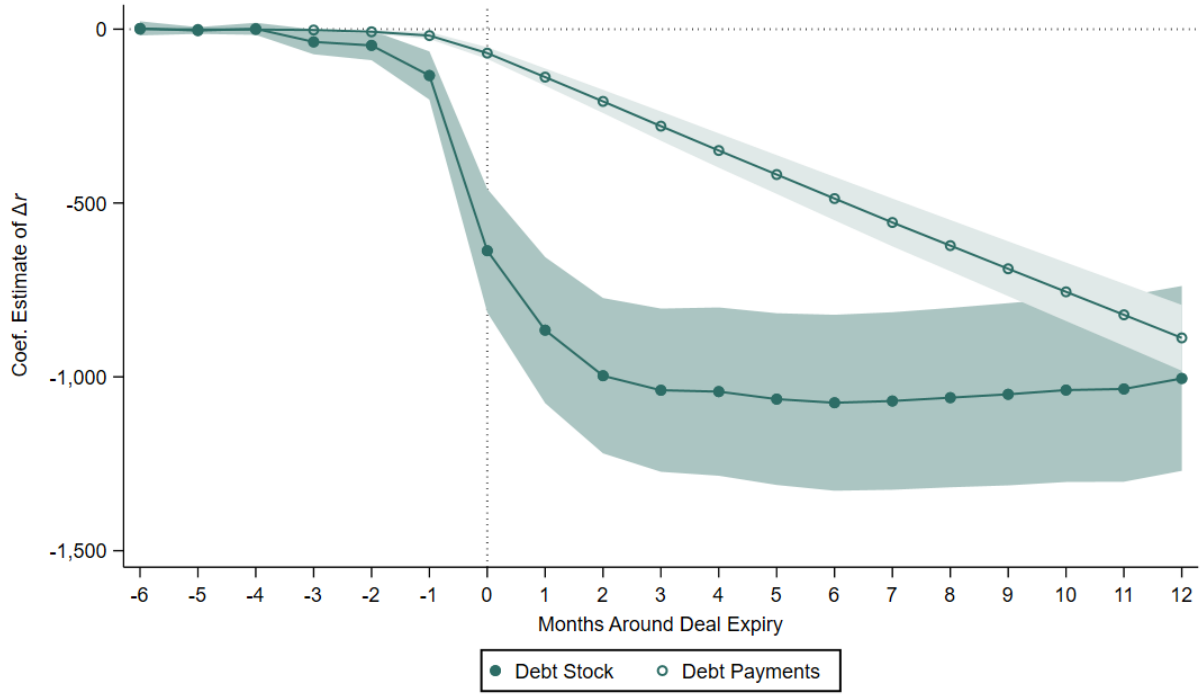



**Figure 10:** Impulse Response of Principal and Monthly Mortgage Payments

## 5.3 Equity Extraction and Mortgage Payments

We close this section by studying the two components of indebted demand. First, when interest rates fall, mortgage payments fall too. Second, after rate cuts, households can extract more equity. Either way, cash on hand rises, which boosts consumption. We show that both mortgage payments and equity extraction respond to interest rates. To make this point we re-estimate the response of cash on hand, but dis-aggregate cash on hand into its two components. That is, we study how cumulative equity extraction responds to interest rate changes. We also study how cumulative mortgage payments respond to interest rate changes.

Figure 10 presents the result. In the figure, the dark line is the cumulative impulse response of equity extraction to a 1 pp interest rise, from 6 months before the deal expires to 12 months afterwards. The light line is the cumulative impulse response of mortgage payments. After 12 months, the cumulative response of mortgage payments and equity extraction are similar. Both components of cash on hand fall by 1000 pounds after a 1 pp increase in interest rates. As such the two components of indebted demand are equally important.

Table 4 reports regressions underlying the results. In columns (1) we report the cumu-

lative response of cash on hand to a 1 pp interest rate rise, after 6 months. In columns (2) and (3) we dis-aggregate into the response of equity extraction and of mortgage payments. Columns (4)-(6) repeat the exercise after controlling for household fixed effects. In this case, equity extraction becomes more important, but the response of payments remains sizeable.

# 6 Debt and the Power of Monetary Policy

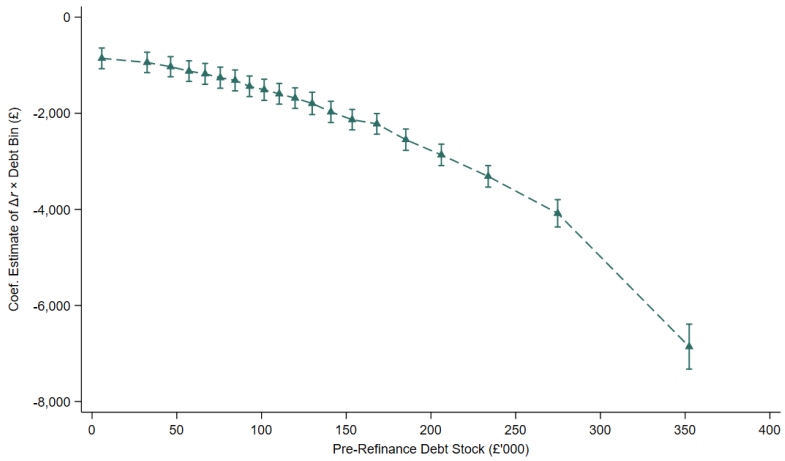
So far we have shown that the indebted demand channel of monetary policy is powerful. This result provokes a follow-up question: is monetary policy more powerful when there is more debt? Our simple conceptual framework suggests that the answer is yes. When debt is high, mortgage payments respond more to interest rate changes. As a result cash on hand responds more to interest rate changes, and so too does consumption. This section finds that interest rates indeed have much larger effects on consumption when debt is high.

To test for how debt affects the power of monetary policy, we re-estimate a version of the baseline regression. In this regression, the outcome variable is the change in cash on hand, in a six month window after deal expiry. The regressor is the change in interest rates upon deal expiry. As before, we control for time fixed effects. However we estimate the response of cash on hand separately for 20 ventiles of the debt distribution.

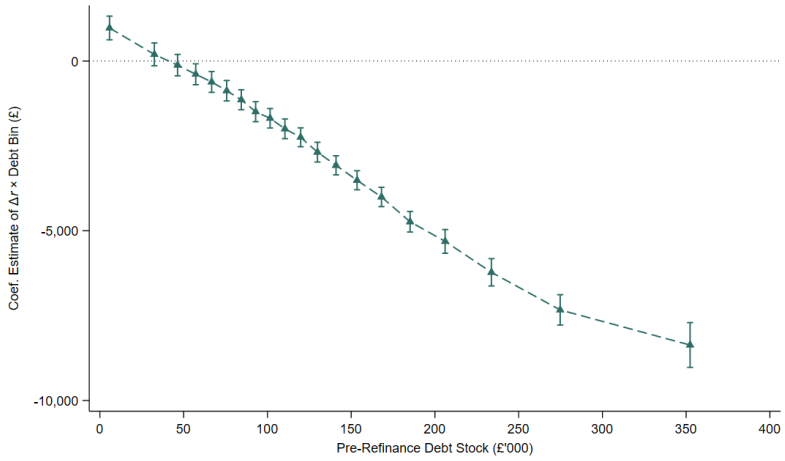
Figure 11 shows that interest rate cuts have bigger effects for households with more debt. In panel (a) of the figure, the y axis is the regression coefficient without household fixed effects—how cash on hand responds to a 1 pp interest rate increase. The x axis is the household's debt before they switch deals, separately for 20 ventiles of the debt distribution. For households in the top ventile of the debt distribution, a 1 pp interest rate cut raises cash on hand by around 7 000 pounds; whereas a household in the lowest ventile experiences an increase in cash on hand of only 1 000 pounds. The gap between the top and bottom ventiles is even larger when we use household fixed effects, and thus only use within-household variation in interest rate shocks to estimate the indebted demand effect. Overall, the figure shows that doubling household debt doubles (or more) the marginal effect of interest rate cuts on cash on hand.

We also present regressions underlying the figure. For the regression, we re-estimate the response of cash on hand to interest rate cuts with time fixed effects, as in the baseline regression. However we also interact interest rate changes with households' debt before their deal expires. That is, we estimate a regression

$$\sum_{j=-3}^{6} [Y_{i,t+j} - Y_{i,t-4}] = \alpha_t + \beta (r_t - r_{t-n_i}) + \gamma \text{debt}_{i,t-1} + \delta (r_t - r_{t-n_i}) \times \text{debt}_{i,t-1} + \text{error}_{ith}, \quad (4)$$




**(a)** Without HH FE




**(b)** With HH FE

**Figure 11:** Cash on Hand Response Across the Debt Distribution

where the outcome variable is the cumulative change in cash on hand, 6 months after deal expiry. We also consider a version of the regression that controls for time fixed effects both at the start and the end of the deal. With these fixed effects, one compares two households whose deals started and ended at the same time, but had different levels of debt when their deals expire. Finally, we study a version of the regression that controls for household fixed effects.

Table 5 presents the results, and confirms that more indebted households respond more to interest rate changes. Column (1) of the table presents the baseline estimate. The middle row is negative and significant, consistent with the figure. That is, when debt before deal expiry is higher, then households tend to increase cash on hand by more after interest rate cuts. Columns (2) and (3) disaggregate the response of cash on hand into equity extraction

and mortgage payments. Both components are significant, but the magnitude of the equity extraction effect interaction with debt is stronger. This has an important implication, as households become more indebted, they become *more* responsive to monetary policy shocks due to the equity extraction channel.

Columns (4)-(6) repeat the exercise, with time fixed effects for the start and end of the deal. While columns (7)-(9) control for household fixed effects. First, notice that the coefficient on the interaction between debt and interest rate change does not change materially across all three specifications. This further confirms the hard-wired nature of this effect. However, the equity withdrawal channel becomes almost four times as strong with more debt in the specification with household fixed effects. Thus when the same household becomes more indebted, they become much more sensitive to future monetary policy shocks.

Mechanically, mortgage payments must respond more to interest rates when debt is higher. To see this, first consider the case of an interest only mortgage. A 1 pp decline in the interest rate would lower mortgage payments by 1 pound for every 100 pound increase in mortgage. In other words, the coefficient on the interaction between debt and the change in mortgage rate would be -1 for an interest only mortgage by construction. For amortizing mortgages, the effect is smaller. Given the average amortization schedule in the U.K. our calculations suggest a coefficient between -0.4 and -0.5—consistent with our estimates.

These results suggest an interdependence between the past and future monetary policy shocks. Suppose that the central bank has cut rates in the past. As a result, debt has increased. We should expect that with higher debt, households become more sensitive to future interest rate shocks. We use one of the appealing features of our data—that we observe households with multiple interest rate shocks at different times—to test how rate cuts in the past affect indebted demand in the future.

We consider two specifications. In the first specification, we study how within a household over time, their response to interest rates changes as their debt changes. To implement this regression, we add an additional control to regression equation (4), namely the interaction of household fixed effects with the change in interest rates as the deal expires. With the additional control, the coefficient $\delta$ in the regression captures how changes in household debt in the past affect sensitivity to interest rates in the future.

In the second specification, we instrument for the change in households' debt, and study how the instrumented change in debt affects the response to monetary policy. Specifically,

we consider a regression

$$\sum_{j=-3}^{6} [Y_{i,t+j} - Y_{i,t-4}] = \alpha_t + \beta (r_t - r_{t-n_i}) + \mu (r_t - r_{t-n_i-1}) \times \text{debt}_{i,t-n_i} + \nu (r_t - r_{t-n_i}) \times (\text{debt}_{i,t-1} - \text{debt}_{i,t-n_i-1}) + \text{controls}_{it} + \text{error}_{it}.$$

In the regression, we separately consider $\text{debt}_{i,t-n_i-1}$ in the previous deal before the one that is currently expiring; as well as the change in debt at the start of the deal that is currently expiring, $\text{debt}_{i,t-1} - \text{debt}_{i,t-n_i-1}$. We study how each of these terms affects the response of cash on hand to interest rate changes.

Next, we instrument for the change in debt at the start of the deal that is currently expiring. Our instrument is how interest rates changed when their previous deal expired. That is, we instrument for household's current debt position with their past interest rate shock from their previous deal. One has good reason to believe that this instrument is valid. We have already seen that interest rate changes around deal expiry are a powerful predictor of debt changes. Moreover we have argued that interest rate changes around deal expiry are likely independent from other factors affecting cash on hand. As an additional benefit, this instrument deals with a natural endogeneity concern—debt may correlate with other variables that affect households' response to interest rate changes. With our instrument, we are measuring variation in debt only due to past interest rate shocks, which are plausibly orthogonal to other factors affecting debt.

Table 6 presents the results, and shows that when debt increases for a household—including because of past interest rates—they subsequently respond more to future interest rate shocks. The first column simply studies regression equation (4), but interacts the change in the rate with household fixed effects. Relative to estimates that do not include this control, the coefficient on the interaction of interest rates with debt increases by a factor of 10. Columns (2) and (3) report the first stage of our instrument for changes in debt, and the interaction of changes in debt. The instrument has strong explanatory power. Column (4), row (3) presents the main coefficient of interest in the instrumented specification. This coefficient shows that when debt increases because of past interest rate cuts, cash on hand becomes more sensitive to future changes in interest rates. The magnitude of the coefficient is similar to Column (1).

Our results have intriguing implications for monetary policy. Suppose that the central bank cuts interest rates today. Borrowers will become more indebted. As a result, they will respond more to future interest rate changes. More generally, we have seen that household

debt is an important determinant of the power of monetary policy, via the indebted demand channel.

# 7 Conclusion

When central banks cut interest rates, what is the effect on consumption? Our paper focusses on a natural experiment in order to estimate how monetary policy affects consumption via indebted demand—that is, via lower payments on debt and greater borrowing. The natural experiment is that in the UK, households choose mortgage deals that end at staggered and pre-determined times, creating sudden interest rate changes and opportunities to extract equity. We show this natural experiment isolates the indebted demand channel, and holds fixed other factor affecting consumption such as income and borrowing outside the mortgage market. We combine the natural experiment with administrative datasets of mortgages and consumption for the UK, for 2015-24. Our approach has an additional benefit: we can estimate how interest rates affect consumption using cross sectional variation.

Our main result is that the indebted demand channel is large. We show that a 1 percentage point cut raises consumption for borrowers by 4%, equivalent to 0.5% of UK GDP. The response of consumption is due to mortgage payments falling after interest rate cuts, and especially a large increase in equity extraction, i.e. borrowing with mortgages.

We also study how debt affects the power of monetary policy. We find that indebted households are more responsive to interest rate cuts. In particular interest rate cuts in the past—which raise debt in the future—make households more sensitive to interest rates in the future. Overall, our results show that debt and leverage are key state variables that determine the strength of the transmission of monetary policy to the real economy.

## Table 1: Summary Statistics for Mortgage Population and Consumption Sample

| | Mortgage Population | | Unweighted Consumption Sample | | Weighted Consumption Sample | |
|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| **Mortgage Variables** | | | | | | |
| Mortgage Debt (£) | 147,581.38 | 115,092.22 | 145,416.28 | 99,986.11 | 147,257.41 | 109,520.54 |
| Home Value (£) | 295,202.66 | 234,177.12 | 250,815.18 | 173,214.74 | 284,773.15 | 202,805.80 |
| Mortgage Payment (£) | 716.67 | 477.73 | 671.99 | 420.32 | 720.21 | 468.94 |
| Mortgage Term (months) | 253.51 | 99.59 | 286.18 | 91.11 | 257.39 | 97.40 |
| Interest Rate (%) | 2.34 | 0.82 | 2.40 | 0.84 | 2.32 | 0.81 |
| Loan-to-value Ratio (%) | 53.81 | 21.20 | 60.52 | 18.78 | 54.52 | 20.85 |
| Loan-to-income Ratio | 2.89 | 1.12 | 3.00 | 1.00 | 2.88 | 1.08 |
| Debt-service Ratio (%) | 17.56 | 6.44 | 16.96 | 5.48 | 17.53 | 6.21 |
| Income (£) | 58,376.28 | 48,805.82 | 55,483.94 | 36,524.98 | 58,482.47 | 40,996.67 |
| Age | 42.49 | 9.82 | 39.63 | 8.71 | 42.07 | 9.51 |
| London Dummy Variable (%) | 12.55 | 33.13 | 8.14 | 27.34 | 12.84 | 33.45 |
| **Consumption Variables** | | | | | | |
| Total Consumption (£) | | | 2,456.62 | 2,904.33 | 2,563.87 | 3,029.01 |
| Durable and Home-related (£) | | | 133.09 | 587.26 | 139.39 | 638.03 |
| Nondurable excl. Home-related (£) | | | 2,174.53 | 2,614.30 | 2,266.50 | 2,701.86 |
| Observations | 6,788,665 | 6,788,665 | 68,681 | 68,681 | 68,681 | 68,681 |

*Notes:* The table shows summary statistics for our datasets. In the first two columns we report summary statistics for observations with mortgage information, i.e. for the universe of mortgages from January 2015 to March 2024. In the middle two columns we report summary statistics for the observations with both mortgage and consumption information, i.e. for households that merge between the mortgage dataset (PSD) and the consumption dataset (ClearScore or MoneyDashboard). The final two columns present the consumption sample, but reweighted based on quintiles of age, income, loan-to-value, mortgage term and home value, as well as broad region (NUTS1) information, in order to match the mortgage sample. In the rows we present summary statistics on information, for either mortgages or consupmtion; including both the mean and standard deviation of variables. The observations are at the level of an expiring deal, i.e. we measure the characteristics of a household as its deal expires. The units are 2015 pounds.

## Table 2: Effect of Mortgage Rates on Cash on Hand

| | Δ Cash on Hand | | | | ΔMortgage Rate | Δ Cash on Hand |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔMortgage Rate | -1410.033*** | -1328.498*** | -830.301*** | -3186.287*** | | -1465.116*** |
| | (42.265) | (107.913) | (145.717) | (204.040) | | (143.399) |
| Long Term Rate Shocks | | | | | 0.265*** | |
| | | | | | (0.014) | |
| Observations | 6788665 | 6788665 | 6788665 | 3675859 | 6726018 | 6726018 |
| Adjusted $R^2$ | 0.007 | 0.007 | 0.007 | 0.080 | 0.987 | 0.000 |
| K-Papp F-Stat | | | | | | 358.241 |
| Trigger Month FE | No | Yes | Yes | Yes | Yes | Yes |
| Deal Length FE | No | No | Yes | No | No | No |
| Household FE | No | No | No | Yes | No | No |

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

*Notes:* The table shows the impact of changing aggregate mortgage rates on the change in cash on hand, in the event window around the end of the mortgage deal. The event window is from 4 months before deal expiry, until 6 months after deal expiry. Results are shown for the full mortgage sample. In this table the change in cash on hand is defined as the change in mortgage principal less 10 times the change in monthly payments. Column 1 shows the regression of the change in cash on hand on the change in aggregate mortgage rates over the deal, with no fixed effects. Column 2 adds a fixed effect for the month of deal expiration. Column 3 further adds a fixed effect for the length of the expiring deal, whether 1,2,3 or 5 years. Column 4 includes a month fixed effect and a household fixed effect. Column 6 instruments for the change in aggregate rates with long term shocks to rates, which are the difference between government bond yields at the time of refinance, less what they were expected to be (from the yield curve) at the start of the mortgage deal. Column 5 shows the first stage of this IV regression. Trigger month clustered standard errors are shown in parentheses. The units are 2015 pounds.

## Table 3: Effect of Mortgage Rates on Consumption

| | Δ Consumption | | | | ΔMortgage Rate | Δ Consumption |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔMortgage Rate | -287.361* | -963.696*** | -929.999*** | -1773.688*** | | -893.341*** |
| | (159.497) | (275.218) | (302.608) | (591.987) | | (314.421) |
| Long Term Rate Shocks | | | | | 0.350*** | |
| | | | | | (0.040) | |
| Observations | 68681 | 68681 | 68681 | 17582 | 67868 | 67868 |
| Adjusted $R^2$ | 0.000 | 0.002 | 0.002 | 0.048 | 0.936 | 0.000 |
| K-Papp F-Stat | | | | | | 77.284 |
| Trigger Year FE | No | Yes | Yes | Yes | Yes | Yes |
| Deal Length FE | No | No | Yes | No | No | No |
| Household FE | No | No | No | Yes | No | No |

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

*Notes:* The table shows the impact of changing aggregate mortgage rates on the cumulative change in consumption, in the event window around the end of the mortgage deal. The event window is from 4 months before deal expiry, until 6 months after deal expiry. Results are shown for the matched mortgage-consumption sample. The results show the cumulative change in consumption during the event window from 3 months before, to 6 months after the month of deal expiry. Column 1 shows the regression of the change in consumption on the change in aggregate mortgage rates over the deal, with no fixed effects. Column 2 adds a fixed effect for the year of deal expiration. Column 3 further adds a fixed effect for the length of the expiring deal, whether 1,2,3 or 5 years. Column 4 includes a year fixed effect and a household fixed effect. Column 6 instruments for the change in aggregate rates with long term shocks to rates, which are the difference between government bond yields at the time of refinance, less what they were expected to be (from the yield curve) at the start of the mortgage deal. Column 5 shows the first stage of this IV regression. Trigger month clustered standard errors are shown in parentheses. The units are 2015 pounds. The regression is weighted, using weights based on quintiles of age, income, loan-to-value, mortgage term and home value, as well as broad region (NUTS1) fixed effects; to target the population of mortgage borrowers.

## Table 4: Effect of Interest Rates on Equity Extraction and Mortgage Payments

| | Δ Cash on Hand | Δ Equity Extraction | −ΔPayments | Δ Cash on Hand | Δ Equity Extraction | −ΔPayments |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔMortgage Rate | -1328.498*** | -660.181*** | -668.317*** | -3186.287*** | -2401.719*** | -784.568*** |
| | (107.913) | (107.354) | (28.357) | (204.040) | (203.085) | (30.409) |
| Observations | 6788665 | 6788665 | 6788665 | 3675859 | 3675859 | 3675859 |
| Adjusted $R^2$ | 0.007 | 0.003 | 0.120 | 0.080 | 0.078 | 0.081 |
| Trigger Month FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Household FE | No | No | No | Yes | Yes | Yes |

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

*Notes:* The table shows the impact of changing aggregate mortgage rates on the change in cash on hand, in the event window around the end of the mortgage deal. The event window is from 4 months before deal expiry, until 6 months after deal expiry. Results are shown for the full mortgage sample and are decomposed into the change in equity extraction and cumulative change in monthly payments. In this table the change in cash on hand is defined as the change in equity extraction less 10 times the change in monthly payments. Column 1 shows the regression of the change in cash on hand on the change in aggregate mortgage rates over the deal, with trigger month fixed effects. In column 2 the dependent variable is the change in principal, in the event window around the end of the mortgage deal. In column 3 the dependent variable is $-10$ times the change in monthly payments, in the event window around the end of the mortgage deal. Columns 4-6 repeat this decomposition, with each regression now also featuring a household fixed effect. Trigger month clustered standard errors are shown in parentheses. The units are 2015 pounds.

## Table 5: Effect of Existing Debt on Response of Cash on Hand to Interest Rate Changes

| | ΔCoH | ΔPrin. | −ΔPaym. | ΔCoH | ΔPrin. | −ΔPaym. | ΔCoH | ΔPrin. | −ΔPaym. |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| ΔMortgage Rate | -27.086 | 100.638 | -127.724*** | | | | 2511.478*** | 2769.330*** | -257.852*** |
| | (140.643) | (144.190) | (24.518) | | | | (259.740) | (267.010) | (27.376) |
| ΔMortgage Rate x Pre Debt | -1.216*** | -0.797*** | -0.419*** | -1.248*** | -0.829*** | -0.419*** | -3.474*** | -3.039*** | -0.435*** |
| | (0.046) | (0.052) | (0.017) | (0.046) | (0.052) | (0.016) | (0.098) | (0.101) | (0.010) |
| Observations | 6788665 | 6788665 | 6788665 | 6788551 | 6788551 | 6788551 | 3675859 | 3675859 | 3675859 |
| Adjusted $R^2$ | 0.014 | 0.006 | 0.195 | 0.016 | 0.008 | 0.199 | 0.184 | 0.175 | 0.169 |
| Trigger Month FE | Yes | Yes | Yes | No | No | No | Yes | Yes | Yes |
| Start Month x Trigger Month FE | No | No | No | Yes | Yes | Yes | No | No | No |
| Household FE | No | No | No | No | No | No | Yes | Yes | Yes |

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

*Notes:* The table shows how pre-existing mortgage debt affects the sensitivity of cash on hand to the change in aggregate rates, in the event window around the end of the mortgage deal. The event window is from 4 months before deal expiry, until 6 months after deal expiry. Results are shown for the full mortgage sample. In this table the change in cash on hand is defined as the change in mortgage principal less 10 times the change in monthly payments. Column 1 shows the regression of the change in cash on hand on interaction of the mortgage balance 7 months prior to the end of the mortgage deal with the change in mortgage rates. This interaction variable is divided by 100 so the coefficient estimate has the interpretation of a semi-elasticity when the outcome variable is the change in principal. This regression includes a trigger month fixed effect. Columns 2-3 show the results for the sub-components of the change in cash in hand, with column 2 showing the response of principal and column 3 showing the cumulative response of payments. Columns 4-6 repeat this specification with a start month x trigger month fixed effect. Columns 7-9 repeat the specification with trigger month and household fixed effects. Trigger month clustered standard errors are shown in parentheses. The units are 2015 pounds.

## Table 6: Effect of Debt Changes on Response of Cash on Hand to Interest Rate Changes

| | OLS | First Stage | | IV |
|---|---|---|---|---|
| | Change Principal | ΔMortgage Rate x ΔDebt | ΔDebt | Change Principal |
| | (1) | (2) | (3) | (4) |
| ΔMortgage Rate | | -6.03 | 2.12 | 1187.77** |
| | | (21.39) | (1326.76) | (495.80) |
| ΔMortgage Rate x Pre Debt | -15.426** | | | |
| | (7.022) | | | |
| ΔMortgage Rate x ΔDebt | | | | -18.80*** |
| | | | | (6.10) |
| ΔMortgage Rate x Prior Debt | | 0.00 | -0.23*** | -1.08*** |
| | | (0.00) | (0.06) | (0.13) |
| Prior ΔMortgage Rate | | -3.21* | -1190.60*** | |
| | | (1.90) | (174.61) | |
| ΔMortgage Rate x Prior ΔMortgage Rate | | -37.28*** | -1170.36*** | |
| | | (4.50) | (183.32) | |
| Observations | 3675859 | 2060792 | 2060792 | 2060792 |
| Adjusted $R^2$ | 0.219 | 0.021 | 0.004 | -0.117 |
| K-Papp F-Stat | | | | 17.508 |
| Trigger Month FE | Yes | Yes | Yes | Yes |
| Household FE | Yes | No | No | No |
| Household x ΔMortgage Rate FE | Yes | No | No | No |

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

*Notes:* The table shows the impact of changing aggregate mortgage rates on the change in principal, in the event window around the end of the mortgage deal. The event window is from 4 months before deal expiry, until 6 months after deal expiry. Results are shown for the full mortgage sample, for the sample of households which are triggered at least twice. Column 1 shows the response of principal to the interaction of the change in mortgage rates with the mortgage balance 7 months prior to the end of the mortgage deal. This interaction variable is divided by 100 so the coefficient estimate has the interpretation of a semi-elasticity. Column 1 includes a household fixed effect and further absorbs the average household-level sensitivity to mortgage rates. For the remaining columns we split the mortgage balance 7 months prior to the end of the mortgage deal into ΔDebt-the change in debt at the expiry of their prior deal-and Implied Debt-the level of debt they would have if they hadn't changed principal at the expiry of their prior deal. Both variables are interacted with the change in aggregate mortgage rates over the deal, and divided by 100 so that the coefficient estimates have the interpretation of semi-elasticities. Column 4 estimates the regression of the change in principal on both interaction variables. As instruments for ΔMortgage Rate x ΔDebt and ΔDebt we use the change in aggregate mortgage rates over the prior deal, and the interaction of this change with the change in aggregate rates over the current expiring deal. Columns 2 and 3 show the first stage regressions. Trigger month clustered standard errors are shown in parentheses. The units are 2015 pounds.

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## Table A.1: Effect of Mortgage Rates on Cash on Hand

| | Δ Cash on Hand | | | | ΔMortgage Rate | Δ Cash on Hand |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| ΔMortgage Rate | -1415.682*** | -1340.211*** | -825.551*** | -3189.666*** | | -1483.901*** |
| | (42.344) | (108.039) | (145.435) | (203.986) | | (143.673) |
| ΔMortgage Rate x 𝕀(Consump. Samp) | -1123.307*** | -1039.136*** | -519.134*** | -2554.141*** | | -1151.692*** |
| | (79.498) | (116.604) | (154.055) | (244.823) | | (153.506) |
| Long Term Rate Shocks | | | | | 0.265*** | |
| | | | | | (0.014) | |
| Long Term Rate Shocks x 𝕀(Consump. Samp) | | | | | 0.260*** | |
| | | | | | (0.014) | |
| Observations | 6788665 | 6788665 | 6788665 | 3675859 | 6726018 | 6726018 |
| Adjusted $R^2$ | 0.007 | 0.007 | 0.008 | 0.080 | 0.987 | 0.000 |
| K-Papp F-Stat | | | | | | 179.155 |
| Trigger Month FE | No | Yes | Yes | Yes | Yes | Yes |
| Deal Length FE | No | No | Yes | No | No | No |
| Household FE | No | No | No | Yes | No | No |

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

*Notes:* The table shows the impact of changing aggregate mortgage rates on the change in cash on hand, in the event window around the end of the mortgage deal. The event window is from 4 months before deal expiry, until 6 months after deal expiry. Results are shown for the full mortgage sample, with separate coefficient estimates for observations in the matched mortgage-consumption sample and the remaining mortgage observations. In this table the change in cash on hand is defined as the change in mortgage principal less 10 times the change in monthly payments. Column 1 shows the regression of the change in cash on hand on the change in aggregate mortgage rates over the deal, with no fixed effects. Column 2 adds a fixed effect for the month of deal expiration. Column 3 further adds a fixed effect for the length of the expiring deal, whether 1,2,3 or 5 years. Column 4 includes a month fixed effect and a household fixed effect. Column 6 instruments for the change in aggregate rates with long term shocks to rates, which are the difference between government bond yields at the time of refinance, less what they were expected to be (from the yield curve) at the start of the mortgage deal. Column 5 shows the first stage of this IV regression. Trigger month clustered standard errors are shown in parentheses. The units are 2015 pounds.

## Table A.2: MPC Out of Cash on Hand

| Change Consumption | | | |
|---|---|---|---|
| | Baseline | Household FE | Shock to Rates |
| | (1) | (2) | (3) |
| $\Delta$ Cash on Hand | 0.725*** | 0.557*** | 0.806*** |
| | (0.207) | (0.186) | (0.306) |
| Second Stage Observations | 68681 | 17582 | 67868 |
| Adjusted $R^2$ | 0.002 | 0.048 | 0.002 |
| K-Papp F-Stat | 151.555 | 243.860 | 81.435 |
| Time FE | Yes | Yes | Yes |
| Household FE | No | Yes | No |

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

*Notes:* The table shows the cumulative marginal propensity to consume out of the change in cash on hand, in the event window around the end of the mortgage deal. The event window is from 4 months before deal expiry, until 6 months after deal expiry. In this table the change in cash on hand is defined as the change in mortgage principal less 10 times the change in monthly payments. The results use the cumulative change in consumption during the event window from 3 months before, to 6 months after the month of deal expiry. The regressions are estimated via Two-Sample Two-Stage Least Squares. The first stage regresses the change in cash in hand on the change in aggregate mortgage rates, in the full mortgage sample, and includes trigger month fixed effects. The second stage regresses the average monthly change in consumption on the fitted change in cash on hand from the first stage. The second stage regression is run in the matched mortgage-consumption sample, and includes trigger year fixed effects. Column 1 shows the baseline regression, with trigger time fixed effects. Column 2 further includes household fixed effects in both the first and second stage regressions. In column 3, trigger time fixed effects are used, and the first and second stage regressions are run with long term shocks to rates, which are the difference between government bond yields at the time of refinance, less what they were expected to be (from the yield curve) at the start of the mortgage deal. Trigger month clustered standard errors are shown in parentheses. The units are 2015 pounds. The regression is weighted, using weights based on quintiles of age, income, loan-to-value, mortgage term and home value, as well as broad region (NUTS1) fixed effects; to target the population of mortgage borrowers.

# B Appendix Figures

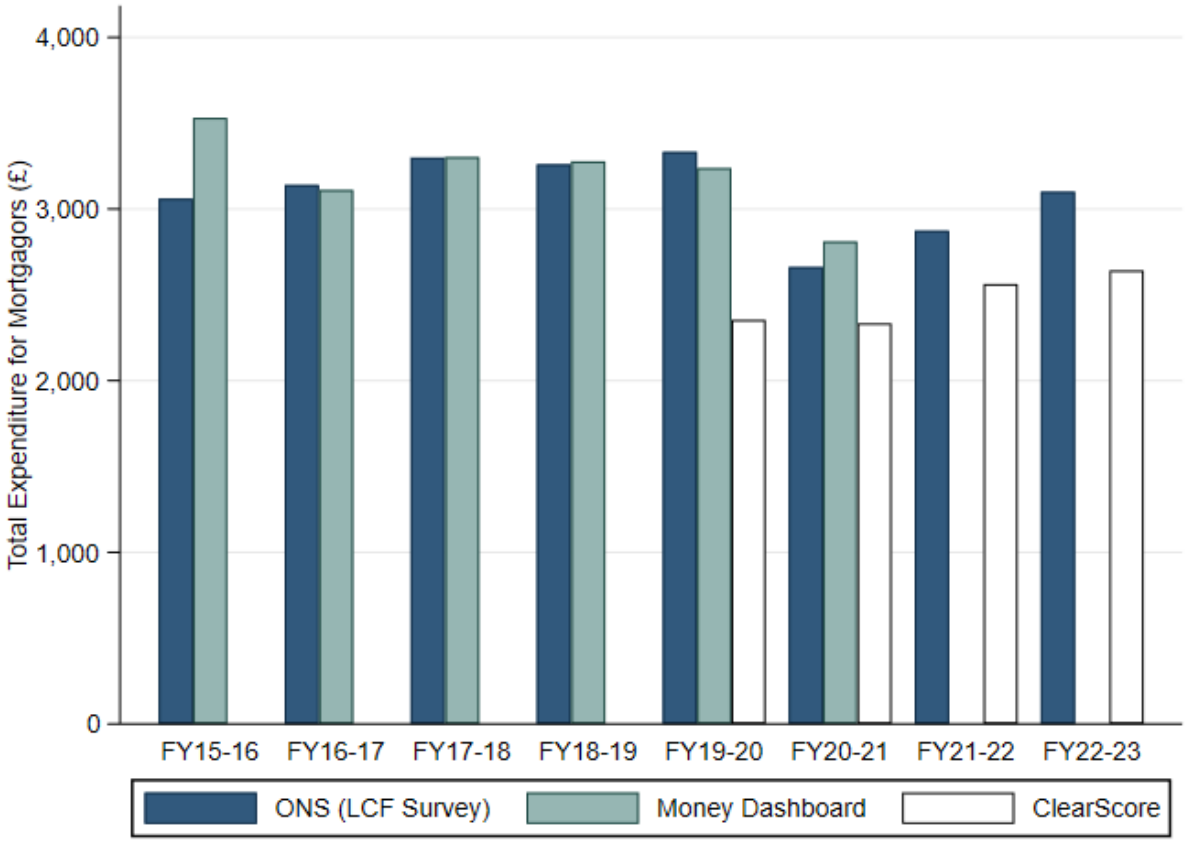



**Figure B.1:** Monthly Average Spending in Apps vs. Official Data

*Notes*: The figure shows the monthly average household total expenditure for mortgagors for the ONS (LCF survey), Money Dashboard and ClearScore from 2015 to 2023. The ONS average values are produced by the Office for National Statistics based on the Living Costs and Food Survey. We use our total consumption measure to calculate the average values for the Money Dashboard and ClearScore apps.

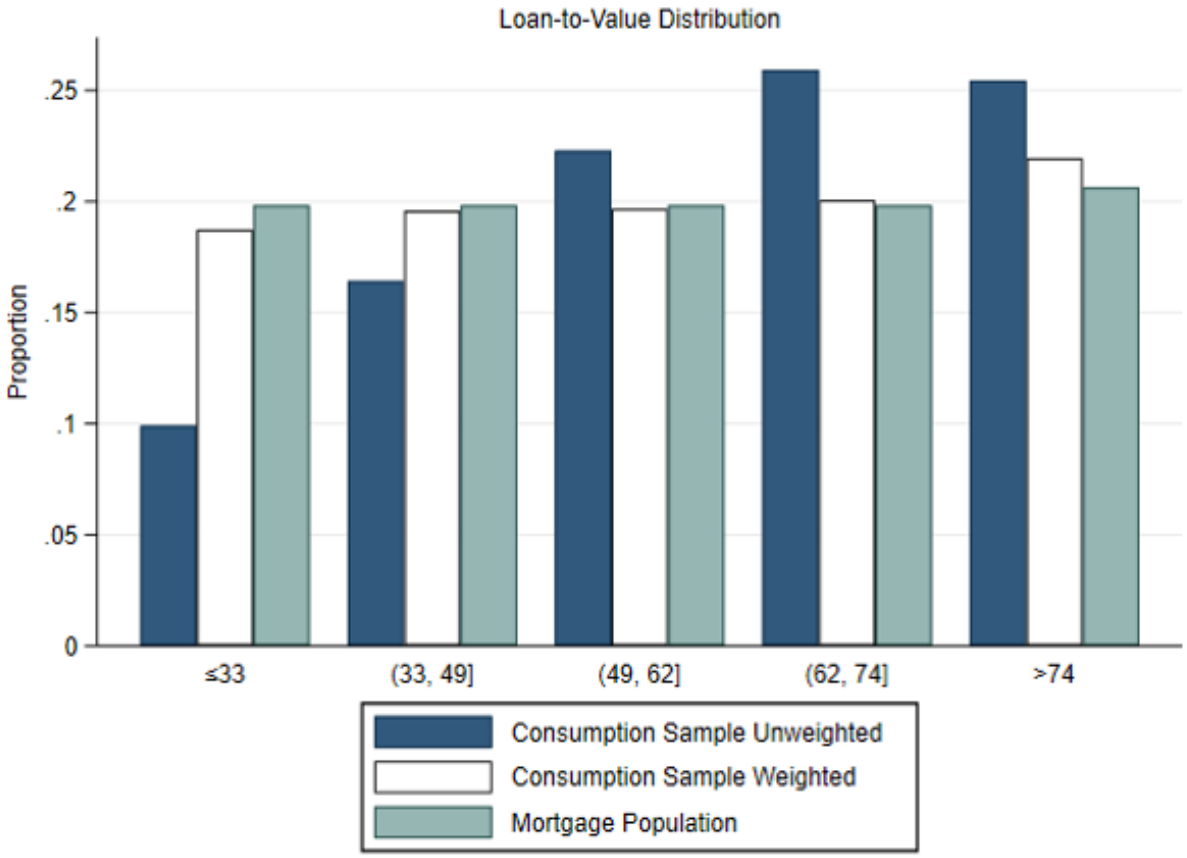



**Figure B.2:** Loan to Value Distribution in Consumption Sample vs. Full Mortgage Sample

*Notes*: The figure shows loan to value distribution across various samples.

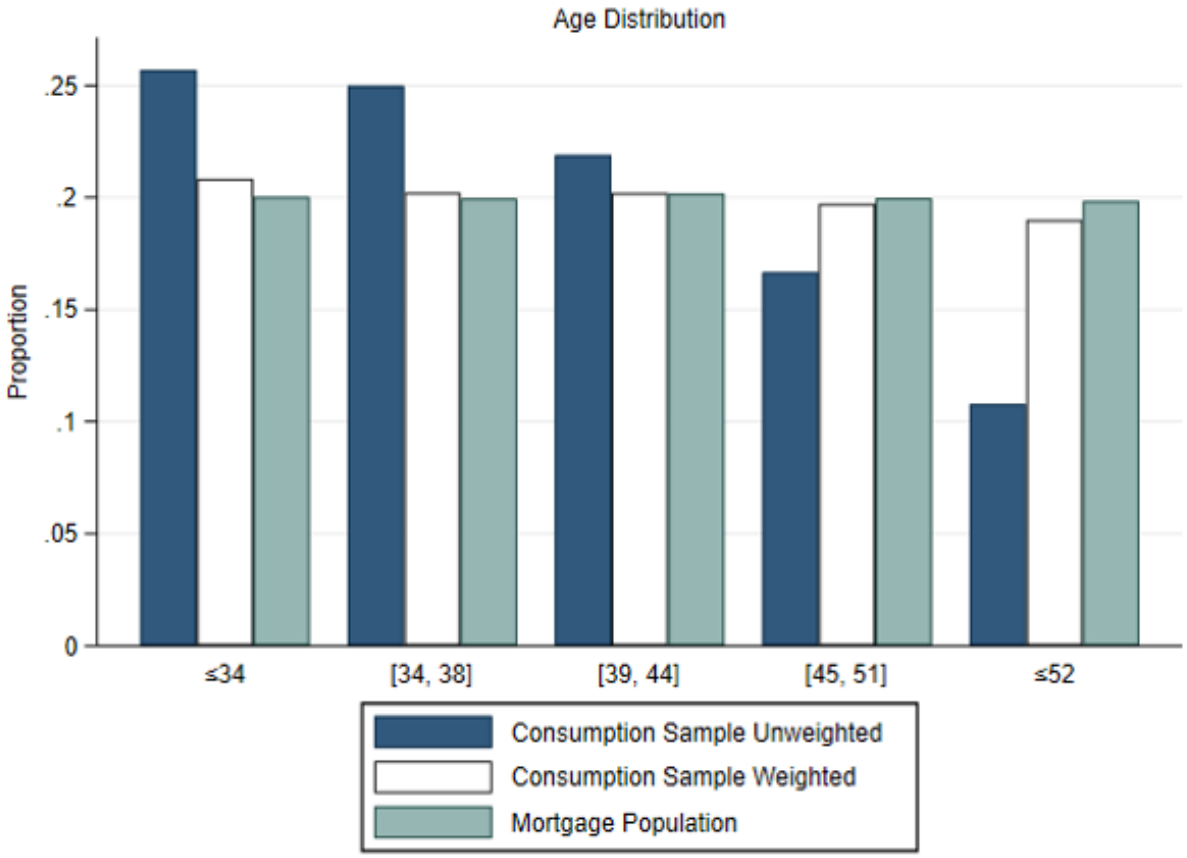



**Figure B.3:** Borrower Age Distribution in Consumption Sample vs. Full Mortgage Sample

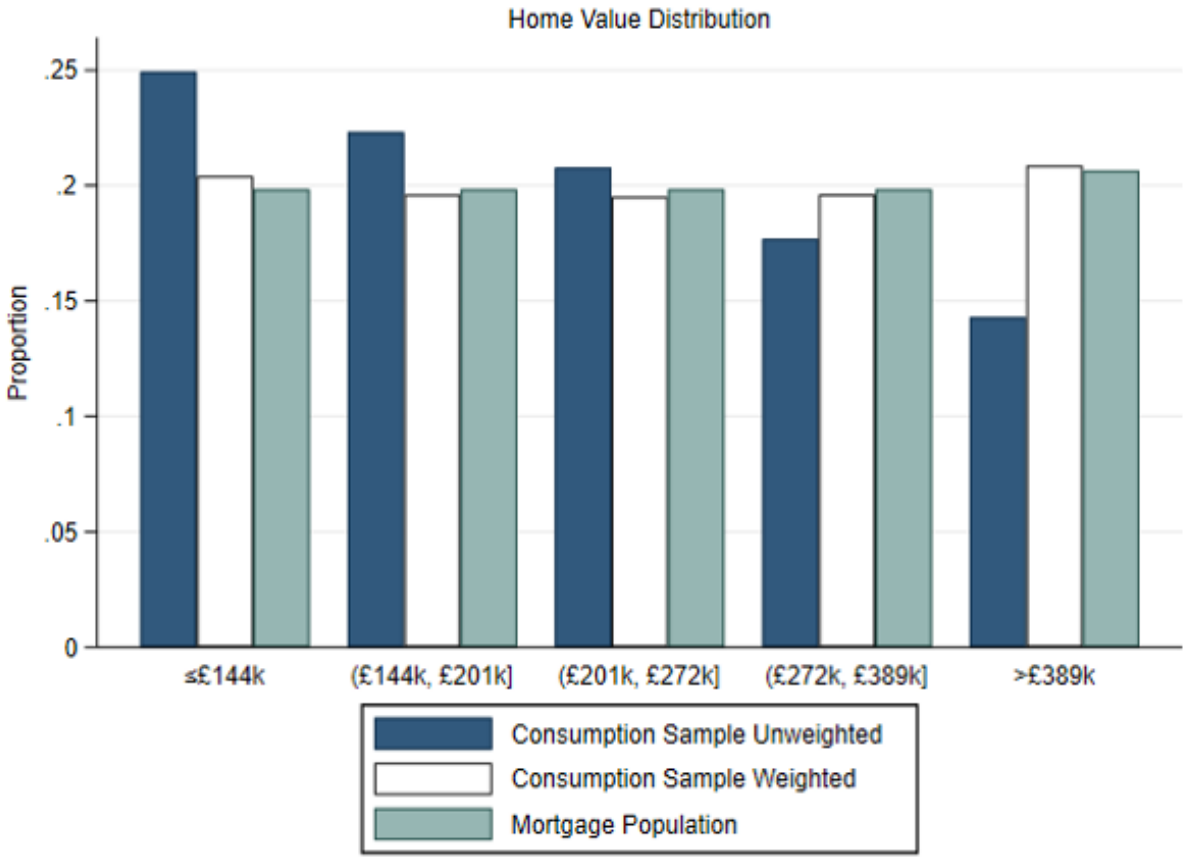



**Figure B.4:** Home Value Distribution in Consumption Sample vs. Full Mortgage Sample

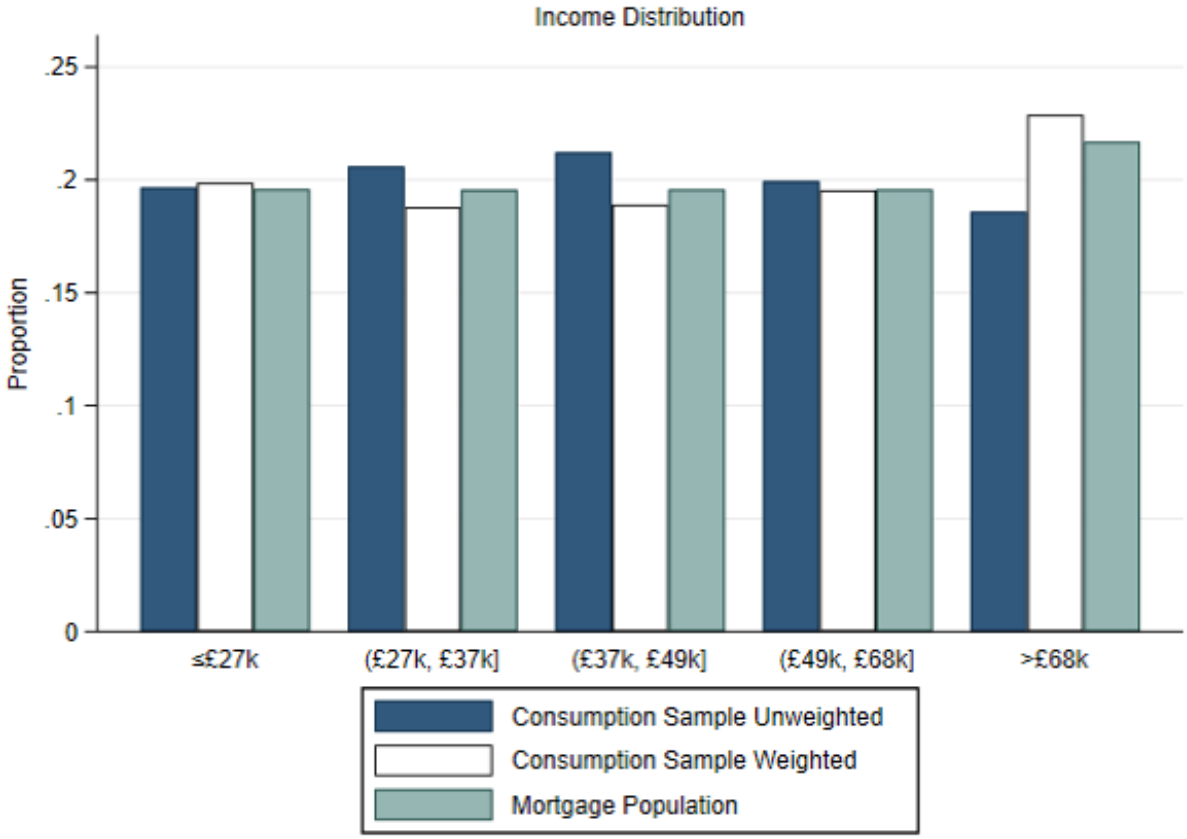



**Figure B.5:** Income Distribution in Consumption Sample vs. Full Mortgage Sample

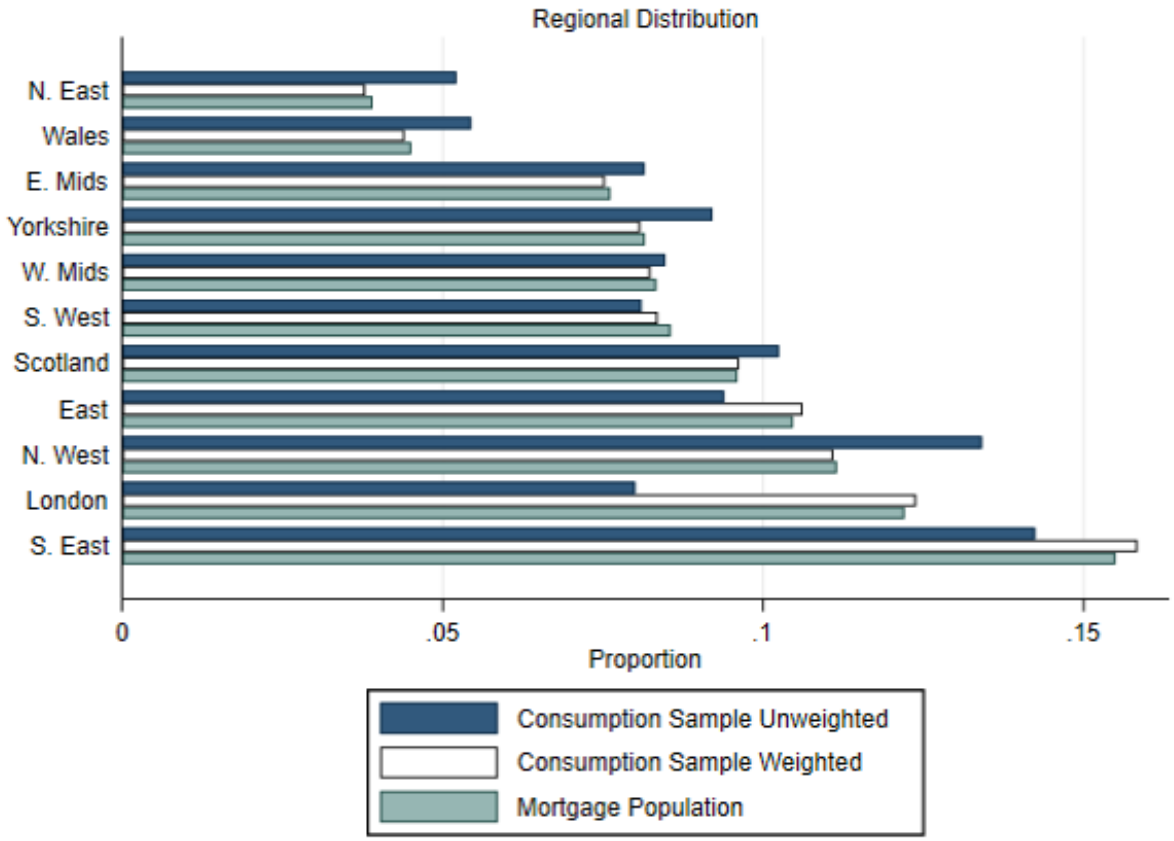



**Figure B.6:** Regional Distribution in Consumption Sample vs. Full Mortgage Sample

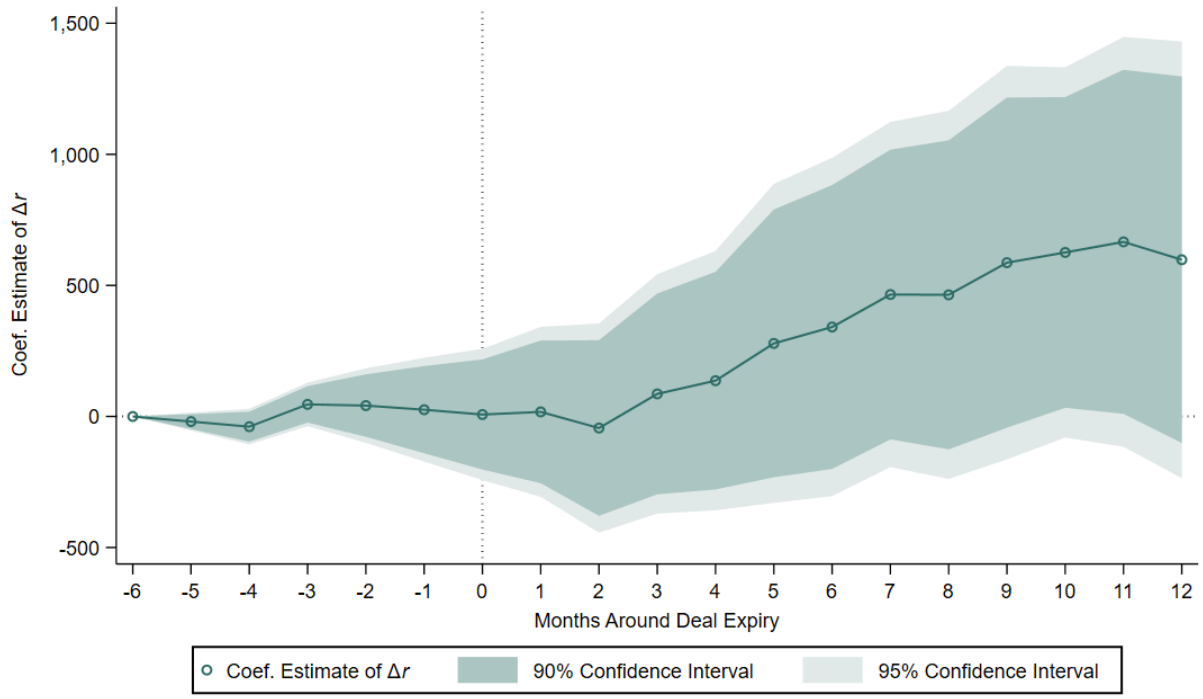



**Figure B.7:** Impulse Response of Wages

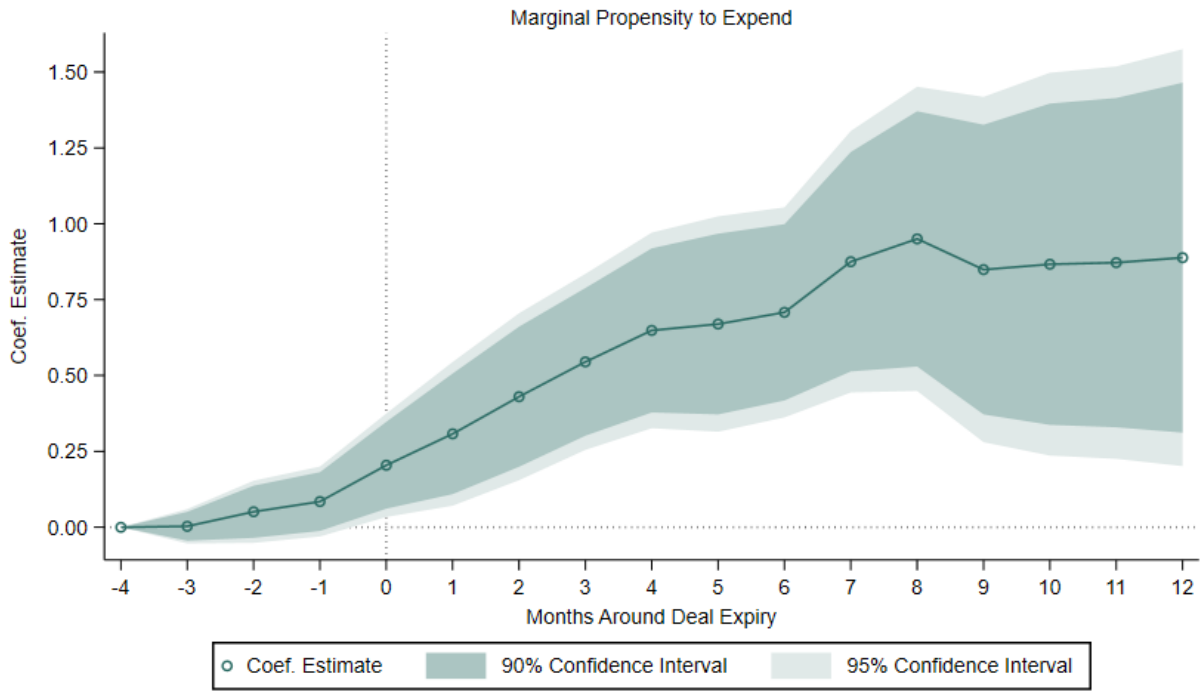



**Figure B.8:** Marginal Propensity to Expend out of Cash on Hand