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# Borrowing and Spending in the Money: Debt Substitution and the Cash-out Refinance Channel of Monetary Policy*

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**Abstract**

We show that the strong negative effect of higher mortgage rates on cash-out refinancing reflects substitution into other borrowing products, not large changes in total new household borrowing. We exploit an exogenous increase in long-term rates to show that, in the cross-section of outstanding mortgage rates, changes in cash-out and alternative borrowing are offsetting. Additionally, we instrument using monetary policy surprises to show that, over the period from 2006-2021, changes in cash-out refinancing are offset by alternative borrowing. Our results suggest that debt substitution substantially weakens the cash-out refinance channel of monetary policy and reduces its path-dependence.

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# 1 Introduction

How do mortgage rates influence economic activity? A potentially important channel occurs through cash-out refinancing and household consumption. Most households' wealth lies in their homes, and mortgage rates affect the cost of extracting equity through a cash-out refinance. A household typically extracts tens of thousands of dollars of home equity when using a cash-out refinance, and the marginal propensity to consume (MPC) out of extracted home equity is often presumed to be high.

Empirically, cash-out refinancing is highest for borrowers whose outstanding mortgage rate is above the current market rate ("in-the-money" borrowers) ((Berger et al., 2021) and (Eichenbaum, Rebelo and Wong, 2022)). Refinancing generates interest savings on these borrowers' existing fixed-rate mortgages. But why are in-the-money borrowers more likely to borrow against home equity? One theory is that the savings from reducing the rate on the existing mortgage also increases the incentive for a cash-out refinance. This could be because borrowers want to extract and spend the wealth created by their lifetime interest savings from refinancing, or because the interest savings from the rate refinance lowers the marginal cost of borrowing against accumulated home equity to spend. Under these assumptions, in-the-money households have higher demand for borrowing and spending out of home equity and cash-out refinancing can be a strong transmission channel for monetary policy.

In this paper, we test a different interpretation of the empirical facts. Increases in the incentive to refinance could prompt substitution across household borrowing products rather than stimulate new borrowing and spending. Borrowers may use cash-out refinances to satisfy an exogenous liquidity need – for example, to smooth consumption through a negative income shock[1] – and so may shift new borrowing from home equity loans or consumer loans towards cash-out refinancing as mortgage rates go down, particularly when the mortgage rate falls below the borrower's outstanding mortgage rate. We find that this substitution

[1] See, for example, Hurst and Stafford (2004); Chen, Michaux and Roussanov (2020); Gupta et al. (2018); Agarwal and Qian (2017)

is quantitatively important and substantially weakens cash-out refinancing as a monetary policy transmission channel.

Using a large dataset of credit bureau records matched to mortgage servicing data, we first estimate the elasticity of cash-out borrowing to 30-year fixed mortgage rates and how this elasticity varies with households' outstanding fixed mortgage rate (the focus of previous literature). Extending the literature, we estimate the elasticity of *alternative borrowing* (i.e. through credit cards, personal loans, HELOCs, and second liens), and how this elasticity varies with households' outstanding fixed mortgage rate. We evaluate cash-out and alternative borrowing elasticities on both the extensive margin (i.e. the probability of new borrowing) and the intensive margin (i.e. quantity of new borrowing).

Consistent with the existing literature, we find that the probability of cash-out refinancing responds negatively to mortgage rate increases and that this response is strongest for borrowers who are on the margin of being in-the-money to refinance. We find that borrowing through alternative products responds positively to mortgage rates, and that the response is also strongest for borrowers on the margin of being in-the-money. This pattern of alternative borrowing, nearly a mirror image of the cash-out response, is consistent with strong substitution between cash-out refinancing and other borrowing products.

We also find that the amount borrowed conditional on a cash-out refinance is positively related to mortgage rates. A positive intensive and negative extensive margin response for cash-out refinancing suggests a borrower selection effect in which borrowers with small liquidity needs substitute away from cash-out refinancing when mortgage rates rise - a dynamic consistent with households choosing the least-cost form of borrowing given the size of their liquidity need. Combining all types of borrowing and accounting for both intensive and extensive margin responses, we find that a 1 percentage point increase in mortgage rates reduces total new household borrowing by between 0 and 8% and that total borrowing elasticity varies little with the borrower's outstanding mortgage rate.

A clear empirical challenge is that mortgage rates and borrower refinance incentives are endogenous to economic conditions, which also drive borrowing. To address the endogeneity of rates and economic conditions, we use two approaches. Our main empirical specification exploits a monetary policy surprise in 2013, which had a large, sustained, and plausibly exogenous effect on mortgage rates – the "Taper Tantrum." This discrete event allows us to compare cash-out and alternative borrowing in the cross-section of outstanding mortgage rates before and after the rate increase, and to establish that the alternative borrowing response is largest among the households with the largest change in refinance incentives, strongly suggestive of substitution.

Only long-term interest rates were affected by the Taper Tantrum, whereas standard monetary policy generally influences rates across the yield curve.[2] Substitution patterns could be different in standard monetary policy episodes, given that borrowing rates on alternative loan products tend to follow the short-end of the yield curve. Estimates derived from the Taper Tantrum episode are therefore most directly relevant for unconventional monetary policy.[3]

To investigate whether our findings hold when monetary policy triggers movements in rates across the yield curve, we rely on longer-term time-series variation in the aggregate share of borrowers in-the-money to refinance. Following Berger et al. (2021), we instrument the for the share of borrowers with positive refinance incentives using a sample of conventional and unconventional monetary policy surprises spanning 2006-2021. Although this approach does not allow us to see the cross-sectional pattern of substitution by individual refinance incentive, as in the Taper Tantrum, our results are broadly similar. Over this long time period, cash-out and alternative borrowing responses to unexpected interest rate changes are offsetting in the aggregate, along both the intensive and extensive margins.

Because interest rates directly affect house prices, the monetary policy surprises that

[2]The Taper Tantrum was driven by a surprise announcement that the Federal Reserve would begin to wind down its large-scale asset purchase (LSAP) of long-term treasury securities and mortgage-backed securities (MBS).

[3]Unconventional monetary policy tools are increasingly relevant, as LSAPs are likely a permanent component of the Fed's emergency toolkit. For example, LSAPs were a major part of the Fed's response to the 2020 Coronavirus pandemic.

affected refinance incentives in our analysis could also have affected housing wealth and, by extension, incentives for home equity extraction.[4] Like much of the existing empirical literature on the refinancing channel of monetary policy, our elasticity estimates abstract from this effect by controlling for mark-to-market LTV. Any wealth effect should not depend on the distribution of outstanding mortgage rates but could affect the level of borrowing.

Our results have implications for the path dependence of monetary policy. If the same monetary policy stimulates different borrowing responses depending on a borrowers' outstanding mortgage rate, then the refinancing channel of monetary policy could depend on the distribution of outstanding mortgage rates, which reflects the previous path of monetary policy. Our findings suggest the path dependence of the cash-out refinancing channel is largely offset by out-of-the-money borrowers substituting to other loan products that leave the original mortgage rate in place. Although rate-term refinancing can generate a path-dependent response that is unlikely to be attenuated by substitution, we show using a back of the envelope calculation that cash-out refinancing has the potential to stimulate far more near-term consumption than rate-term refinancing. Because cash-out refinancing is the most important of the refinancing channels of monetary policy, and because we find the path dependence of cash-out refinancing is offset by borrower substitution, we conclude that the path dependence of overall monetary policy is weaker than suggested by previous research (Berger et al. (2021), Eichenbaum, Rebelo and Wong (2022)).

## 1.1 Related Literature

Our paper contributes to the literature on the refinancing channel of monetary policy.[5] Amromin, Bhutta and Keys (2020) provide a review of the literature showing that both conventional and unconventional monetary policy have substantive direct effects on mortgage rates – the first step of the transmission of monetary policy through the refinancing channel.

[4] See Aladangady (2017); Berger et al. (2018); Greenwald (2018); Mian, Rao and Sufi (2013); DeFusco (2018); Gorea, Kryvtsov and Kudlyak (2022).

[5] Other recent, related work on refinancing includes DeFusco and Mondragon (2020); Keys, Pope and Pope (2016); Andersen et al. (2020); Johnson, Meier and Toubia (2019).

Related to the subsequent steps of monetary policy transmission, several empirical papers show that declines in monthly mortgage payments due to lower interest rates stimulate borrower consumption (Abel and Fuster (2021); Di Maggio et al. (2017); Agarwal et al. (2023)). Measures of consumption that can be linked to mortgage data are limited, however, with much of the evidence on consumption coming from proxies for car purchases (McCully, Pence and Vine (2019)). In addition, the data do not allow these papers to measure the potentially offsetting declines in spending from mortgage lenders or mortgage investors who receive lower mortgage payments. As a result, the effect of lower mortgage payments from refinancing on aggregate demand remains somewhat an open question. In fact, in Greenwald (2018) and Beraja et al. (2019) where the lender side is modeled, rate-term refinancing contributes little to monetary policy transmission, especially in a closed economy. In contrast, cash-out refinancing is key for transmission because it involves large, newly issued credit that can be spent by borrowers immediately upon receipt whereas lenders smooth consumption using the income they receive from future repayment of this credit. Cash-out refinancing also plays a key role in monetary policy pass-through in Wong et al. (2019).

In the empirical literature related to cash-out refinancing and monetary policy, Di Maggio, Kermani and Palmer (2020) and Beraja et al. (2019) show that mortgage rate declines increased cash-out refinancing and durable goods spending during QE. Beraja et al. (2019) emphasizes the heterogeneity of the response with respect to household leverage. Bhutta and Keys (2016) ("BK") estimate a strong effect of rate declines on home equity extraction during the 2003 housing boom and show that house prices amplify this relationship. We relate our estimates to BK in Section 6.2 and Appendix Section A.0.3.

BK also study how borrowers use extracted equity to pay down other debt. They find that about 6% of extracted equity goes towards debt paydown. Using event studies, we find a similar result: about 10% of the increase in new mortgage debt from cash-out refinances is used to pay down other outstanding debt. We further find that the share of the cash-out amount used for debt paydown does not vary with mortgage rates.

Our work is closely related to Eichenbaum, Rebelo and Wong (2022) and Berger et al. (2021) on the path- and state-dependency of monetary policy through the mortgage refinance channel. Eichenbaum, Rebelo and Wong (2022) focus on cash-out refinancing, which is our focus in this paper. In their model, many borrowers have little liquid savings but plenty of home equity, as in Kaplan and Violante (2014). Borrowers do not extract home equity to alleviate their short-term constraints and smooth consumption, because refinancing involves transaction costs and increases the mortgage rate on the existing mortgage balance, creating a large fixed cost. Mortgages are the only type of borrowing allowed in the model, precluding substitution across borrowing products. A monetary policy shock that pushes mortgage rates below a borrower's outstanding mortgage rate creates a financial incentive to refinance, allowing constrained borrowers to also extract home equity when refinancing without incurring additional transaction costs. Their calibrated model predicts that cash-out refinances generate large, path dependent consumption responses in the aggregate. Very little of the consumption response to mortgage rate changes in their model comes from changes in house prices. The effects of mortgage rates on the refinance incentive, which is the focus of our paper, is the dominant channel for the consumption response.[6]

Overall, Eichenbaum, Rebelo and Wong (2022) and Berger et al. (2021) conclude that the refinancing channel is weak in recessions that follow a period of low mortgage rates. Our results suggest that substitution is an additional factor that weakens the refinancing channel, even during recessions that follow a period of higher mortgage rates.

# 2 Data & Summary Statistics

We use the Equifax Credit Risk Insight Servicing McDash (CRISM) dataset, which anonymously matches credit bureau records on consumers' credit histories to mortgage servicing records from McDash.[7] This dataset allows us to measure the main inputs to our analysis,

[6]In the model of Berger et al. (2021), house prices are exogenous and so the housing wealth channel plays no role.

[7]No personally identifiable information is available in this dataset.

including equity extraction via a cash-out refinance, the borrower-specific refinance incentive, alternate forms of equity extraction, and alternative forms of non-mortgage borrowing. For our main results, we draw a 16.5% sample of fixed-rate, first-lien mortgage loans from CRISM in 2013. We observe the details of each mortgage loan, and the full credit report of the mortgage borrower, at a monthly frequency until the mortgage is paid off. The Data Appendix describes how we identify the reason for a mortgage's prepayment, i.e. rate-term refinance, cash-out refinance, or move.

For each mortgage borrower in our data, we follow Berger et al. (2021) and measure the borrower's refinance incentive using the "rate gap," the borrower's outstanding mortgage rate minus an estimate of the 30-year fixed mortgage rate available to the borrower if he were to refinance. This measure of the refinance incentive allows us to explicitly capture the dependence of borrowing and refinancing decisions on the outstanding mortgage rate.[8] We estimate the borrower's available market rate in a given month based on a sample of mortgage originations from McDash. We set the borrower's market rate equal to the predicted value from a regression of mortgage rates on a quadratic function of the borrower's LTV and original credit score[9], an interaction of original credit score and LTV, indicators for loan type and investor type, and month fixed effects.

We define borrowing events on five credit instruments: cash-out refinance, home-equity line of credit (HELOC), closed-end second loan (CES, often referred to as home equity loan), credit card, and personal loan. We require a borrowing event to involve at least $5,000 in new credit. For revolving credit products like HELOCs or credit cards, we allow extraction to occur at origination or also following origination. To distinguish credit card borrowing from spending, we define credit card borrowing as a sustained increase of at least $5,000 on the borrower's credit card balance. To limit measurement error arising from revolving balances gradually ramping up, we do not separately count consecutive borrowing events.

[8] In practice, the borrower's refinance incentive depends on other variables (Agarwal, Driscoll and Laibson (2013)). Two important ones are the outstanding mortgage balance and the term of the loan, which we control for in all of our specifications.

[9] FICO at origination, as provided by McDash.

The Data Appendix provides further details.

We apply several filters to the data. First, we drop mortgages linked to borrowers with multiple first liens, because we cannot assign a unique refinance incentive to the household. For similar reasons, we also drop loans financing non-owner occupied properties, because the credit report does not allow us to distinguish mortgage originations (such as HELOCs, CES, or refinances) on the property in the CRISM universe from originations on another property owned by the borrower. We also restrict to fixed-rate mortgages, as in Berger et al. (2021), because the dependence of the refinancing decision on the borrower's outstanding mortgage rate is likely to be strongest for fixed-rate mortgages. In the Appendix, we show that our results are little changed the sample includes adjustable-rate mortgages, which constitute about 10% of outstanding mortgages in 2013. After applying these filters, we have a monthly panel of loans in 2013 corresponding to approximately 35 million loan-month observations.

Table I reports summary statistics. Borrowing events are rare, as the monthly probability of any sort of new borrowing at all is less than 1%. Consumer borrowing events, (i.e., credit cards and personal loans), are more common than home equity borrowing events, (i.e., CES, HELOC, or cash-out refinances). However, conditional on a borrowing event, households borrow much more when they use home equity borrowing than when they use consumer credit. Borrowers using cash-out refinances have the highest outstanding mortgage rates and HELOC borrowers have the lowest outstanding mortgage rates, consistent with households extracting via a cash-out refinance in part to reset a high original mortgage rate and with households extracting via a HELOC when they prefer to keep their original mortgage rate intact. HELOC borrowers have the highest credit scores which may reflect tighter credit standards in the wake of the housing crisis, although there still may be a role for differential demand for HELOC borrowing across credit score groups. Home equity borrowers have lower LTVs than consumer credit borrowers, consistent with binding collateral constraints.

# 3 Motivating Empirical Patterns

We first establish basic qualitative borrowing patterns using the full sample of data. We estimate the correlation between a borrower's refinance incentive and household borrowing and refinancing. Our preferred estimates in Section 5 address the endogeneity of the borrower's refinance incentive using a monetary policy surprise from 2013. Our well-identified estimates differ somewhat from the ones we show here, but the qualitative patterns that we highlight in this section are the same.

We first focus on the extensive margin of borrowing. We consider a borrower's choice each month to do a cash-out refinance, a rate-term refinance, an other borrowing event, or none of the three. Table I provides a list of the four types of borrowing events that we consider other borrowing.

We group rate gap into 25 basis point bins and estimate a non-parametric relationship between borrowing and rate gap using a multinomial logit model. A higher rate gap implies that the incentive to refinance is higher. The probability borrower $i$ chooses outcome $j$ in month $t$ is modeled as

$$\sigma_{i,t}^{j} = \frac{exp(v_{i,t}^{j})}{exp(v_{i,t}^{none}) + exp(v_{i,t}^{cash}) + exp(v_{i,t}^{rate}) + exp(v_{i,t}^{other})} \tag{1}$$

where $j$ denotes cash-out refinance ("cash"), rate refinance ("rate"), other borrowing event ("other"), or no action ("none") and $v^j$ denotes the utility of each option, represented as

$$v_{i,t}^{j} + \epsilon_{i,t} = \beta_g^j I(RateGapBin)_{i,t} + \beta_X^j X_{i,t} + \epsilon_{i,t} \tag{2}$$

$\mathbb{I}(RateGapBin)_{i,t}$ is a dummy for the rate gap bin of borrower i in month t. $X_{i,t}$ includes controls for various borrower characteristics, such as credit score and mark-to-market LTV, loan characteristics, as well as year and origination year fixed effects. The full set of controls are listed in the notes to Figure 1. Throughout the paper, we use a two-month lag of the credit score so that the credit score is not affected by the borrowing event. $\epsilon$ is an idiosyncratic, type-1 extreme value term.

Equations 1 and 2 show that the utility of each option, $v^j$, depends on the same set of variables, and the coefficients on those variables are allowed to vary by j. We normalize the utility of no action, $v^{none}$, to zero.

Figure 1 plots marginal effects for each bin of rate gap. Consistent with the findings in Berger et al. (2021), the propensity to cash-out refinance is generally increasing in rate gap, and nonlinear with a "step-like" pattern. The slope is fairly flat for borrowers with negative rate gaps, and is steepest for borrowers with slightly positive values of rate gap. These borrowers are on the margin of being in-the-money for a rate-term refinance after accounting for the fixed costs of refinancing. The slope flattens out again and even turns negative at high values of rate gap, though our main results reported in section 5 show that once we address the endogeneity of the rate gap, cash-out refinancing is everywhere at least weakly increasing.[10]

The non-linearity in the Figure 1 implies that the effect of a decrease in mortgage rates on cash-out activity depends on the distribution of rate gaps across borrowers. This non-linearity generates the path- and state-dependency of monetary policy in the models of Berger et al. (2021); Eichenbaum, Rebelo and Wong (2022).

A new result relative to the existing literature is that other borrowing, however, has almost the opposite relationship with rate gap. For negative rate gaps, the probability of other borrowing is slightly decreasing in rate gap, whereas the probability of a cash-out refinance is slightly increasing. As rate gap turns positive, the slope for other borrowing with respect to rate gap becomes more negative exactly as the slope for cash-out refinancing becomes more positive. These patterns are suggestive of substitution between cash-out refinancing and other borrowing.[11]

[10]In the model of Berger et al. (2021), the flattening out of the refinance hazard at high rate gaps is explained by borrower inattention.

[11]Appendix Figure A.3 provides further evidence of substitution in the aggregate data. It shows that cash-out refinancing and HELOC borrowing are inversely related over time and borrowing levels for the two

Turning to rate-term refinances, Figure 1 shows that rate-term refinances have the same increasing and non-linear pattern with respect to rate gap as cash-out refinances, but the sensitivity to rate gap is about two times as large for rate refinances.

Finally, Figure 2 plots results on the intensive margin of cash-out refinancing. The figure shows that the average amount of equity extracted conditional on a cash-out refinance varies significantly over time. For example, the average cash-out refinancing borrower in 2006 extracted almost twice as much equity (in dollars) as the average cash-out refinancing borrower in 2013. In addition, the figure shows that the average amount extracted is strongly negatively correlated with the borrowers' refinance incentive, measured in this figure as the share of cash-out refinancing borrowers with rate gaps between 0 and 2. This negative correlation is consistent with a borrower selection effect in which borrowers with small liquidity needs substitute away from cash-out refinancing when higher mortgage rates push them out of the money for a refinance.

## 4 Conceptual Framework

Figure 1 shows that cash-out refinancing varies non-linearly by rate gap. A possible implication of this fact is that total borrowing and spending also vary non-linearly by rategap. This could happen if mortgages are the only borrowing product available and households have little liquid savings but substantial accumulated home equity and want to borrow to smooth consumption. Households can only overcome the fixed costs associated with cash-out refinancing to borrow against home equity when their existing mortgage rate falls above the market mortgage rate and refinancing generates positive interest savings. Households will be unable to borrow and spend when the mortgage rate falls above their existing mortgage rate. Under these assumptions, total borrowing and spending will vary non-linearly by rate gap just as cash-out refinancing does.

products shift in opposite directions following large changes in the mortgage rate, such as during QE1 and the Taper Tantrum.

In this section, we describe a simple alternative theory in which cash-out refinancing varies non-linearly by rate gap but total borrowing and spending do not.

We model a homeowner's optimal choice of which borrowing product to use to satisfy an inelastic liquidity need of $l$ dollars that arrives with probability $\lambda$. For example, the borrower may urgently need a housing repair or experience a negative health shock. The borrower's outstanding mortgage rate is $r^0$ and we normalize the outstanding mortgage balance, $b$, to \$1. There are two borrowing products available: a cash-out refinance and an alternative borrowing product (e.g. a HELOC or personal loan) available at interest rates of $r^m$ and $r^a$, respectively. We assume $r^m < r^a$ because mortgage rates are typically lower than alternative borrowing rates. However, cash-out refinancing tends to be associated with fixed costs, which we denote as $F$. $r^0 - r^m$ is the borrower's rate gap. It measures the interest savings or penalty associated with the borrower's existing mortgage from refinancing.

The utility of borrowing through each product is

$$v^{cash} = -F - r^m(1 + l) - \sigma\epsilon \tag{3}$$

$$v^{alt} = -r^0 - r^a l \tag{4}$$

where $\epsilon \sim N(0, 1)$ is an idiosyncratic factor shifting relative demand for cash-out refinancing and the alternative product across borrowers. For example, $\epsilon$ could reflect heterogeneity in fixed costs, $F$, across borrowers. The important difference between the two borrowing products is that in a cash-out refinance, the borrowing rate on the outstanding mortgage automatically becomes the borrowing rate on the new borrowing amount, $r^m$. For the alternative borrowing product, $r^a$ has no bearing on the interest cost associated with the existing mortgage. The key tradeoff highlighted by the model is that cash-out refinancing always brings a lower interest expense on the liquidity need relative to the alternative borrowing product, but it brings a higher interest expense on the existing mortgage when the rategap is negative.

The probability of a cash-out refinance is

$$p^{cash} = \lambda\Phi(\frac{r^O - (r^m + F) + l(r^a - r^m)}{\sigma}) \tag{5}$$

where $\Phi$ is the standard normal cdf. $p^{cash}$ is decreasing in $r^m$ and increasing in $r^0$, $r^a$, $l$. The Appendix describes the details of simulations of the model that illustrate how $\partial p^{cash}/\partial r^m$ varies with a borrower's rate gap. To summarize, the simulations show that $p^{cash}$ is nonlinear with respect to the rate gap, as in Figure 1. But the probability of borrowing through the alternative borrowing product has the opposite pattern because of substitution. The model simulations imply that when borrowers are in-the-money to refinance, they generally satisfy their liquidity need using a cash-out refinance. When borrowers are not in-the-money, they generally satisfy their liquidity need via the alternative borrowing product even though $r^a > r^m$ because the alternative borrowing product keeps the existing mortgage rate intact.

To understand how the intensive margin of borrowing varies with a borrower's refinance incentive, we extend the model to consider heterogeneity across borrowers in their liquidity need $l$. The value of $l$ is an important parameter, because for borrowers who are not in-the-money to refinance, the implicit rate on new borrowing via a cash-out refinance (i.e. the total new interest costs divided by $l$) depends on the size of $l$ relative to the size of the existing mortgage $b$ (normalized to 1 in our case). Low values of $l$ imply higher effective interest rates. The implied borrowing rate on $l$ converges with $r^m$ as $l/b$ approaches infinity (e.g., the borrower takes out a new mortgage on an unmortgaged property).

The Appendix reports details of simulations of the intensive margin. To summarize, $E[l|v^{cash} > v^{alt}]$ increases after the rise in mortgage rates, consistent with the data shown in Figure 2. The increase is due to borrower selection, as $E[l]$ is fixed and does not vary with mortgage rates. The amount of the increase depends on rate gap. $E[l|v^{cash} > v^{alt}]$ rises the most for borrowers who are pushed out of the money by the rise in mortgage rates or who were already out of the money before the rise in mortgage rates. When $r^m$ rises, out of the money borrowers with low $l$ are relatively more likely to substitute into the alternative borrowing product, driving up $E[l|v^{cash} > v^{alt}]$. However, in the money borrowers are relatively less likely to substitute because their implicit borrowing cost on a cash-out refinance is less sensitive to $r^m$.

In the model, the intensive and extensive margin of the cash-out refinance response to changes in mortgage rates have the opposite sign. This result arises because borrowers with high liquidity needs face the lowest effective rate on their new borrowing, and are least likely to substitute to other products. This result is inconsistent with some alternative models where mortgages are the only form of borrowing permitted and therefore demand for household borrowing is sensitive to the mortgage rate.[12] We will show that a positive intensive margin elasticity and a negative extensive margin elasticity is a robust feature of the data, consistent with our model simulations that highlight the role of debt substitution.

Our model assumes an exogenous $l$ but in practice $l$ could depend on mortgage rates. In this case, we might expect borrowing to vary negatively with rates but less strongly than when mortgages are the only type of borrowing available. Consistent with this intuition, we do find a negative relationship between borrowing amounts and mortgage rates in some specifications, as described in Section 5.4.

# 5 Effect of Refinance Incentive on Borrowing

## 5.1 Endogeneity of rate gap and the Taper Tantrum

An important issue that arises in the estimation of equation 1 is that a borrower's rate gap may be endogenous. For example, in the time series, negative economic news could decrease market interest rates, which would increase all borrowers' rate gaps while also decreasing unobserved borrower income or assets, increasing the need for equity extraction. In the cross section, a borrower's rate gap could also be high because of a high outstanding mortgage rate

[12] In the model simulations of Eichenbaum, Rebelo and Wong (2022), the elasticity of the extensive and intensive margin of cash-out refinancing with respect to changes in mortgage rates have the same sign.

related to borrower unobservables, creating endogeneity if these unobservables are associated with the propensity to refinance.

For exogenous variation in the refinance incentive, we exploit a monetary policy surprise in 2013, dubbed the "Taper Tantrum." During the financial crisis, the Federal Reserve committed to buying long-term Treasuries and MBS to keep long-term interest rates low. In late spring of 2013, Figure 3 (a) shows that the 30-year fixed mortgage rate increased from its very low level by 80 basis points over the course of just one month. Mortgage rates and other long-term interest rates increased because market participants believed that a tapering of the Fed's bond purchases would occur sooner than previously expected. Two FOMC communication events highlighted in the Figure triggered the shift in expectations and the increase in rates, with much of the 80 basis point increase in mortgage rates occurring discretely after these two events.[13]

Figure 3 (b) shows changes in the broader interest rate environment in 2013. Because the Taper Tantrum shifted expectations about long-term interest rates, the 10-year treasury and household interest rates tied to the long end of the yield curve, such as the 30-year mortgage rate and the CES rate, increased substantially. The federal funds and bank prime rates were unchanged and so household interest rates tied to these rates, such as consumer credit and HELOC interest rates, were little changed. Average interest rates in 2013 were 3.88% for mortgages, 4.67% for HELOCs, 5.92% for CES, 10.2% for personal loans, and 11.9% for credit cards. The spreads between the different borrowing products in 2013 are fairly typical relative to historical standards.

The Taper Tantrum provides a large, sustained, and plausibly exogenous increase in mortgage rates, allowing us to compare household borrowing over a number of months with

[13] The FOMC did not announce any concrete change in policy over this time period and were arguably not expecting such a large shift in market expectations in response to their communications, limiting the scope for any "Fed information effect" to influence our results (Nakamura and Steinsson (2018)). In his memoir, Ben Bernanke reflects on the market's response to his communication: "The response puzzled me: I had anticipated that talking about slowing purchases would induce some reaction, but I had also thought that the plan I laid out was close to market expectations, which should have limited the response." (Bernanke (2015))

starkly different mortgage rate regimes. The ability to compare borrowing by rate gap over a number of months allows us to examine the cross-section of the response to changes in mortgage rates, to show within narrow rate-gap bins, declines in cash-out refinances are matched by increases in other types of borrowing. However, the Taper Tantrum did not significantly impact interest rates on other loan products that households may use as substitutes to a cash-out refinance. This feature of the shock means that we estimate the elasticity of household borrowing with respect to the mortgage rate, holding most other interest rates that influence household borrowing fixed - an empirical setting that may not generalize to other types of monetary policy. We address debt substitution under traditional monetary policy in section 7.

## 5.2 Extensive Margin Results

In this section, we estimate the effect of the Taper Tantrum on the extensive margin of borrowing, i.e., the probability that the household will engage in new borrowing through cash-out refinances or other instruments. Our main regression equation exploits the Taper Tantrum as follows:

$$Y_{i,t} = \beta_1 \mathbb{I}(RateGapBin)_i + \beta_2 Post_t + \beta_3 \mathbb{I}(RateGapBin)_i \times Post_t + \beta_4 X_{i,t} + \epsilon_{i,t} \quad (6)$$

where $Y_{i,t}$ is a dummy variable for a borrowing event, $Post_t$ is a dummy if month $t$ is after the Taper Tantrum (July - December 2013), and $\mathbb{I}(RateGapBin)_i$ is a dummy for the rate gap bin of borrower $i$ given average pre-Taper market mortgage rates.[14] Rate gap in equation 6 does not have a time subscript: borrowers with identical characteristics have identical values of rate gap, regardless of the month $t$. By interacting rate gap and $Post_t$, we can estimate how the propensity to borrow changes for borrowers with different ex-ante

[14]The pre-Taper market interest rate facing borrower $i$ is the predicted value from a regression of mortgage rates at origination on a quadratic function of the borrower's ltv and credit score and an interaction effect using data only from January 2013 - June 2013.

refinance incentives when the refinance incentive decreases due to the rise in market mortgage rates during the Taper Tantrum.

$X_{i,t}$ includes a detailed set of controls and fixed effects for borrower and loan characteristics, including time-invariant ones (e.g. property zipcode and vintage year fixed effects) and time-varying ones (e.g. mark-to-market LTV, current credit score, month-county unemployment rate). The note to Figure 4 lists the full set of controls. The time-varying controls address the possibility that the jump in mortgage rates during the Taper Tantrum coincided with changes in other economic variables which separately drive borrowing decisions. For example, the borrower's mark-to-market LTV controls for the effect of changing local house prices on household leverage.[15] The borrower's current credit score controls for any changes in household credit quality.

We estimate equation 6 for different outcome variables using linear probability models (LPMs), clustering standard errors by loan id. We use LPMs instead of the multinomial logit model described in Section 3 to easily work with a larger sample, multiple interaction effects, and a very large number of dummy variables. We discuss the main results using Figure 4 and report the exact estimates in Appendix Table A.1.

The blue line of Figure 4 shows the results of $\beta_2 + \beta_3$ for each rate gap bin when the dependent variable is an indicator for a cash-out refinance. After the 80-bps rise in mortgage rates during the Taper Tantrum, the propensity to cash-out refinance declines for all values of the pre-Taper rate gap. The magnitude of the decline depends importantly on the rate gap, with the largest declines occurring for borrowers with rate gap who are pushed out of the money by the Taper Tantrum. These results are qualitatively consistent with those shown in Figure 1. Figure 4 shows how the probability of refinancing *changes* in response to an increase in mortgage rates by rate gap. The response in Figure 4 is most negative for intermediate values of rate gap, which is the region of rate gap where the slope is steepest

[15] Appendix Figure A.9 shows that national house prices grew at a similar rate in the six months before and after the Taper Tantrum, though house price growth declined slightly over the post period, possibly due to the effects of higher rates. A small house price response to changes in interest rates would be consistent with some recent empirical evidence (Fuster and Zafar (2021)).

in Figure 1.[16]

Borrowers with pre-Taper rate gaps of around 1 percent have a 0.0012 decline in the monthly probability of refinancing after the Taper Tantrum, which is more than an 85 percent decrease relative to the baseline probability of refinancing shown in Table I. A pre-Taper rate gap of 1 percent becomes around 0.2 percent after the Taper Tantrum, and so the Taper Tantrum substantially changes the moneyness of refinancing for these borrowers, considering that fixed costs typically set the moneyness threshold at a little above zero.

Borrowers with pre-Taper rate gaps of around -0.25 percent have a more modest 0.0003 decline in refinance probability. A pre-Taper rate gap of -0.25 percent becomes around -1.05 percent after the Taper Tantrum. Because these borrowers are out of the money before and after the Taper Tantrum, the Taper Tantrum has a much smaller effect on the refinance probability for these borrowers.

The black line of Figure 4 shows the results of a separate regression when $Y_{i,t}$ is a dummy for any type of borrowing event that is not a cash-out refinance, an "other borrowing event." The black line has almost the exact opposite pattern as the blue line. The Taper Tantrum increases the probability of an other borrowing event, and especially for the intermediate values of rate gap. These patterns are strongly suggestive of substitution between cash-out refinancing and other types of borrowing. In the Appendix, we show that borrowers substitute using both other home equity extraction and consumer credit products.

Returning to Figure 4, the red line shows the results when $Y_{i,t}$ is a dummy for any type of borrowing event, cash-out refinance or otherwise. Overall, the rise in mortgage rates during the Taper Tantrum has little effect on the probability of borrowing. In addition, the point estimates suggest only a small amount of dependence of the effect on rate gap. Evidently, substitution into other borrowing products almost completely offsets the negative and nonlinear effect of higher mortgage rates on borrowing through cash-out refinances. This

[16] In Figure 1, higher mortgage rates *lower* the rate gap so the slope in Figure 1 is positive. The effect shown in Figure 4 is negative and opposite in sign because higher mortgage rates lower the probability of refinance.

finding is consistent with cash-out refinancing reflecting a liquidity need that is fairly interest rate inelastic.

## 5.3 Intensive Margin Results

Next, we investigate the effects of mortgage rates and refinance incentives on the intensive margin: how much households borrow conditional on a borrowing event occurring. We use the same regression equation 6, except we replace the dependent variable with the log of the borrowing amount:

$$ln(l_{i,t}) = \beta_1 \mathbb{I}(RateGapBin)_i + \beta_2 Post_t + \beta_3 \mathbb{I}(RateGapBin)_i \times Post_t + \beta_4 X_{i,t} + \epsilon_{i,t} \quad (7)$$

We pull a 100% sample from CRISM, apply the same filters to the data as described in Section 2, and restrict to new borrowing events. We discuss the main OLS results using Figure 5 and report the exact estimates in Appendix Table A.2.

The blue line of Figure 5 shows the results for the sample of cash-out refinances. Interestingly, the intensive margin effect for cash-out refinances is almost the complete opposite of the extensive margin effect for cash-out refinances, shown by the blue line in Figure 4. The average borrowing amount conditional on a cash-out refinance increases following the rise in mortgage rates, and the increase is larger for borrowers with intermediate values of rate gap than for borrowers with high values of rate gap. For example, while borrowers with pre-Taper rate gap of 1 percent are much less likely to do a cash-out refinance after the Taper, conditional on a cash-out refinance, their borrowing amount increases by about 20 percent on average after the rise in mortgage rates during the Taper Tantrum. The intensive margin results work against, rather than strengthening, the extensive margin results for cash-out refinances.[17]

[17] Eichenbaum, Rebelo and Wong (2022) find a negative intensive margin in their empirical results (Panel C of their Table 2), and so the negative intensive margin response strengthens their negative extensive margin response. However, their data are more limited than ours: they only have data on a sample of cash-out refinances from Freddie Mac and they estimate regressions using county-level data.

Consistent with the model predictions we described in Section 3, the positive intensive margin effect is driven by borrower selection. Figure 6 shows that the increase in average borrowing after the Taper Tantrum is driven by a sharp decline in small extraction amounts (relative to the outstanding balance). Borrowers with lower liquidity needs are most likely to substitute away from cash-out refinances as mortgage rates increase in the model in Section 3 because these borrowers face the highest increase in borrowing costs as their rate gap turns negative. Overall, the estimates in Figures 4 and 5 are consistent with the model predictions described in Section 4.

The red line of Figure 5 shows that once we consider all types of borrowing events, the effect of higher mortgage rates on borrowing is no longer positive and is slightly negative. In addition, there is little dependence of the borrowing amount on rate gap, consistent with the extensive margin results shown in the red line in Figure 4.

### 5.4 Aggregate Borrowing Elasticity

To estimate the total elasticity of borrowing to a change in mortgage rates, we need to combine the estimates in sections 5.2 and 5.3. An appealing approach may be to combine the two dimensions by using the dollar volume as the dependent variable. However, modeling the dollar volume as the dependent variable does not allow for the decision to borrow and the decision of how much to borrow to respond differently to covariates. This is especially problematic in our setting because the intensive and extensive margins of cash-out refinancing have different responses to rate gap.

To get around this concern, we instead estimate an elasticity of the total amount borrowed to mortgage rates using a two-tiered or "hurdle" model (see Wooldridge (2002)). This approach combines intensive and extensive margin results while allowing the explanatory variables to affect the intensive and extensive margins differently.

The first tier of the hurdle model models the probability of borrowing and the second tier models the amount borrowed conditional on a borrowing event occurring. The decisions of whether to borrow and how much to borrow, $l$, are separate.

Specifically, we define the two tiers:

1. $Pr(borrow_{i,t} = 1|x) = (x\gamma)$

2. $E[l_{i,t}|x, borrow_{i,t} = 1) = exp(x\beta + \frac{\sigma^2}{2})$

Where $\sigma$ is the standard error from the intensive margin OLS regression.[18] We determine the covariates $x$ in each model according to the intensive and extensive margin specifications described in Section 5. We can then write the expected value of borrowing at the mean of the covariates as:

$$(\boldsymbol{x}\hat{\gamma})exp(\boldsymbol{x}\hat{\beta} + \frac{\hat{\sigma}^2}{2}) \tag{8}$$

We calculate the total predicted amount borrowed pre- and post- Taper using Equation 8. We then calculate the percentage change in the total predicted amount borrowed pre- and post-Taper and scale this change by the size of the mortgage rate increase to produce an aggregate borrowing elasticity.

The blue and black lines in Figure 7 report the cash-out probability elasticity and the aggregate borrowing elasticity to rates, respectively. Confidence intervals are derived by bootstrapping. Comparing the black and blue lines of Figure 7, the aggregate borrowing elasticity is much closer to zero than the cash-out elasticity and varies much less by rate gap. Averaging across rate gap bins, the cash-out elasticity is equal to 45 (in absolute terms). The aggregate borrowing elasticity (shown in black) is not statistically significantly different from zero, and a lower bound estimate of the aggregate borrowing elasticity, shown in red, is at most 8 (in absolute terms).[19] Accounting for substitution with alternative loan products and for intensive margin responses substantially reduces the level and the path dependence of the sensitivity of borrowing to mortgage rates.

[18]Consistent with our estimation of Equation 6, we estimate the first tier of the hurdle model using OLS instead of probit because OLS more easily handles the large number of fixed effects in our model.

[19]The derivation of the lower bound of the aggregate borrowing elasticity is described in Section 6.2.

## 5.5 Substitution with existing debt

We have shown that the path-dependent effects of monetary policy on new household borrowing are small because the flow of cash-out refinances substitutes for other forms of new household borrowing. Given that the flow of new consumer debt and mortgage debt substitute for one another depending on the rate environment, a symmetric question is whether equity extraction differentially substitutes for *existing debt* depending on the borrower's refinance incentive. Large changes in debt paydown out of cash-out refinances would suggest that the MPC out of cash-out refinances responds to the rate environment, thereby affecting the pass-through of monetary policy.

We use an event study to compare the change in total household debt (first lien mortgage plus all other mortgage credit lines) with the change in the total mortgage balance following a cash-out refinance. We define total debt as the sum of all types of household borrowing recorded in CRISM, including cash-out refinances, HELOCs, CES, personal loans, credit cards, student loans, and auto loans.

We find that the share of funds used for debt paydown is constant following the rate increase. Appendix figure A.4 (a) plots the coefficients on the month dummy variables for two time-to-event OLS regressions with total debt and mortgage debt as the dependent variables. The omitted time period is the month before the cash-out refinance closes. The vector of controls includes origination month-year, zipcode, and loan type fixed effects, and the same loan-level controls as our main specification. Across rate gap categories, total debt increases by about 88% of the total increase in mortgage balance in the first 2 months after refinance, suggesting debt paydown of about 12%. By 6 months after the cash-out refinance, non-mortgage balances have risen somewhat, suggesting longer-term net paydown of about 8%. Following the taper, the paydown share remains essentially unchanged.

# 6 Robustness

## 6.1 QE1

In the Appendix, we show results using a sample around the decrease in mortgage rates after the announcement of QE1 in 2008, the first LSAP program. There are a few reasons to prefer the Taper Tantrum to QE1 as a source of exogenous variation, as we discuss in the Appendix. Nonetheless, consistent with our results from the Taper, we find evidence that households substitute into cash-out refinancing from other borrowing, especially for borrowers who are pushed into the money by the rate decline. The results from QE1, combined with the suggestive evidence of substitution in Figure 1 over our full 2006-2019 sample period, suggest that our estimates may generalize to other periods.

## 6.2 Placebo Test

Within our framework we cannot easily rule out seasonal effects or longer-term trends that could plausibly confound our results. For example, if borrower selection drives both pre-Taper rate gap and a propensity to spend on credit cards in the second half of a calendar year, we would mistakenly attribute the post-Taper borrowing change to the borrowers' refinance incentive.

To provide further evidence that the change in mortgage rate drives substitution across loan products in our empirical setting, we shift our sample back 6 months and run the same analysis as in sections 5.2 and 5.3 over the 12 months preceding the Taper.[20] Figure 8 shows no differential substitution by rate gap during this period.[21]

The results shown in Figure 8 are consistent with the Taper Tantrum mortgage rate change driving borrower substitution that roughly equalizes the total borrowing response

[20] The pre-period is defined as the second half of 2012 and the post period as the first half of 2013.

[21] Figure 3 (a) shows that during the 12-month period before the Taper Tantrum, mortgage rates held fairly steady at around 3.5 percent. In addition, the federal funds rate remained at zero, and other household interest rates were fairly steady.

across rate gap groups. The figure does, however, show a negative and statistically significant coefficient on the Post dummy for other borrowing, and consequently, any borrowing. Other borrowing declines in the placebo post period across all values of rate gap. Appendix Figure A.11 shows that while the monthly probability of cash-out refinancing is fairly flat in the one year before the Taper Tantrum, the probability of other borrowing is more volatile and may have been on a downward trend before the Taper, suggesting that our estimate of the Post dummy in equation 6 for other borrowing and any borrowing may be biased.[22]

### 6.2.1 Bounding aggregate household borrowing elasticity

In this section, we provide a method for calculating the aggregate elasticity of household borrowing to mortgage rates that does not rely on the estimated coefficient on the Post dummy. This is informative for two reasons: (1) The long event window for our main analysis means that seasonal effects or longer-term trends could plausibly confound our estimates of this coefficient. And (2), as we discussed in section 6.2, a pre-trend in "other borrowing" may exist.

Figure 7 provides lower-bound estimates of our elasticities of total borrowing that do not use the Post dummy in the extensive margin regressions (Equation 6) to estimate the probability of any borrowing. To compute these estimates, we set the estimate of the Post dummy for any borrowing in equation 6 equal to the estimate of $Post_t + RateGapBin_i \times Post_t$ for the lowest rate gap group from the regression with cash-out refinancing as the dependent variable.[23]

To estimate the response of any borrowing across rate gap groups, we use our estimates of

$$\mathbb{I}(RateGapBin)_i \times Post_t$$

[22]The figure shows that other borrowing moves a couple months before cash-out refinancing moves lower. One potential explanation for the earlier response in other borrowing is that some borrowers saw offer rates on cash-out refinances moving up in May and June, as shown in Figure 3, and substituted into other consumer credit products at that point. Because borrowing through consumer credit is recorded in our data more quickly than through cash-out refinances, other borrowing responds before cash-out refinancing.

[23]From Figure 4 or Appendix Table A.1, the estimate for the lowest pre-Taper rate gap of -0.5 is 0.000165.

from Equation 6, with "any borrowing" as the dependent variable. This approach assumes zero substitution from cash-out refinancing to other borrowing after the Taper Tantrum for the lowest rate gap group. Since there may in fact be some substitution for this rate gap group, this assumption gives us a lower-bound estimate. This interpretation is valid if our estimate of the Post dummy for cash-out refinancing reflects the causal effect of the rise in mortgage rates during the Taper Tantrum.

The red line in Figure 7 reports the sensitivity of aggregate borrowing to rates using the lower bound method. Averaging across rate gap bins, the lower bound sensitivity of borrowing to rates is roughly -8%, larger in absolute terms than the unadjusted aggregate borrowing elasticity (which is not statistically significantly different from zero), and much lower than the elasticity of the cash-out refinancing probability to rates of roughly -45%.

We are not aware of any other estimates of this elasticity in the literature to compare our estimate with. Bhutta and Keys (2016) provide a related but not directly comparable elasticity of equity extraction to mortgage rates of 28%. The Appendix discusses how our estimates compare to BK in more detail.

# 7 Conventional Monetary Policy Shocks

The Taper Tantrum is an ideal event for studying an exogenous shock to unconventional monetary policy, which by design affect long rates more than short rates (see Figure 3). Conventional monetary policy, in contrast, operates by moving both long and short rates (Gertler and Karadi (2015)). A rise in mortgage rates (which are influenced by long rates) accompanied by a rise in other household borrowing rates (which are influenced by short rates) could dampen the substitution across borrowing products we find in response to the Taper Tantrum shock through two pathways: First, the interest rate spread between the two types of borrowing options would be narrower, reducing the combinations of borrowing amount ($l/b$) and rate gap for which substitution makes financial sense. Second, when short rates increase, borrowers face a higher rate on the alternative product. If borrowers' liquidity needs are sensitive to the absolute cost of borrowing (and not just the relative cost of borrowing through the alternate products), total borrowing may decline among the group of borrowers who, given a change only in long-rates, might have substituted.[24] In this section, we devise an approach to test substitution in the context of standard monetary policy more broadly.

A conventional approach in the literature for managing the endogeneity in standard monetary policy changes is to use shocks to monetary policy.[25] For this analysis, we follow Berger et al. (2021), and estimate the effect of standard monetary policy shocks on cash-out refinances, non-mortgage borrowing, and all borrowing. We use monetary policy shocks to instrument for the share of borrowers with rate-gaps between 0 and 2, and we evaluate the relationship between the instrumented in-the-money share and borrowing on the intensive and extensive margins.[26]

More formally, we use the full sample of data (2006-2021) to estimate the following aggregate regressions:

$$\sigma_t = \alpha(frac)_t + \beta X_t + \epsilon_t \tag{9}$$

where $\sigma_t$ is the probability of a borrowing event in month $t$, $(frac)_t$ is the fraction of outstanding mortgages in month $t$ with a rate gap between 0 and 2, and $X$ is a vector of time-varying controls (e.g. average LTV). We estimate equation (9) separately for cash-out refinance borrowing events, other borrowing events, and any borrowing (i.e. cash-out refinance or other borrowing).

Because $frac$ is likely endogenous, we instrument for it using the moving 6-month sum

[24] Note that in the Taper Tantrum, borrowers who were clearly in-the-money both before and after the rate increase faced the full increase in borrowing cost when mortgage rates rose, because drawing on alternative products was never optimal. As figure 4 shows, the borrowing response was muted, suggesting very inelastic borrowing. But very in-the-money borrowers may be quite different than borrowers at lower rate gaps.

[25] See, for example Gorea, Kryvtsov and Kudlyak (2022).

[26] As shown in Figure 1, decreases in mortgage rates that push borrowers into this rate gap region have the largest effect on borrowing.

of monetary monetary policy shocks from Bu, Rogers and Wu (2021) (BRW).[27] BRW derive their measure using shocks to the entire yield curve following FOMC meetings and so the shock measure reflects both conventional and unconventional monetary policy. The BRW measure is best thought of as an average effect of Fed funds rate, forward guidance, and LSAP shocks following FOMC meetings. As a result, the variation in rate gap used to estimate equation (9) will reflect variation from monetary policy shocks where both short and long rates are moving.

BRW show that their series is not predicted by past economic information and does not contain private information revealed by the Federal Reserve ("Fed information effect"), which could independently change households' outlook for the economy and affect their extraction decisions. By eliminating this potential source of endogeneity, the BRW IV satisfies the exclusion restriction.

Table II reports results from estimating Equation 2 instrumenting for rate gap using the BRW monetary policy shocks. In the first stage, we find that expansionary BRW shocks have a positive effect on $frac$, as such shocks tend to lower mortgage rates and push more borrowers into the money. The F-statistic for the first stage is around 11. Interpreting the IV results, the cash-out probability responds positively to the share of borrowers in-the-money to refinance. Additionally, as we saw with the Taper Tantrum episode, the probability of borrowing using non-mortgage debt responds negatively to the share of borrowers in-the-money to refinance. Combined, the overall borrowing probability has a small and statistically insignificant response to rate gap, consistent with borrowers substituting from cash-out refinancing to other borrowing according to their refinance incentives.

Table III estimates the intensive margin borrowing elasticities. In these regressions, the dependent variable in equation 9 is the average borrowing amount conditional on a borrowing event occurring. Interpreting the IV results, the amount borrowed through a cash-out refinance responds negatively to rate gap. The overall amount borrowed conditional on

[27]Because the effect of rate gap on borrowing is nonlinear and we have one instrument, we use $(frac)_t$ as the independent variable to capture the nonlinearity rather than a full set of rate gap bins.

any borrowing responds positively to rate gap but this effect is not statistically significant. A negative cash-out intensive margin response is consistent with borrowers with small liquidity needs selecting into cash-out borrowing when rates fall. Our results for both the extensive and intensive margins of household borrowing using the monetary policy shock series are similar to our findings from the Taper Tantrum, implying debt substitution is strong even during conventional monetary policy episodes.

# 8 The refinance channel of monetary policy

We have shown that when mortgage borrowers become out-of-the-money to refinance, they substitute toward other forms of borrowing, largely offsetting any decline in total borrowing. However, cash-out refinances are one of two mortgage channels through which interest rates are believed to influence consumption; the other operates by reducing households' monthly payments when they refinance without withdrawing cash (a "rate-term" refinance).

We argue in this section that despite the relatively high interest rate sensitivity of rate-term refinances, cash-out refinancing carries far greater potential to stimulate near-term consumption under standard assumptions. We illustrate this point through a simple back-of-the-envelope calculation. Our calculation focuses on near-term liquidity and thus does not account for interest savings that can accrue over the life of the mortgage.

From 2005-2021, the monthly probability of a rate-term refinance was about 1.5 times as high as for a cash-out refinance. Rate-term refinances, though more frequent, generated far smaller near-term liquidity: over the same period, we estimate that the average borrower who refinanced lowered their mortgage payments by about $3,000 per year, whereas first-lien equity extractions during cash-out refinances averaged $40,000. Our empirical results suggest that the semi-elasticity of the probability of cash-out refinancing to the mortgage rate is about half as large as for rate-term refinancing.[28] Using the standard assumptions

[28]See Section 5 and Appendix Section A.0.1. Figure 1 implies a more equal elasticity of both types of refinancing to rates, but we prefer to use our well-identified estimates to calibrate the elasticity. Using equal

in the literature that the MPC out of cash-out borrowing is 100 percent in the first year, and assuming an 80 percent MPC out of rate-term refinancing savings, we can generate a back-of-the-envelope estimate of the relative importance of cash-out refinancing in driving near-term consumption.[29] The responsiveness of consumption from a refinancing type $i$ given a percentage point change in rate $r$ is roughly:

$$\frac{\partial C_i}{\partial r} = \eta_i^r * \bar{p}_i * V_i * MPC_i \tag{10}$$

where $\eta^r$ is the semi-elasticity of the probability of refinancing to a percentage point change in the mortgage rate, $\bar{p}$ is the probability of refinancing, V is the liquidity change, and MPC is the marginal propensity to consume. All of these variables vary by $i$ and for simplicity we assume $V$ and MPC do not depend on $r$. Plugging the numbers in above and taking the ratio of $\frac{\partial C_{cash}}{\partial r} / \frac{\partial C_{rate}}{\partial r}$, we find that the potential change in consumption driven by a change in rates is 5.5 times as strong through the cash-out refinancing channel as through the rate-term refinance channel. This calculation ignores lenders' offsetting losses from lower monthly payments, which should roughly affect both rate-term and cash-out the same and therefore should not have a large influence on the relative stimulus potential of cash-out refinances.

Whether the stimulus effect from rate refinancing is important on its own is beyond the scope of this paper. As discussed in the literature review, there is evidence that rate refinancing increases narrow measures of spending. Empirical evidence for a meaningful aggregate spending impact, accounting for potentially offsetting effects from mortgage investors who receive losses from rate-refinancing, is limited. If the MPC out of the interest savings from refinancing is large and if borrower MPCs are much larger than investor MPCs, then rate refinancing could be an important transmission mechanism. For example, the calibrated model

elasticities would imply even stronger consumption stimulus from cash-out refinances relative to rate-term refinances.

[29] See Di Maggio et al. (2017) for a rough calculation of an 80 percent MPC. Direct evidence on the MPC of cash-out refinancing is limited but it is often thought to be close to one – households are borrowing to spend. See, for example, Di Maggio, Kermani and Palmer (2020) and Mian and Sufi (2011).

in Berger et al. (2021), which allows for rate refinancing, but not cash-out refinancing, and foreign-owned financial intermediaries, predicts that consumption increases by 0.6 or 0.8 percent in response to a 100 basis point expansionary monetary policy shock, depending on the previous path of interest rates.

# 9 Conclusion

We find that debt substitution substantially weakens the cash-out refinance channel of monetary policy. Monetary policy transmission is not as strong or path-dependent as it appears from cash-out behavior alone because borrowers adjust to changes in mortgage rates by borrowing through alternative loan products. Additionally, we show that household borrowing is surprisingly inelastic to interest rates.

Our estimates in this paper describe the near-term effects of the cash-out refinancing channel of monetary policy. Because house prices tend to be slow moving, in the longer-run, effects of interest rates on house prices may lead to an additional wealth effect that stimulates cash-out refinancing and borrowing. This housing wealth effect will not depend on the distribution of outstanding rates but may affect the level of equity extraction. Longer-run effects of rates on spending may also be larger as household debt paydown from cash-out refinancing lowers debt service, eventually allowing for higher consumption.

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**Table I**

## Summary Statistics

Note: Reports summary statistics of borrowing events from a 16.5% sample of fixed-rate mortgage loans from CRISM in 2013. Mortgages linked to borrowers with multiple first liens, and mortgages financing non-owner occupied properties are dropped. Loans become censored after December 2013. Sample corresponds to approximately 35 million loan-month observations. Riskscore is the borrower's current risk score (i.e. not at origination) and LTV is a mark-to-market LTV imputed using a county-level house price index. Mortgage rate is the outstanding fixed-mortgage rate associated with the loan. Further details on sample construction provided in Section 2.

| Event Type | Monthly Probability | Average Amount ($) | Risk Score | LTV | Borrowing Rate |
|---|---|---|---|---|---|
| Any | 0.83% | 22197.3 | 749 | 63 | 4.70 |
| Personal Loan | 0.28% | 16933.79 | 721 | 74 | 4.72 |
| Credit Card | 0.22% | 10586.5 | 750 | 68 | 4.64 |
| Cash-out Refinance | 0.14% | 39888.23 | 758 | 52 | 5.10 |
| HELOC | 0.17% | 29149.49 | 784 | 46 | 4.42 |
| CES | 0.02% | 39183.54 | 746 | 62 | 4.55 |

**Table II**

## Extensive Margin: Instrumenting for Rate Gap with Monetary Policy Shocks

Note: Reports results from extensive margin regressions that instrument for rate gap using the monetary policy shock surprise series from Bu, Rogers and Wu (2021). $frac$ defined as the share of borrowers with rate gaps between 0 and 2. Dependent variables are the probability of borrowing through a Cash-out refinance ("Cash-out"), an other borrowing product ("Other"), or through a cash-out or other borrowing product ("All"). Controls include mark-to-market LTV, current principal balance, and origination year. Elasticity defined as the coefficient on $frac$ divided by the mean of the dependent variable. Standard errors estimated using Newey-West method.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Cash-out | Other | All | Cash-out | Other | All |
| $frac$ | 0.00525*** | -0.00506*** | 0.000158 | 0.00782*** | -0.00685*** | 0.000924 |
| | (0.000733) | (0.000872) | (0.000770) | (0.00155) | (0.00184) | (0.00206) |
| F-stat | . | . | . | 10.947 | 10.947 | 10.947 |
| Elasticity | 2.367 | -.646 | .016 | 3.525 | -.873 | .092 |
| Reg. | OLS | OLS | OLS | IV | IV | IV |
| N | 196 | 196 | 196 | 186 | 186 | 186 |

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**Table III**

## Intensive Margin: Instrumenting for Rate Gap with Monetary Policy Shocks

Note: Reports results from intensive margin regressions that instrument for rate gap using the monetary policy shock surprise series from Bu, Rogers and Wu (2021). $frac$ defined as the share of borrowers with rate gaps between 0 and 2. Dependent variables are the amount borrowed through each borrowing type. Controls include mark-to-market LTV, current principal balance, and origination year. Elasticity defined as the coefficient on $frac$ divided by the mean of the dependent variable. Standard errors estimated using Newey-West method.

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Cash-out | Other | All | Cash-out | Other | All |
| $frac$ | -28067.3*** | -4850.4*** | 1892.2* | -26439.5*** | -4319.0* | 3109.9 |
| | (2863.1) | (856.2) | (778.4) | (5600.0) | (2135.2) | (2263.1) |
| F-stat | . | . | . | 10.211 | 10.211 | 10.211 |
| Elasticity | -.621 | -.248 | .075 | -.585 | -.221 | .124 |
| Reg. | OLS | OLS | OLS | IV | IV | IV |
| N | 196 | 196 | 196 | 186 | 186 | 186 |

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

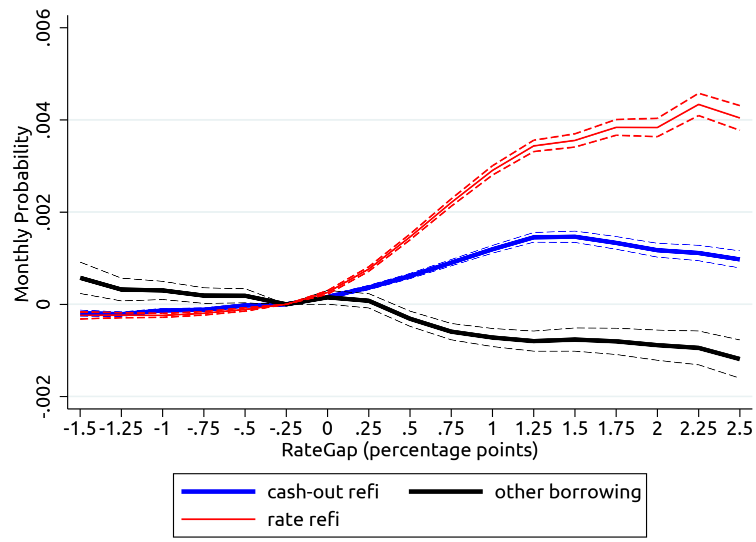



**Figure 1. Probability of Cash-out Refinance or Other Borrowing by Rate Gap.** Marginal effects at means of covariates from a multinomial logit model estimated using data from 2006-2019. Marginal effects shown relative to the effects of the omitted rate gap group (-.25). The outcomes are cash-out refinance, rate-term refinance, other new borrowing event, or none of the three, which is the baseline outcome. Rate gap is a measure of the borrower's refinance incentive in percentage points. Standard errors clustered by loan id. Covariates include a quadratic in mark-to-market LTV, a quadratic in current credit score (lagged by two months), an interaction between LTV and credit score, outstanding principal balance, a quadratic in borrower age, dummies for the term of the loan (e.g. 30 year or 15 year), dummies for the purpose type of the loan (e.g. purchase or refinance), origination year fixed effects, and year fixed effects

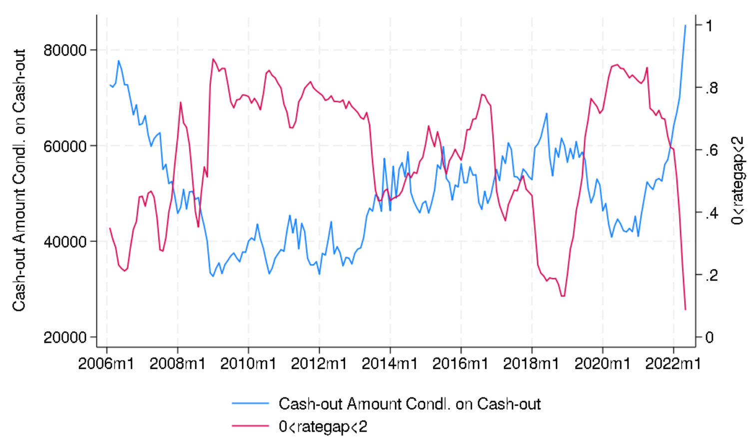
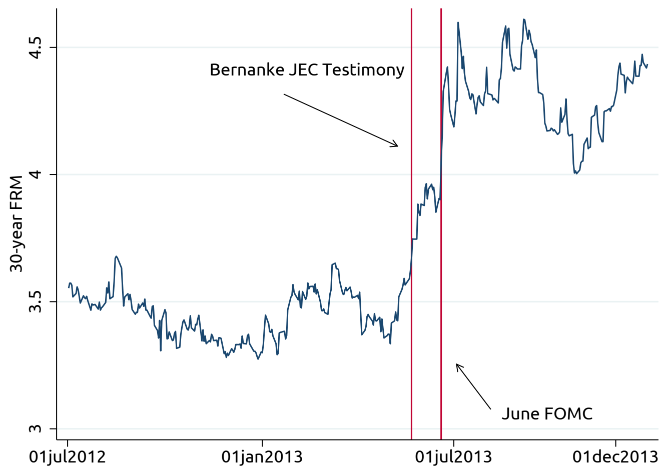
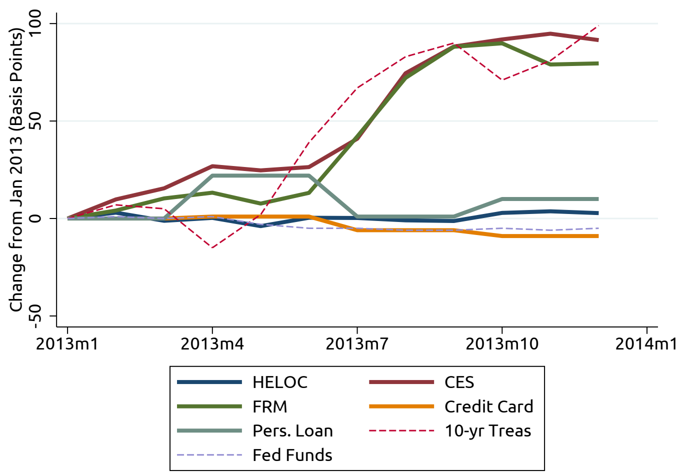



**Figure 2. Aggregate Time Series Borrowing, Intensive Margin.** This figure plots the average amount extracted through a cash-out refinance in blue and the share of borrowers with rategaps between 0 and 2 in red over time.




**(a) Panel A: Daily Mortgage Rates**




**(b) Panel B: Monthly Household Interest Rates**

**Figure 3. Interest Rates in 2013.** Figure (a) shows thirty-year conforming fixed-rate mortgage rates from Optimal Blue. In Figure (b), the 30 year fixed-rate mortgage, HELOC rate, and CES rate is the estimated month dummies from a regression of interest rates at origination on borrowing characteristics and origination month dummies. Personal Loan and Credit Card interest rates are average interest rates at commercial banks. Mortgage rates are computed using loan-level data from McDash. HELOC and CES rates are computed using loan-level data from CoreLogic. Personal loan and credit card interest rates are from the Federal Reserve G19 statistical release:
`https://www.federalreserve.gov/releases/g19/HIST/cc_hist_tc_levels.html`.

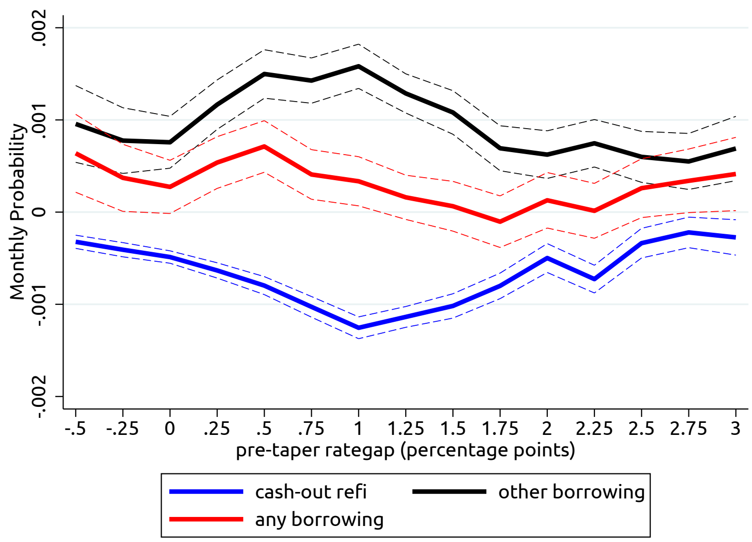



**Figure 4. Extensive Margin Results.** Change in monthly probability of borrowing after the Taper Tantrum by pre-Taper rate gap. Estimates from LPMs with SE clustered by loan id. Controls include a quadratic in mark-to-market LTV, a quadratic in current credit score, an interaction between LTV and credit score, outstanding principal balance, a quadratic in borrower age, a cubic in loan age, dummies for the term of the loan (e.g. 30 or 15 year), dummies for the purpose type of the loan (e.g. purchase or refinance), the county-unemployment rate, four-digit property zipcode FE, and origination year FE.

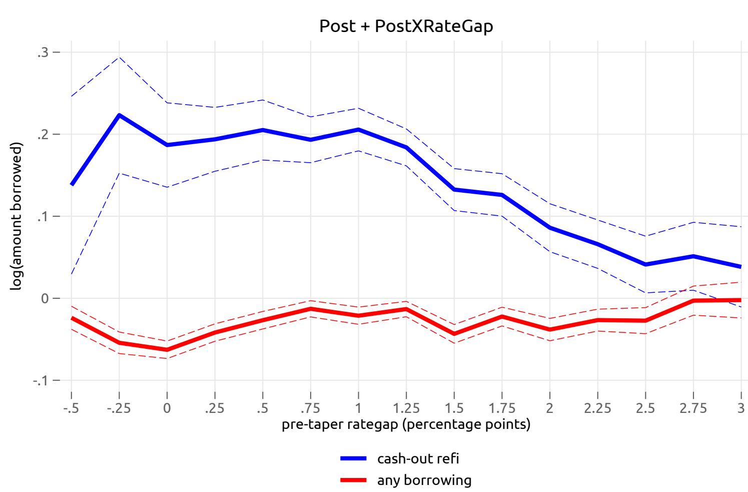



**Figure 5. Intensive Margin Results.** Shows change in amount borrowed conditional on borrowing after the Taper Tantrum by pre-Taper rate gap. Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4. Controls for credit score, ltv, and balance are twice lagged to eliminate the effect of paydown on these variables.

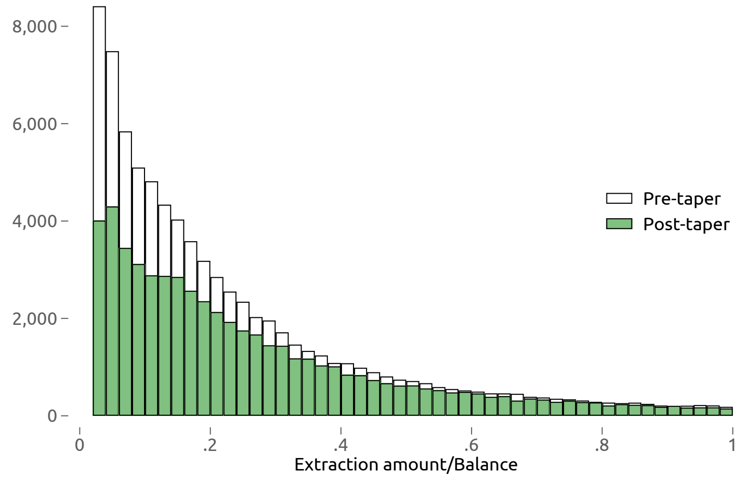



**Figure 6. Distribution of Extraction Amounts from Cash-out Refinances.** Distribution of cash-out extraction amounts as a share of the pre-refinance unpaid balance before and after the Taper Tantrum. The units are counts per 2 percentage-point bin.

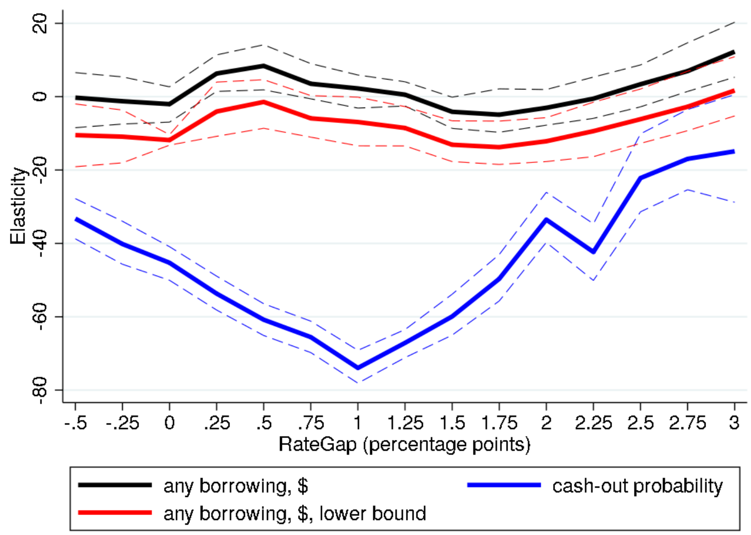



**Figure 7. Aggregate Borrowing Elasticity.** The elasticity of aggregate borrowing to rates is derived using a hurdle model described in Section 5.4 which combines intensive and extensive margin responses. The lower bound of the aggregate elasticity of borrowing to rates is described in Section 6.2. Confidence intervals are bootstrapped.

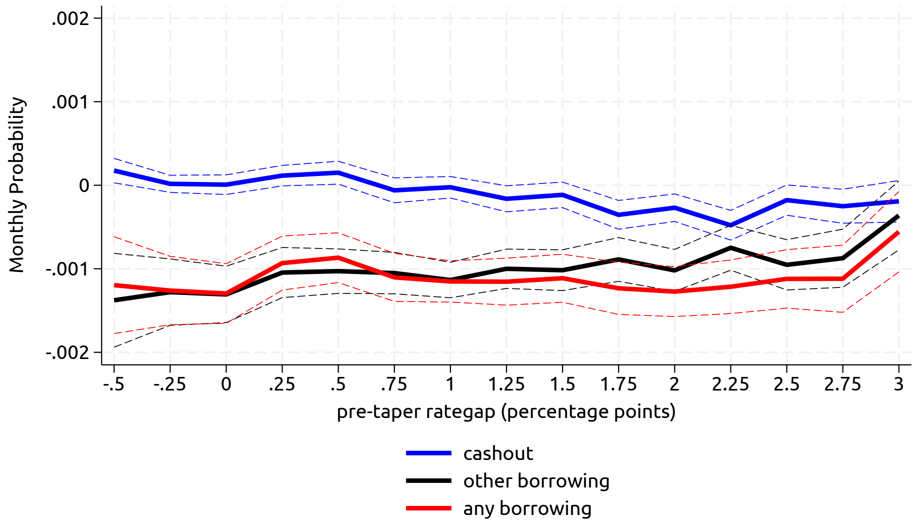



**Figure 8. Extensive Margin Results, Placebo Analysis.** This figure shows results from a placebo test, estimating the main specification in Equation 6 shifted to a period of flat mortgage rates. The figure shows the change in monthly probability of borrowing in the six months following January 2013, by pre-2013 rate gap. The pre-period is defined as the six months before January 2013. Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4.

Appendix for Online Publication:

# Borrowing and Spending in the Money: Debt Substitution and the Cash-out Refinance Channel of Monetary Policy

Elliot Anenberg, Tess Scharlemann, and Eileen van Straelen

November 14, 2023

## A.0 Data Appendix

### A.0.1 Defining Prepayment Types

In McDash, we observe when a loan prepays but not the reason for the loan's prepayment; we cannot distinguish between a rate-term refinance, a cash-out refinance, or a move. We use the credit report data from CRISM, which reports when and where a borrower opens a new mortgage and the new mortgage size, to differentiate between different types of prepayment.

- First, we classify a prepaying mortgage as a move, if within 12 months of the mortgage pay off date the borrower's zipcode changes.
- Second, we classify a prepaying mortgage as a rate-term refinance if:
  1. The prepaying mortgage is not a move.

2. The borrower opened a new mortgage in either the previous month, the current month, or the following month.

3. The new mortgage has an opening balance such that 0.98 of the new balance is less than the paid off amount plus $5,000, to account for closing costs.

   (a) Following Berger et al. (2021), we treat a refinance where equity is extracted to pay down other housing debt as a rate-term refinance. If condition (3) does not hold BUT total housing debt (first mortgage plus HELOC balance plus CES balance) after the refinance is less than $5,000 plus total housing debt before the refinance plus closing costs, then the borrowing event is coded as a rate-term refinance.

4. The LTV of the new mortgage is less than 1.2. We calculate the home value in the LTV using the mark to market LTV of the prepaying mortgage.

- Third, we classify a prepaying mortgage as a cash-out refinance if:

1. The prepaying mortgage is not a move.

2. The prepaying mortgage is not a rate-term refinance.

3. The borrower opened a new mortgage in either the previous month, the current month, or the next month.

4. The new mortgage has an opening balance such that 0.98 of the new balance is greater than or equal to the paid off amount plus $5,000, to account for closing costs. A refinance where equity is extracted to pay down other housing debt will satisfy condition (4) but not condition (2) and so will not be classified as a cash-out refinance.

5. The LTV of the new mortgage is less than 1.2. We calculate the home value in the LTV using the mark to market LTV of the prepaying mortgage.

- We apply these same rules to define rate-term refinances and cash-out refinances for second mortgages.
- Finally, we define a loan as a pay off if the mortgage prepays but is not a move, a rate-term refinance, or a cash-out refinance.

### A.0.2 Defining Borrowing Events

We construct five different borrowing events in CRISM.

- Cash-out refinance: We measure the amount borrowed through a cash-out refinance using the method described in Section A.1.
- Credit card: We measure credit card balance as the sum of the total balance of all retail accounts and all bank accounts.
- Personal loan: We measure personal loan balance as the sum of balances for other accounts and balances for all consumer finance accounts.
- HELOC/CES: HELOC and CES balances are reported directly in CRISM.

Identifying borrowing events:

- Credit card
  - We define a credit card borrowing event as occurring at time $t$ if in time $t$, the credit card balance increases by at least \$5,000, the balances in the subsequent 3 months are at least \$5,000 greater than the balance at time $t-1$, and if the balance at time $t$ is greater by at least \$5,000 than the balances in the preceding three months. We also require that the change in balance at time $t$ be less than \$100,000.
  - To eliminate borrowing events where borrowing has been gradually ramping up over time, we set credit card borrowing events to 0 in which the 1-month change

in the credit card balance in each of the preceding three months is greater than \$5,000 and less than \$100,000.

- Personal loan
  - We define a personal loan borrowing event as occurring at time $t$ if in time $t$, other balance increases by at least \$5,000, the balances in the subsequent 3 months are at least \$5,000 greater than the balance at time $t-1$, and if the balance at time $t$ was greater by at least \$5,000 than the balances in the preceding three months. We also require that the balance at time $t-1$ and at time $t$ be less than \$1,000,000.
  - To eliminate borrowing events where borrowing has been gradually ramping up over time, we set personal loan borrowing events to 0 in which the 1-month change in the personal loan balance in each of the preceding three months is greater than \$5,000.
- HELOCs
  - We define a HELOC borrowing event as occurring at origination and also following origination, to account for the fact that borrowers can make draws on a previously-opened HELOC.
  - For newly opened HELOCs, we define the borrowing amount as the maximum observed borrowing amount over the five months following the HELOC origination.
  - We also require the maximum HELOC balance observed since the new HELOC borrowing event be at least \$5,000.
  - We are careful to not treat refinances of HELOCs as borrowing events. If the origination date of the HELOC changes and the maximum balance observed after the new origination is less than \$5,000 greater than the balance observed 3 quarters

before the new origination, then we do not consider that new origination to be an extraction event.

- We define a HELOC draw (following origination) as occurring when the HELOC balance increases by at least \$5,000, the balance increase is less than \$1,000,000, the HELOC has been open already for at least 7 months, the HELOC is less than 30 years old, and the balances in the subsequent 3 months are at least \$5,000 greater than the balance at time $t-1$.
- To eliminate borrowing events where borrowing has been gradually ramping up over time, we set HELOC borrowing events to 0 for existing HELOCs (older than 7 months and younger than 30 years), in which the 1-month change in the HELOC balance in each of the preceding three months is greater than \$5,000 and less than \$1,000,000.

- CES
  - We define the borrowing amount for a CES event as the maximum observed borrowing amount over the five months following the CES origination.
  - We require that the CES balance at origination be at least \$5,000.
  - We are careful to not treat refinances of CES as borrowing events. We define CES borrowing events where the difference between the current CES balance and the three-month lagged CES balance is less than \$5,000 to be a refinance.
  - For a CES origination that occurs in the three months following a rate-term refinance, we set the date of the CES origination as the date of the rate-term refinance.
  - Finally, we do not define CES originations that coincide with a move or a payoff as borrowing events.

### A.0.3 Sample Filters

- We drop mortgages for borrowers who have more than one mortgage.

- We drop households with multiple liens but also allow for the possibility that single liens will overlap slightly when refinancing. We first drop loans which ever have more than three loans outstanding at once because we cannot attribute three simultaneous loans outstanding to refinancing. We next drop loans which have at least six observations with more than two loans outstanding at once.

- A household can also have multiple liens where not all of the liens appear in McDash. We also drop loans which have at least six observations in which the difference between the McDash mortgage balance and the credit report mortgage balance is greater than $20,000, suggesting the borrower has another mortgage which does not appear in the servicing data.

- We also drop mortgages for non-owner-occupied properties.

- We consider a property owner-occupied if the borrower's zipcode matches the property zipcode. We drop loans which never have an observation of owner-occupancy and which have more than six observations in which the borrower zipcode does not match the property zipcode.

- Equifax produces a Match Confidence Score ranging from 0 to 0.9 to track the match quality between the mortgage servicing records and the credit bureau data. We require that mortgages in our sample have a confidence score of at least 0.8, capturing approximately 90% of mortgages.

- For a mortgage associated with multiple borrowers, we keep only the consumer classified by Equifax as the primary borrower.

## A.0 Simulations of Model of Household Borrowing and Substitution

This section report simulation results of the simple model of household borrowing and substitution presented in the main text. To see how $\partial p^{cash}/\partial r^m$ varies with a borrower's rate gap, Figure A.1 (a) plots results from a calibration of equation 5. We set $F = 0, r^a = 10, r^O = 6, l = 0.1, \sigma = 2, \lambda = 0.1$. We plot $p^{cash}$ for a range of rate gap, which corresponds to a range of $r^m$ because $r^0$ is fixed in the calibration. The probability of borrowing through the alternative borrowing product (not shown) is simply the mirror image of Figure A.1 (a). The simulation does a good job of matching the data, as shown in Figure 1. For high, positive levels of rate gap, $p^{cash}$ is large and fairly flat. For these borrowers, cash-out refinancing brings substantial relative interest savings on both the liquidity need and the existing mortgage. Only a large value of $\epsilon$ would cause such a borrower to choose the alternative borrowing product. As rate gap decreases, the interest rate savings associated with a cash-out refinance decrease, more households are on the margin of choosing the alternative borrowing product, and the slope steepens. Eventually the slope flattens out again when rate gap is sufficiently negative. In this region, the alternative borrowing product dominates for almost all borrowers because the interest penalty on the existing mortgage from doing a cash-out refinance is so large. For low $r^0$, the alternative borrowing product dominates cash-out refinancing for most borrowers even though $r^m < r^a$.

To simulate the intensive margin, we parameterize the liquidity as $l \sim lognormal(\mu_l, \sigma_l)$. We simulate how $E[l|v^{cash} > v^{alt}]$ changes in response to a change in mortgage rates for different levels of the refinance incentive. We calibrate $\mu_l = -2.3$ and $\sigma_l = 0.9$ so that the mean and variance of the distribution of $l$ as a share of the outstanding mortgage principal balance is consistent with the corresponding distribution in our data. For the other parameters, we set $F = 0, r^a = 10, r^O = 6, \sigma_l = 1.2$. We chose these parameters to produce a simulation that looks close to our intensive margin empirical results that we present below. We consider an 80 basis point increase in the mortgage rate, consistent with the size of the mortgage rate increase we use in our empirical work. Figure A.1 (b) shows the percent change in $E[l|v^{cash} > v^{alt}]$ after the increase in the mortgage rate for different levels of the refinance incentive, $r^0 - r^m$, where $r^m$ is the mortgage rate measured prior to the 80 basis point increase.

## A.0 Additional Empirical Results

### A.0.1 Elasticity of Rate-Term Refinances versus Cash-out Refinances

Figure A.2 shows results from the main extensive margin regression where we use rate-term refinances as the outcome variable. The figure shows that rate-term refinances are an order of magnitude more sensitive to mortgage rates and rate gap than cash-out refinances. However, the baseline probability of a cash-out refinance was much lower than the baseline probability of a rate-term refinancing in 2013. Expressing the effects in terms of semi-elasticities, we find that the semi-elasticity of rate-term refinancing to mortgage rates is about two times as large as the semi-elasticity of cash-out refinancing to mortgage rates. To compute the elasticities, we compare cash-out refinancing and rate-term refinancing responses over the rategap interval (0,1) when the difference in slopes is greatest.

### A.0.2 Results Including Adjustable-Rate Mortgages

About 10% of outstanding mortgages in 2013 are ARMs in our sample. Figure A.5 shows the extensive margin results when we include all product types in the sample and do not restrict to fixed-rate mortgages. The results are very similar to Figure 4.

### A.0.3 Comparison to Bhutta and Keys (2016)

BK find an aggregate elasticity of equity extraction to rates of 28%. Our estimate is much lower. In this section, we explain why our results are not directly comparable and are lower. First, BK do not include consumer credit in their borrowing measure. We find that borrowers substitute away from cash-out refinancing to consumer credit when mortgage rates rise, so accounting for consumer credit in the borrowing measure substantially reduces the responsiveness of overall borrowing to rates. Second, BK study a period when HELOC and mortgage rates declined roughly in tandem, meaning borrowers had less incentive to substitute between HELOCs and mortgages implying a higher elasticity of total borrowing to rates. Third, we exploit a monetary policy surprise to get plausibly exogenous variation in mortgage rates, whereas BK exploit yearly variation in mortgage rates, controlling for observables that could affect both interest rates and equity extraction. Finally, we estimate the elasticity of new borrowing to mortgage rates during the post-GFC period. The mortgage market changed from pre- to post-crisis in a number of important ways which could influence the elasticity of borrowing to rates. For example, credit standards for cash-out refinancing tightened substantially following the crisis, borrowers may have become more debt averse post-crisis, and borrowers had less equity in their homes. All these changes should have reduced the sensitivity of borrowing to mortgage rates. Our data, however, do not cover the pre-crisis period and so we cannot directly compare elasticities over time.

### A.0.4 Evidence from QE1

The Taper Tantrum provides an increase in mortgage rates, resulting in a decrease in borrower refinance incentives. In this section, we consider a plausibly exogenous decrease in mortgage rates to test whether household borrowing and substitution responds asymmetrically to mortgage rate increases and decreases. This exercise also allows us to test the external validity of our Taper Tantrum results.

We exploit the decrease in mortgage rates in response to QE1. In late November of 2008, the Federal Reserve announced that it would start buying long-term securities to provide additional monetary accommodation during the financial crisis.[1] In response to this largely unanticipated announcement, Figure A.6 shows mortgage rates fell suddenly and

[1]This event marks the start of the program whose potential unwinding sparked the Taper Tantrum in 2013. A number of papers have studied the mortgage borrowing response to the jump in rates from QE1 – see, for example, Beraja et al. (2019), Di Maggio, Kermani and Palmer (2020), Fuster and Willen (2010).

significantly, declining about 100 basis points between late November 2008 and January 2009. As with the Taper Tantrum, QE1 allows us to compare household borrowing over a number of months with starkly different mortgage rate regimes, where the change in rate regimes is triggered by a monetary policy surprise.

QE1 is different from the Taper Tantrum, however, in that the Federal Reserve announced it in the middle of a financial crisis. In the months before and after the announcement of QE1, mortgage market and household borrowing conditions were changing rapidly, potentially affecting household borrowing, and differentially so across rate gap groups. For example, mortgage availability tightened considerably for borrowers with lower credit scores over this time period. Because these trends can potentially bias our results, we present the Taper Tantrum results as our preferred ones.

Figure A.7 shows the results from estimating equation 6 using a sample of fixed-rate mortgages between July 2008 and April 2009. Post is now a dummy for post-QE1, defined as December 2008 - April 2009. The blue line shows that cash-out refinance probability rises after QE1, and especially for borrowers with rate gaps that are pushed into the money by the decline in mortgage rates. Qualitatively, the response is very symmetric to the response shown in Figure 4 for the Taper Tantrum. The magnitude of the response is much larger during QE1. But the baseline probability of a cash-out refinance around QE1 was also much larger, possibly because a need for liquidity was relatively high during the financial crisis. Another possibility for the lower baseline probability during the Taper Tantrum is that rates increased after a long period of low rates, and so the more rate sensitive borrowers may have refinanced well before the Taper. Comparing the sizes of the responses to their respective baselines and accounting for the somewhat larger change in mortgage rates during QE1, the magnitudes of the cash-out elasticity are fairly similar across the two episodes.

The black line of Figure A.7 shows the results when $Y_{i,t}$ is a dummy for an "other borrowing event." Consistent with the results in Figure 4, the black line generally has the opposite pattern from the blue line, suggestive of substitution. After QE1, households are less likely to borrow through a non cash-out refinance product, and the magnitude of the decrease is comparable to the magnitude of the increase for cash-out refinance borrowing. In addition, the propensity for other borrowing declines the most for the rate gap borrowers whose propensity to cash-out refinance increases the most. The red line shows the results when $Y_{i,t}$ is a dummy for any type of borrowing event. Overall, the decline in mortgage rates during QE1 has little effect of the probability of borrowing. The point estimates show some dependence of the effect on rate gap for borrowers with negative pre-QE rate gaps. The magnitude of this dependence is a little larger than the dependence we estimated in Figure 4 during the Taper Tantrum. But overall, the red line is much closer to zero and flatter with respect to the rate gap than the blue line, consistent with the results shown in Figure 4 for the Taper Tantrum.

Figure A.8 shows the intensive margin results. The results are very symmetric to those shown in Figure 5. Average borrowing amount among cash-out refinancers decreases after QE1, especially for borrowers with intermediate values of rate gap, consistent with a selection effect caused by substitution out of other borrowing products. Overall, the red line shows a small positive intensive margin response to the decrease in mortgage rates, and only a small dependence on rate gap.

**Table A.1**

## Extensive Margin Results

| | (1)<br>Cash-out Refi | (2)<br>Other Borrowing | (3)<br>Any Borrowing |
|---|---|---|---|
| post=1 | -0.000487*** | 0.000757*** | 0.000274* |
| | (0.0000343) | (0.000143) | (0.000147) |
| RateBin = -.5 × post=1 | 0.000165*** | 0.000199 | 0.000365 |
| | (0.0000455) | (0.000247) | (0.000251) |
| RateBin = -.25 × post=1 | 0.0000793* | 0.0000183 | 0.0000983 |
| | (0.0000477) | (0.000221) | (0.000226) |
| RateBin = .25 × post=1 | -0.000145*** | 0.000408** | 0.000264 |
| | (0.0000506) | (0.000188) | (0.000194) |
| RateBin = .5 × post=1 | -0.000310*** | 0.000741*** | 0.000439** |
| | (0.0000573) | (0.000187) | (0.000195) |
| RateBin = .75 × post=1 | -0.000540*** | 0.000669*** | 0.000135 |
| | (0.0000640) | (0.000182) | (0.000193) |
| RateBin = 1 × post=1 | -0.000767*** | 0.000824*** | 0.0000609 |
| | (0.0000672) | (0.000182) | (0.000193) |
| RateBin = 1.25 × post=1 | -0.000650*** | 0.000530*** | -0.000113 |
| | (0.0000648) | (0.000174) | (0.000185) |
| RateBin = 1.5 × post=1 | -0.000530*** | 0.000323* | -0.000210 |
| | (0.0000739) | (0.000183) | (0.000197) |
| RateBin = 1.75 × post=1 | -0.000313*** | -0.0000648 | -0.000378* |
| | (0.0000774) | (0.000187) | (0.000202) |
| RateBin = 2 × post=1 | -0.0000108 | -0.000134 | -0.000145 |
| | (0.0000864) | (0.000193) | (0.000211) |
| RateBin = 2.25 × post=1 | -0.000239*** | -0.0000107 | -0.000260 |
| | (0.0000834) | (0.000193) | (0.000210) |
| RateBin = 2.5 × post=1 | 0.000151* | -0.000158 | -0.0000139 |
| | (0.0000884) | (0.000200) | (0.000218) |
| RateBin = 2.75 × post=1 | 0.000267*** | -0.000208 | 0.0000659 |
| | (0.0000907) | (0.000210) | (0.000228) |
| RateBin = 3 × post=1 | 0.000213** | -0.0000675 | 0.000140 |
| | (0.000103) | (0.000227) | (0.000249) |
| Observations | 22569292 | 22569292 | 22569292 |

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Note: Shows detailed results associated with the results in Figure 4.

**Table A.2**

## Intensive Margin Results

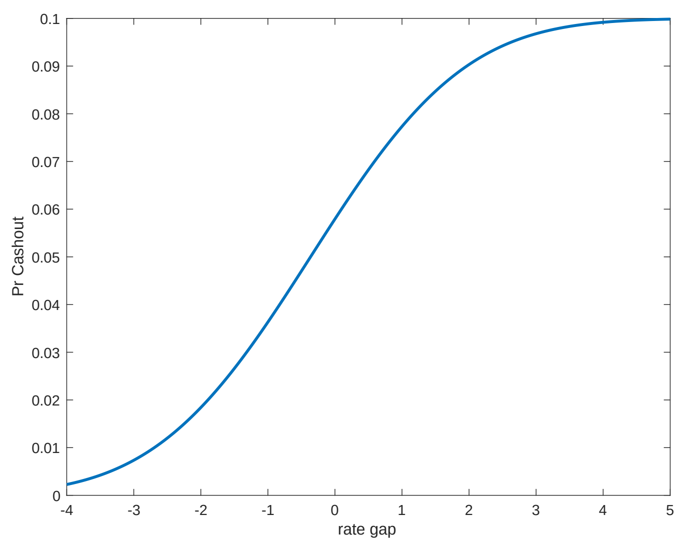
| | (1) Cash-out Refi | (2) Other Borrowing | (3) Any Borrowing |
|---|---|---|---|
| post=1 | 0.187*** | -0.0356*** | -0.0628*** |
| | (0.0262) | (0.00530) | (0.00543) |
| RateBin = -.5 × post=1 | -0.0490 | 0.0403*** | 0.0391*** |
| | (0.0600) | (0.00838) | (0.00852) |
| RateBin = -.25 × post=1 | 0.0365 | 0.0121 | 0.00851 |
| | (0.0432) | (0.00794) | (0.00799) |
| RateBin = .25 × post=1 | 0.00697 | 0.0364*** | 0.0211*** |
| | (0.0323) | (0.00724) | (0.00738) |
| RateBin = .5 × post=1 | 0.0183 | 0.0499*** | 0.0361*** |
| | (0.0304) | (0.00737) | (0.00741) |
| RateBin = .75 × post=1 | 0.00640 | 0.0708*** | 0.0500*** |
| | (0.0288) | (0.00715) | (0.00711) |
| RateBin = 1 × post=1 | 0.0189 | 0.0715*** | 0.0416*** |
| | (0.0290) | (0.00740) | (0.00750) |
| RateBin = 1.25 × post=1 | -0.00286 | 0.0596*** | 0.0497*** |
| | (0.0277) | (0.00695) | (0.00686) |
| RateBin = 1.5 × post=1 | -0.0543* | 0.0377*** | 0.0194** |
| | (0.0298) | (0.00744) | (0.00771) |
| RateBin = 1.75 × post=1 | -0.0608** | 0.0348*** | 0.0405*** |
| | (0.0295) | (0.00769) | (0.00766) |
| RateBin = 2 × post=1 | -0.101*** | 0.0259*** | 0.0246*** |
| | (0.0300) | (0.00866) | (0.00863) |
| RateBin = 2.25 × post=1 | -0.121*** | 0.0324*** | 0.0362*** |
| | (0.0302) | (0.00848) | (0.00852) |
| RateBin = 2.5 × post=1 | -0.146*** | 0.0307*** | 0.0355*** |
| | (0.0318) | (0.00963) | (0.00966) |
| RateBin = 2.75 × post=1 | -0.136*** | 0.0347*** | 0.0599*** |
| | (0.0335) | (0.0105) | (0.0106) |
| RateBin = 3 × post=1 | -0.149*** | 0.0475*** | 0.0606*** |
| | (0.0367) | (0.0119) | (0.0121) |
| Observations | 175229 | 867853 | 1041804 |

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

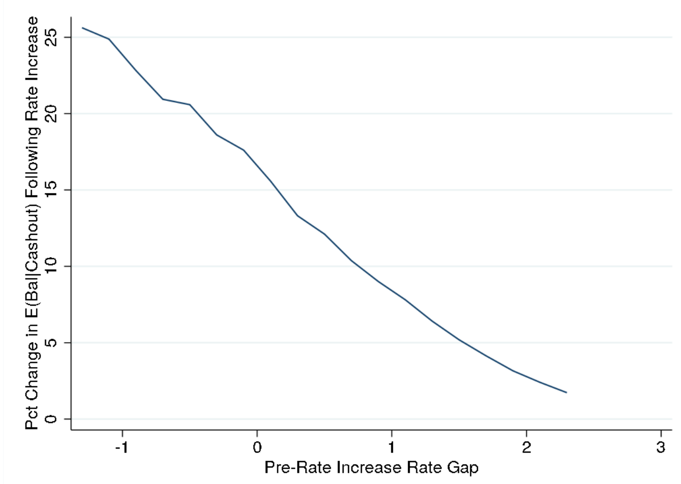
Note: Shows detailed results associated with the results in Figure 5.

**Figure A.1. Conceptual Framework Model Simulations**

(a) Cash-out Refinance Probability by Rate Gap




(b) Amount Borrowed Conditional on Cash-out Refinance by Rate Gap




Note: Figure (a) shows probability of a cash-out refinance by rate gap according to simulations of the simple model of housebold borrowing and substitution. Figure (b) shows simulated average change in cash-out amount conditional on a cash-out refinance by rate gap following an 80 basis point increase in mortgage rates.

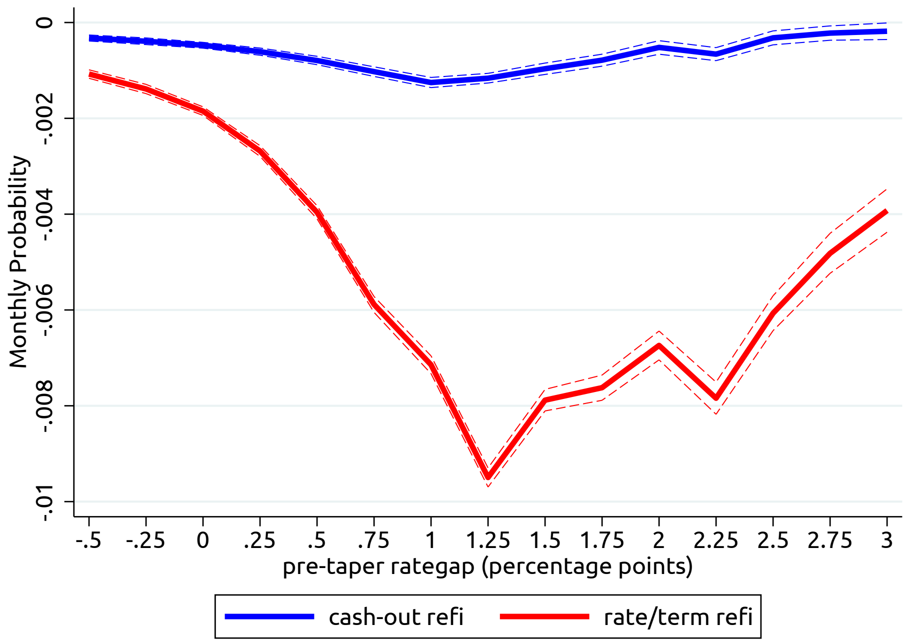
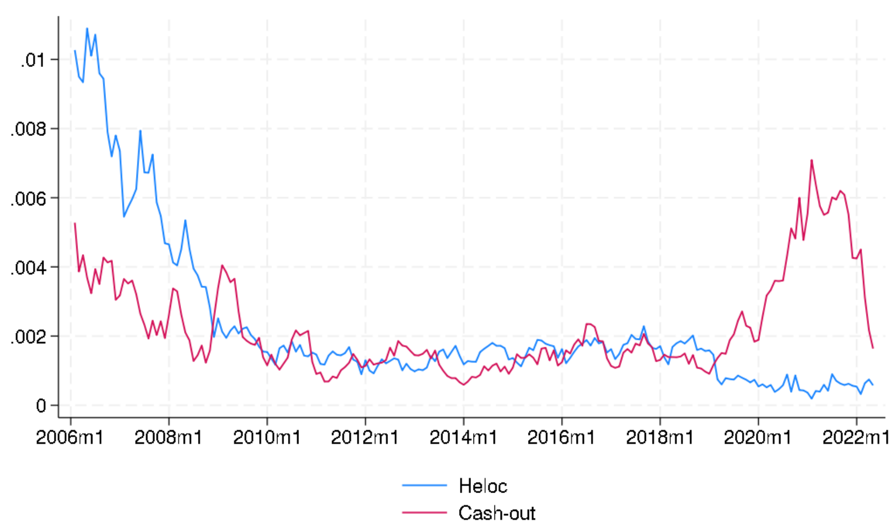
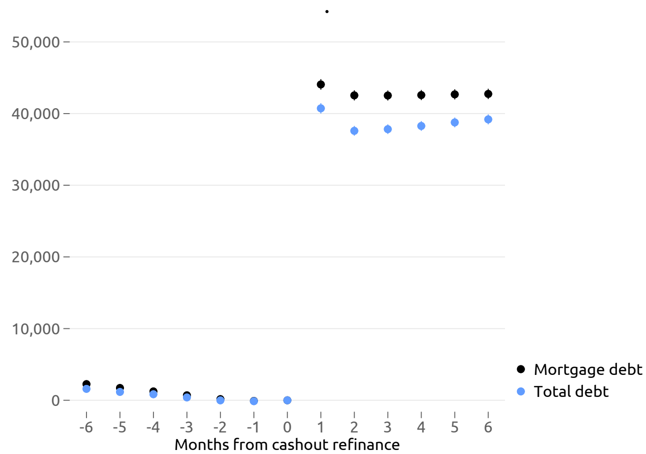



**Figure A.2. Extensive Margin Results with Rate-term Refinancing.** Note: Shows change in monthly probability of rate-term and cash-out refinancing after the Taper Tantrum by pre-Taper rate gap. Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4.

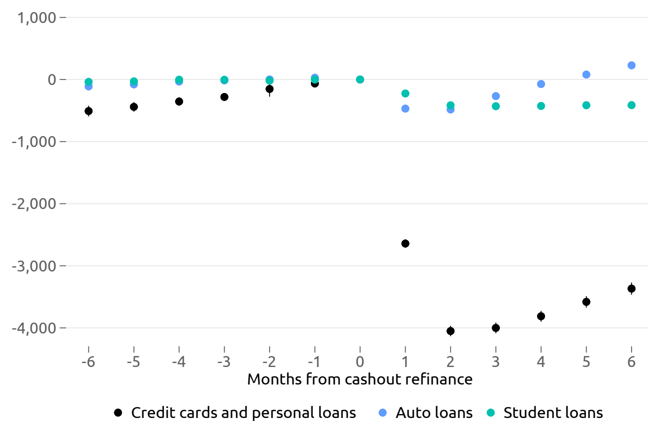
**Figure A.3. Aggregate Time Series Borrowing, Extensive Margin**




Note: Shows the aggregate probability of cash-out refinancing and HELOC borrowing over time.



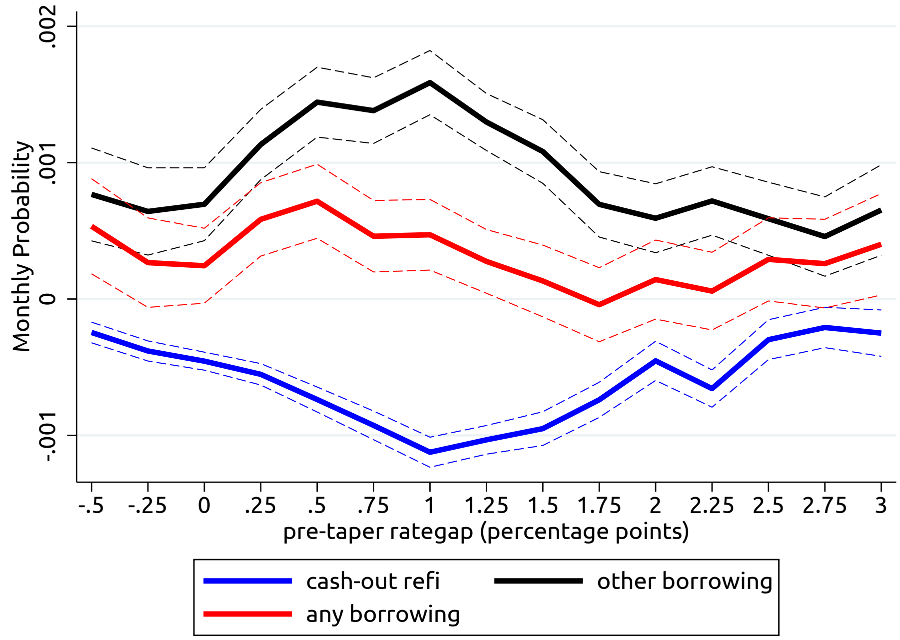

**(a) Panel A: Substitution of Cash-out Refinancing with Existing Debt**




**(b) Panel B: Evolution of non-mortgage debt**

**Figure A.4. Substitution with Existing Debt.** Figure (a) shows the increase in mortgage debt and total debt following a cash-out refinance and (b) shows how. different categories of non-mortgage debt change following a cash-out refinance. The top figure plots two time-to-event OLS regressions: one with total mortgage debt as the dependent variable and the second with total debt as the dependent variable. The omitted time period is the month of the cash-out refinance. Standard errors clustered by 4-digit zip. Additional controls include credit score, combined LTV (CLTV), an interaction of credit score and LTV, borrower age, and fixed effects for 4-digit zips, month of refinance, origination year, and loan type.

**Figure A.5. Extensive Margin Results: Including Adjustable-Rate Mortgages**

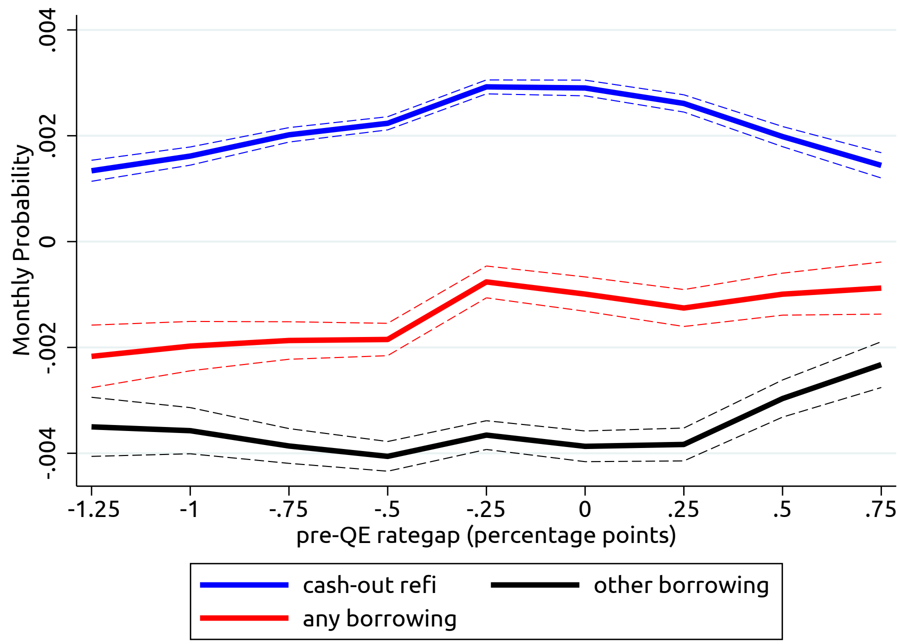



Note: Shows change in monthly probability of borrowing after the Taper Tantrum by pre-Taper rate gap when we include all product types in the sample and do not restrict to fixed-rate mortgages. Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4.

**Figure A.6. Mortgages Rates Around QE1**

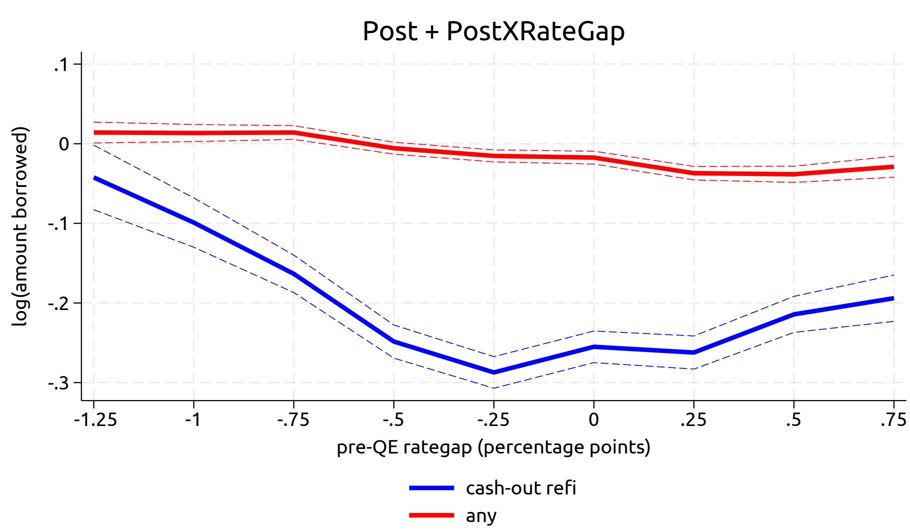

Note: Weekly mortgage rates from Freddie Mac primary mortgage market survey.

**Figure A.7. Extensive Margin Results: QE1**



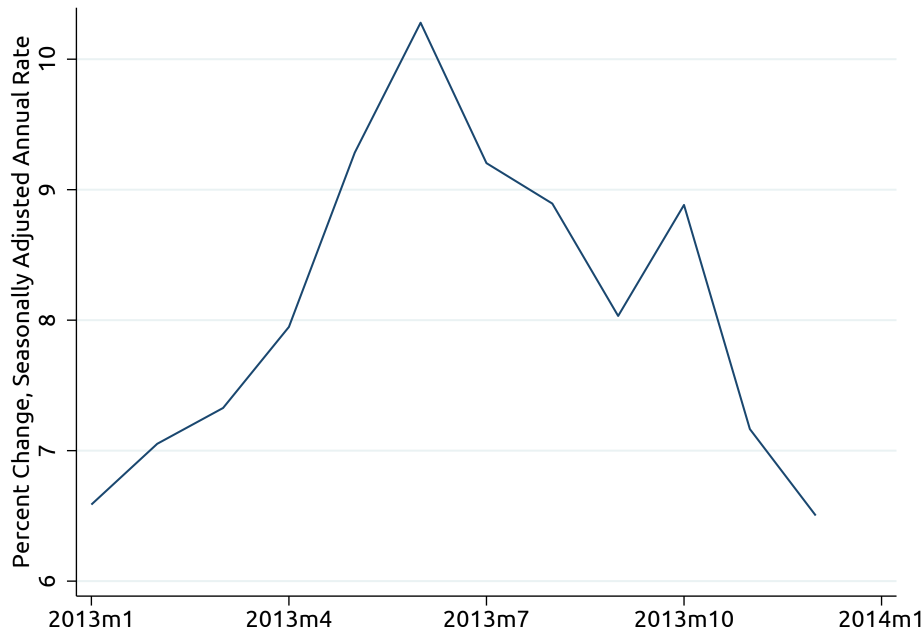

Note: Shows change in monthly probability of borrowing after QE1 by pre-QE1 rate gap. Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4.

**Figure A.8. Intensive Margin Results: QE1**



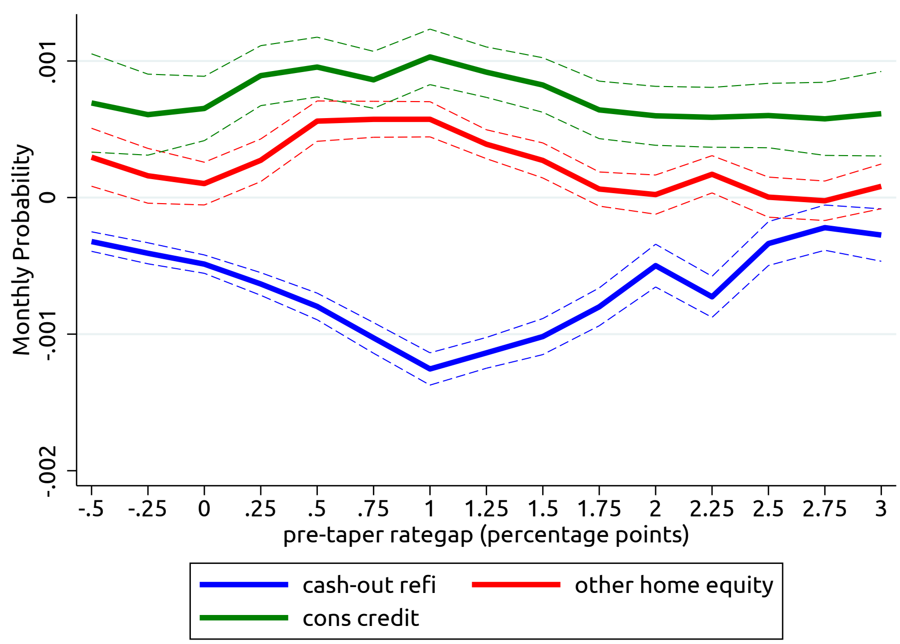

Note: Shows change in amount borrowed conditional on borrowing after QE1 by pre-QE1 rate gap. Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4.

**Figure A.9. Monthly House Price Growth in 2013**



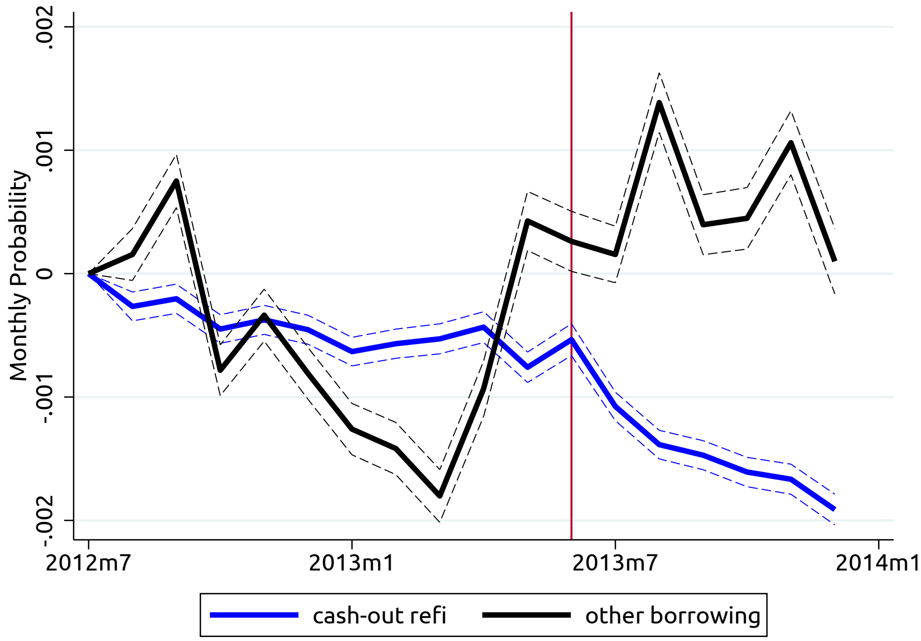

Note: National monthly house price growth according to the Zillow home value index. Monthly house price growth is shown at a seasonally adjusted annualized rate.

**Figure A.10. Extensive Margin Results: By Borrowing Type**




Note: Shows change in monthly probability of borrowing after the Taper Tantrum by pre-Taper rate gap. This figure breaks out "other borrowing event" from Figure 4 into "other home equity extraction" (i.e. HELOCs or CES) and "consumer credit" (i.e. personal loans or credit cards). Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4.

**Figure A.11. Probability of Borrowing by Calendar Month**




Note: Shows the monthly probability of borrowing across cash-out refinancing and other borrowing. Estimates from LPMs with standard errors clustered by loan id. Control variables listed in notes to Figure 4. Red line denotes the end of the pre-taper tantrum period, which we define as June 30, 2013.