MORTGAGE RATES, HOUSEHOLD BALANCE SHEETS, AND THE REAL ECONOMY

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ABSTRACT

This paper investigates the impact of lower mortgage rates on household balance sheets and other economic outcomes during the housing crisis. We use proprietary loan-level panel data matched to consumer credit records using borrowers' Social Security numbers, which allows for accurate measurement of the effects. Our main focus is on borrowers with agency loans, which constitute the vast majority of U.S. mortgage borrowers. Relying on variation in the timing of resets of adjustable rate mortgages, we find that a sizable decline in mortgage payments ($150 per month on average) induces a significant drop in mortgage defaults, an increase in new financing of durable consumption (auto purchases) of more than 10% in relative terms, and an overall improvement in household credit standing. New financing of durable consumption by borrowers with lower housing wealth responds more to mortgage payment reduction relative to wealthier households. Credit-constrained households initially use more than 70% of the extra liquidity generated by mortgage rate reductions to repay credit card debt— a deleveraging response that can significantly restrict the ability of monetary policy to stimulate these households' consumption. These findings also qualitatively hold in a sample of less-prevalent borrowers with private non-agency loans. We then use regional variation in mortgage contract types to explore the impact of lower mortgage rates on broader economic outcomes. Regions more exposed to mortgage rate declines saw a relatively faster recovery in house prices, increased durable (auto) consumption, and increased employment growth, with responses concentrated in the non-tradable sector. Our findings have implications for the pass-through of monetary policy to the real economy through mortgage contracts and household balance sheets.

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I.   Introduction

There has been a long-standing debate among economists regarding the effects of monetary policy on the real economy (e.g., Bernanke and Gertler 1995). During the Great Recession, the Federal Reserve reduced short-term interest rates and made large purchases of mortgage-backed securities in an attempt to stimulate household spending and support the prices of assets such as houses.[1] Remarkably, despite the economic importance of such actions, empirical evidence on the consequences of this extraordinary policy intervention is fairly limited. In this paper we aim to inform this debate by providing novel evidence on the impact of lower interest rates on mortgage borrowers and broader economic outcomes during the recent economic downturn.

Two challenges have confronted researchers who have tried to explore the effects of lower interest rates on a broad set of household choices: the availability of data and an empirical strategy to achieve credible identification. The first challenge reflects a general issue with consumer credit analysis—namely, that there is substantial dispersion in borrowers' credit outcomes due to differences in creditworthiness, income, or location. Thus one needs a sufficiently large and representative sample with information on a rich array of consumer outcomes—such as monthly mortgage payments, outstanding credit card debt, and auto loan debt balances—to detect potential effects.

We address the first challenge by relying on a comprehensive proprietary dataset belonging to a large financial institution. This loan-level panel data on millions of U.S. mortgage borrowers in the agency market has detailed information on loan, property, and borrower characteristics and monthly payment history on mortgage debt. All records in this data have been matched to consumer credit bureau records using borrowers' Social Security numbers. This merge results in a highly accurate dataset on the credit conditions and consumer debt spending patterns for each borrower, giving us more power to detect even small effects in noisy consumer credit measures. In addition, our sample is quite representative of the U.S. population, since the vast majority of mortgages in the U.S. are agency loans.

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[1] See Stroebel and Taylor (2012) who discuss such interventions and estimate the impact of the mortgage-backed securities purchases by the Federal Reserve on mortgage interest rate spreads.

The second challenge confronting researchers studying the effects of lower interest rates on household choices is a credible research design. Factors that impact interest rates also typically affect households and economic outcomes through a variety of other mechanisms. For example, households that face lower interest rates are usually more creditworthy, and hence their subsequent behavior may reflect their inherently strong credit profile and not just their lower cost of credit. Similarly, changes in interest rates over time are unlikely to be fully exogenous to the evolution of economic conditions and instead reflect other aspects of broader economic activity.

We address this challenge by using variation in the timing of rate resets of adjustable-rate mortgages (ARMs) across homeowners to trace the differential response of otherwise similar households. We focus on the recent period (late 2007 through 2012) in which the major interest rate indices, such as the LIBOR and one-year Treasury rates, experienced an unprecedented and rapid decline and subsequently remained low for an extended period of time. Due to the rate indexation of ARM contracts, borrowers with ARMs benefited on average more from this decline in interest rate indices—at least in the short term—relative to borrowers with fixed-rate mortgages (FRMs). Moreover, less creditworthy or underwater borrowers had limited refinancing opportunities during our period of interest, and were thus even more exposed to changes in mortgage rates through ARM rate resets.

To study the impact of mortgage rates on households' decisions, we exploit institutional features of adjustable-rate mortgage contracts. In particular, we use the fact that commonly used 5/1 ARMs contracts have an initial five-year fixed rate period, while 7/1 ARMs have a seven-year fixed rate period (and reset annually thereafter). In months 61 and 73 of the loan's life, 5/1 ARMs reset to a new interest rate based on prevailing indices (which were much lower during our sample period, on average), while 7/1 ARMs remain in their fixed rate period. Consequently, monthly scheduled mortgage payments of 5/1 ARM borrowers fell on average by $124 during the first year after the reset and $163 during the second year. These changes are measured relative to 7/1 ARM borrowers who see no change in mortgage payments prior to reaching their first rate reset. Our identification assumption, which we substantiate later, is that in the absence of the earlier reset, borrowers with 5/1 ARM contracts would display comparable patterns of behavior (up to a constant difference) relative to borrowers whose mortgages reset two years later.

Employing this empirical strategy to our uniquely matched data, we explore the impact of lower monthly mortgage payments on a range of credit market outcomes. Unsurprisingly, and consistent with other studies, we find that households subject to lower mortgage rates have lower mortgage default rates. Unlike previous studies, however, we examine the full credit portfolio, and find that households use the additional funds generated by lower mortgage payments to improve their position in the unsecured credit market, with significant declines in outstanding credit card debt, delinquent card balances, and credit card utilization rates after their mortgage rate resets. We estimate that outstanding credit card debt falls by $616 on average during the first two years of lower rates, and that roughly 18% of the liquidity provided by lower mortgage payments goes toward "saving" in the form of paying down unsecured debts.

We also observe a relative *increase* in the auto debt balance of 5/1 ARM borrowers after the rate reset. Two years after the reset, the auto balances of these borrowers increase on average by about $324, which constitutes about 10% of the extra liquidity generated by rate reductions over the first two years of rate decreases. This additional auto debt is driven by a sizable increase in new auto loan financing, reaching more than 10% in relative terms two years after the mortgage payment reduction. This finding supports the view that debt service costs inhibit durables purchases, as in Mian, Rao, and Sufi (2013), and in the literature on "consumption commitments" (see, e.g., Chetty and Szeidl 2007).

Interestingly, we find significant heterogeneity in these effects across different types of borrowers. We find that new financing of durable consumption (auto purchases) by borrowers with lower wealth levels—as proxied by lower housing wealth—is significantly more responsive to mortgage payment reduction when compared with wealthier households. This finding is consistent with mainstream life-cycle household finance models (Zeldes 1989; Carroll and Kimball 1996; Carroll 1997) that predict a larger increase in consumption due to an income shock among borrowers with lower wealth levels.

However, we also find important heterogeneity in this response depending on the amount of credit card debt carried by the borrower. Less-creditworthy borrowers with significant credit card debt balances use more than 70% of the liquidity provided by lower mortgage payments to repay

4

their credit card debts during the first year after the rate reset. These borrowers also display significantly smaller increases in auto debt financing, suggesting a more muted response of their durable consumption to mortgage rate reductions. Our findings suggest that the debt deleveraging process may significantly restrict the ability of monetary policy to quickly stimulate consumption for some borrowers.

We also verify that our findings hold beyond agency mortgages. Employing our empirical strategy on another dataset that provides mortgage performance and credit records for borrowers with non-agency loans, we broadly find similar qualitative effects. Any discrepancies between the two samples, as we discuss later, can best be explained by the nature of borrowers with non-agency loans in this sample relative to the overall population of U.S. mortgage borrowers. Overall, we document significant heterogeneity across borrowers in their response to mortgage payment reductions depending on their credit position and housing wealth.

In the second part of our analysis, we explore the impact of monetary policy on broader economic activity such as housing prices, aggregate durable consumption, and employment. In order to investigate such a connection, we exploit the significant regional heterogeneity in the share of mortgages that are of adjustable-rate type. The fraction of adjustable-rate mortgages in a region (zip code) is generally persistent over time and was determined prior to the large declines in interest rate indices that occurred during the recent crisis. Thus, we can trace the effects of these rate declines on economic outcomes using variation in this ex ante measure of regional exposure. That is, we compare changes in economic outcomes in zip codes that had a higher concentration of adjustable-rate mortgages—and therefore were also regions more likely to benefit from interest rate reductions—to changes in economic outcomes in similar regions with a relatively lower concentration of loans of adjustable-rate type.

We take a number of steps to address the natural concern that zip codes with a larger share of adjustable-rate mortgages could be different from those that have a lower share. First, we use propensity score matching methods to identify zip codes that have "common support" on observable characteristics. Second, in our analysis we control for a rich set of regional characteristics to account for any remaining observable differences across zip codes. Finally, we note that our analysis allows for constant differences (controlling for other observables) in the

5

evolution in outcomes across zip codes with higher and lower shares of ARMs that are not due to interest rate declines.

Consistent with our earlier evidence, we show that regions with a higher concentration of adjustable-rate mortgage loans experienced a significant decline in prevailing mortgage interest rates following a drop in major interest rate indices. These more exposed regions also saw a relative decrease in mortgage default rates, lower rates of house price decline, increases in durable consumption (auto sales), and a relative improvement of employment growth in the non-tradable sector. This evidence indicates that a reduction in mortgage rates during the most recent recession had an economically meaningful impact on foreclosures, delinquencies on non-targeted consumer debt, durable consumption, house prices, and employment (at least in the near term). These findings have direct implications for the literature that studies the pass-through of monetary policy to the real economy through mortgage contracts and household balance sheets (Mian and Sufi, 2012).

Our analysis contributes to the household finance literature and especially to studies that investigate the role of liquidity constraints and interest rates on consumer behavior (e.g., Gross and Souleles 2002).[2] Our paper is also related to the literature on how households respond to income changes and government stimulus programs.[3] In the context of this literature, we provide an empirical assessment of the household response to a different form of stimulus: the reduction in mortgage rates during the economic crisis through monetary policy. Our setting is unique because of the size and persistence of the change in the cost of servicing mortgage debt, which reduces payments each month and by thousands of dollars over the loan term.

Our paper is also connected to prior studies that explore the effects of mortgage rate resets and mortgage renegotiations on mortgage-specific outcomes.[4] This previous research has confirmed

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[2] See Campbell (2006) and Tufano (2009) for recent surveys of this literature.
[3] Previous research has carefully examined the household responses to fiscal stimulus, in the form of tax refunds (Shapiro and Slemrod 1995), rebates (Shapiro and Slemrod 2003, Johnson et al. 2006, Agarwal et al. 2007, Shapiro and Slemrod 2009, Parker et al. 2013), or other transfer programs (Agarwal and Qian 2014, Hsieh 2003). See Jappelli and Pistaferri (2010) for a recent review of the literature on the consumption response to income changes and Parker (2011) for the discussion of studies on the effects of fiscal policy in recessions.
[4] Piskorski et al. (2010) and Agarwal et al. (2011) examine the impact of securitization on mortgage foreclosure and renegotiation rates. Mayer et al. (2014) study the effects of the announcement of mortgage modification programs on household payment behavior. Focusing on similar types of borrowers as our study, Tracy and Wright (2012) use

that homeowners who face smaller mortgage payments are less likely to default, which reduces the extent of foreclosures. In contrast, we take advantage of administrative data on agency mortgage performance perfectly matched to a panel of consumer credit records to assess the impact of lower mortgage rates on a wide range of homeowners' consumer debt and credit outcomes. In closely related, concurrent work, Di Maggio, Kermani, and Ramcharan (2014) focus on a sample of non-agency loans and employ a similar identification strategy to also document a positive impact of mortgage rate reductions on new auto financing and debt repayments.

Finally, the literature surrounding the recent housing and financial crisis, most notably, the extensive work of Mian and Sufi (2009, 2014), has emphasized the importance of household leverage in understanding the scope and depth of the recession.[5] Agarwal et al. (2012) provide evidence showing that debt relief programs, when used with sufficient intensity, may meaningfully reduce foreclosures and delinquencies on non-targeted consumer debt, and positively impact house prices. Our paper explores another key policy approach to encourage deleveraging by reducing households' debt service obligations—namely, monetary policy through both conventional and unconventional ("quantitative easing") channels. Our results, together with those of the previous work, support the view that policies designed to improve household balance sheets had a direct and sizeable positive impact on a broad range of economic outcomes during the recovery.[6]

II.   Data

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variation in mortgage rates implied by differences in contract types to estimate the impact of mortgage rate reductions on mortgage performance. Fuster and Willen (2013) use a similar microeconometric approach, comparing differential lengths of fixed initial periods on non-agency ARM contracts to study the impact of payment declines on mortgage outcomes. Haughwout et al. (2010), Agarwal et al. (2011, 2012), and Zhu (2012) explore the reduction in default risk and foreclosure rates on mortgage modifications made by private lenders and through government modification and refinancing programs, respectively.

[5] See, among many others, Keys et al. (2010, 2012, 2013), Mian and Sufi (2009), Mian et al. (2011), and Favilukis, Ludvingson, and Van Nieuwerburgh (2013).

[6] Our findings on the impact of monetary policy and lower mortgage rates on consumer spending also broadly relate to the literature on the real effects of government spending (e.g., see Auerbach and Gorodnichenko 2011; Nakamura and Steinsson 2014).

The main data used in this study comes from a large proprietary database of conventional mortgages securitized by a large secondary market participant. These mortgages are conforming loans made to borrowers with relatively high credit scores (620 or higher on average). Conforming mortgages meet the conforming loan limit, which has been $417,000 since 2006 for a one-unit, single-family dwelling in a low-cost area. Our sample includes 5/1 and 7/1 ARMs originated between January 2003 and July 2007 that were used to finance single-family, one-unit properties. In order to evaluate the impact of differential timing of payment shocks to these two different contracts, loans in our sample must have made at least four years of payments and thus remain active at a loan age of 48 months. Our sample has 348,259 such loans, of which 244,765 are 5/1 ARMs and 103,494 are 7/1 ARMs.

From this mortgage data, we can identify all of the original loan information and subsequent payment activity in each month until the loan is voluntarily prepaid, foreclosed, or still active as of 2013:Q3. Information at origination includes borrower income, original FICO score, LTV ratio, loan balance, initial teaser rate, and the index and margins used for rate resetting. Payment activity in each month includes the actual mortgage rate based on index and margin, loan balance, and payment and delinquency (DLQ) status. We focus on 60+ days delinquent as our measure of delinquency status. Using the data provider's proprietary zip-code-level home price indices and information on all liens on a given property, we are able to track the monthly mark-to-market combined LTV (CLTV) ratio for loans in our sample.

The data provider has merged this mortgage data with each borrower's consumer credit bureau records using Social Security number. The merge results in perfect match quality between these datasets for all borrowers. This combined data constitutes a considerable advantage over commercially available products, which instead employ statistical match algorithms to conduct such merges, often resulting in substantial matching errors and mismeasurement. In addition, unlike commercially available products, our data is much more representative of the overall distribution of U.S. mortgage borrowers.[7]

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[7] Commercially available products primarily rely on statistical matching algorithms and consequently guarantee a good match quality for only a subset of mortgages. For example, the BlackBox-Equifax database guarantee a high match quality for less than 50% of non-agency mortgages (see Piskorski et al. 2014). In addition, such datasets cover only non-agency securitized loans, which constitute a smaller share of all outstanding U.S. mortgages. We focus instead on agency loans that constitute the vast majority of outstanding residential mortgages in the United States.

Our merged data allow us to observe the current credit history of mortgage holders in each month following loan origination. To capture the household balance sheet, we use information on the borrower's current FICO credit score, outstanding credit card balance, utilization rate of all credit cards, balance of all delinquent credit cards, auto debt balance, and outstanding student loan debt. The auto debt balance also allows us to identify new auto financing transactions, since such transactions are accompanied by a significant discontinuous increase in a borrower's outstanding auto debt. We also use recent credit inquiries as a proxy for new credit demand. Put together, this data provides a comprehensive look at each homeowner's overall credit portfolio.

Finally, we note that on observable characteristics, our data is broadly representative of most U.S. mortgage borrowers. First, as Table 1 shows, our borrowers have mortgage balances and FICO credit scores that are close to the population averages (see Keys et al. 2010). Second, our data consists of agency-insured loans, a category of loans constituting the vast majority of residential mortgage loans issued in the United States. Third, while we focus on ARMs, we also verify that the distribution of observable risk characteristics in our sample is similar to the overall distribution of these characteristics among agency loans.

III.   Empirical Methodology and Descriptive Statistics

Our research design is predicated on the fact that 5/1 ARMs have a five-year fixed rate period, while 7/1 ARMs have a seven-year period. After the fixed period concludes, these loans reset once a year thereafter based on the relevant index to which they are benchmarked. Thus in months 61 and 73 of the loan's life, the 5/1 ARMs reset to a new interest rate, while the 7/1 ARMs remain in their fixed-rate period. A similar identification strategy has been used to explore sensitivity of the mortgage default to interest rates in Tracy and Wright (2012) and Fuster and Willen (2013). This previous research has confirmed that homeowners who face smaller mortgage payments are less likely to default. We confirm that these patterns are also present in our nationally representative dataset. We then turn to the main focus of our analysis: the impact of lower mortgage rates on a broad range of spending and credit outcomes and the broader economic consequences of rate reductions.

More formally, to analyze the household-level response to rate resets, we run difference-in-differences regressions of the form:

$$Y_{it} = \alpha + \beta_1 1_{Type_i=5/1} + \beta_2 1_{Loan\ Age_{it}>60} + \beta_3 1_{Type_i=5/1} 1_{Loan\ Age_{it}>60} + \delta X_i + \varepsilon_{it}. \quad (1)$$

In the above specification, the dependent variable, Y_{it}, is a credit-related outcome variable for borrower i at time t. β_1 captures any baseline difference between credit outcomes of borrowers with 5/1 and 7/1 ARM loans, β_2 captures the vintage effect of having a mortgage which is outstanding for at least 60 months, and β_3 is our key coefficient of interest, indicating the differential effect due to the mortgage rate adjustment. X_i is a vector including borrower- and loan-level characteristics at origination, such as the initial rate, initial FICO score, and initial CLTV, as well as month of origination fixed effects and state fixed effects. For robustness, we also interact the product dummy and loan age dummies with other controls to allow for more flexible specification.

A key identification assumption of our analysis is that credit outcomes of 5/1 and 7/1 ARM loans in our sample were generally similar across a range of characteristics at origination, and also experienced similar trends (up to a constant difference) prior to interest rate resets beginning in month 61. Table 1 provides support for this assumption in terms of borrower and contract characteristics, both at the beginning of our sample (in month 48 of their life, panel A) and in month 60, the month immediately prior to the reset date (panel B). At the time of loan origination, the average FICO scores of the borrowers of these two contract types are only four points apart, less than one-tenth of a standard deviation. The average mortgages also feature very similar interest rates, loan amounts, LTV ratios, and reset margins. In Panel B of Table 1, it is clear that by month 60, the fortunes of the two groups remain quite similar. The difference in FICO scores between borrowers with a 5/1 and 7/1 ARM is 11 points, or one-seventh of a standard deviation. In addition, 5/1 ARM borrowers have slightly more revolving debt and slightly higher utilization rates. Finally, Panel C of Table 1 indicates that both 5/1 and 7/1 borrowers have a similar distributions of outstanding revolving debt balances, credit scores, and credit utilization rates prior to the first 5/1 rate reset.

As we will show, between months 48 and 60 (the "pre-reset" period), 5/1 and 7/1 ARM borrowers exhibit similar trends in all of these variables. Observing similar trends prior to the first rate reset is comforting given that 5/1 ARM borrowers carry somewhat more credit card and auto debt and have slightly lower FICO scores, which suggest that the 5/1 ARM borrower group contains a slightly larger share of risky borrowers. We also look for anticipatory behavior of households prior to the rate change in month 61 and, as discussed below, do not find significant evidence of anticipatory effects.

We next confirm that the rate reset has a substantial impact on the prevailing interest rate faced by borrowers and thus on their monthly payments during this period. Figure 1A shows the average current interest rate for each type of mortgage. In this figure and all subsequent figures using this microdata, vertical lines are added at month 60, the month preceding the first rate reset for the 5/1 ARM borrowers, and at month 72, which precedes the second interest rate reset. The corresponding difference-in-differences estimates, shown in the first column of Tables 2A and 2B, indicate that that interest rates were 114 basis points lower on average one year after reset, and 175 basis points lower two years after reset for 5/1 borrowers relative to 7/1 borrowers.

These rate resets translate into substantially lower monthly payments for 5/1 ARM borrowers, as shown in Figure 1B. Monthly payments drop dramatically in months 61 and 73, producing declines in monthly payments on average of $125 during the first year and $163 in the second year relative to their 7/1 counterparts (see Column (2) of Tables 2A and 2B), implying a 20% reduction in monthly mortgage payments and a two-year cumulative savings of $3,456 on average. This result represents the first stage of our analysis, as it is clear from Figures 1A and 1B that 5/1 ARM borrowers face very different monthly mortgage obligations after their reset date, despite being similar to 7/1 borrowers both at origination and at the time of the rate reset across a wide range of mortgage and credit characteristics.

IV. Micro Evidence

IV.A Impact of Mortgage Payment Reduction on Mortgage Default

We first verify that, consistent with prior studies, lower mortgage payments induced by rate resets significantly reduce the likelihood of delinquency. Mean mortgage delinquency rates of 5/1 and 7/1 ARM borrowers follow similar patterns prior to the month 61 rate reset, but start to diverge with 5/1 ARM borrowers experiencing a relative decline in delinquencies when their payments are reduced (see Appendix A1). Our difference-in-difference estimates, shown in Column (3) of Tables 2A and 2B, indicate that the likelihood of 60+-day delinquency falls by 0.5 percentage points on average after one year and 1.8 percentage points after two years. These estimates imply that a reduction of monthly mortgage payments by about 20% on average reduces the likelihood of mortgage delinquency after two years by about 40% relative to the mean delinquency rate among 5/1 ARM borrowers.[8]

A decline in mortgage delinquency of this magnitude is in line with previous estimates of the impact of payment reductions on default risk. Tracy and Wright (2012) use comparisons of ARM and FRM borrowers to estimate the impact of rate reduction on mortgage default. Haughwout et al. (2010) and Agarwal et al. (2011, 2012) explore the reduction in default risk from mortgage modifications made by private lenders and through the HAMP modification program, while Zhu (2012) explores the impact of loan refinancing under the HARP program. Fuster and Willen (2013), using a similar research design, find smaller reductions in default risk, with a one-half payment reduction required to reduce delinquency hazards by 55 percent. Their sample of non-agency Alt-A loans experienced relatively higher baseline default hazards, which may account for part of this difference.[9]

IV.B Impact of Mortgage Payment Reduction on Consumer Revolving Debt

Our data, which merges administrative mortgage records with credit bureau records using Social Security numbers, allows us to explore the impact of lower monthly mortgage payments not only on mortgage performance but also on a range of other credit market outcomes. In this subsection

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[8] In results not shown, we also verify that these differences in default rates lead to corresponding differences in foreclosure rates. Results available from the authors upon request.

[9] An Alt-A mortgage, short for Alternative-A, is a type of mortgage that, due to various factors, is considered riskier than "prime" loans that constitute the majority of residential loans in the United States, and less risky than "subprime," the riskiest category. In particular, Alt-A loans were commonly given to borrowers that provided no or limited income documentation and often did not intend to reside in the properties collateralizing these loans (e.g., these properties were used for investment purposes or as second homes). See Keys et al. (2013) for more details.

we investigate the impact of rate reduction on consumer revolving debt, which mainly consists of credit card debt.

Figure 2A shows that the two groups had similar pre-reset trends in outstanding revolving debt, but that 5/1 ARM borrowers' outstanding debt falls steadily after the reset date. As Column (4) of Table 2 shows, one year after their rates reset substantially downward, 5/1 ARM borrowers had on average $218 less in revolving credit card debt than 7/1 ARM borrowers who had not experienced a rate reset. Although the adjustments on this dimension of the credit portfolio are gradual, the gap in revolving debt widens to $616 on average by two years after the rate reset. Our estimates imply that the borrowers used on average about 18% of the additional liquidity generated by rate reductions to pay down their revolving debts (e.g. credit cards).

We next analyze the dynamics of revolving debt balances in the periods before and after the reduction in mortgage payments (due to a rate reset). For this purpose we estimate a version of specification (1) with outstanding revolving debt balance as the dependent variable, but instead of a "post-reset" time dummy we include quarterly fixed effects for the loan's life and their interactions with the 5/1 mortgage type dummy. This allows us to estimate the cumulative differential change in the revolving debt balances of 5/1 ARM borrowers during the first three quarters preceding the interest rate reset as well as during each of the eight quarters following the rate reset (with the fourth quarter preceding the rate reset serving as the excluded category).

Figure 2B presents these estimates. The results show no significant evidence of differential changes in the outstanding revolving debt balances of 5/1 ARM and 7/1 ARM borrowers prior to the rate reset. This confirms our inference from Figure 2A, which also shows no visible changes in the evolution of mean debt balances between these two groups of borrowers prior to the rate reset. Furthermore, consistent with our results from Table 2, Figure 2B shows a progressive relative decline in the revolving debt balances of 5/1 ARM borrowers after the reduction of their mortgage payments. We also estimate the version of specification (1) where we use quarterly changes in the revolving balance as the dependent variable and find similar results (see Section IV.E for more discussion).

These deleveraging effects can also be seen in the revolving credit utilization rate, which falls relatively by an estimated 1.6 percentage points for borrowers with 5/1 ARMs after the rate reset (see Appendix A2). We also find that mortgage borrowers who benefit from the rate reset are also less likely to carry any delinquent revolving credit debt balance after two years (see Appendix A1). These improvements in 5/1 ARM borrowers' position in the credit card market are highly statistically significant two years after the reset date.

IV.C Impact of Mortgage Payment Reduction on Durable Consumption (Auto) Financing and Other Credit Outcomes

We next turn our attention to the financing of car purchases by borrowers. As Figure 3A indicates, outstanding auto debt of the two groups of borrowers follows a similar pattern prior to the reset rate of 5/1 ARM contracts. Interestingly, we observe a steady relative *increase* in auto debt balance for 5/1 ARM borrowers after the rate reset. This effect is also visible in Table 2B: during the two years after the reset, the auto balances of these borrowers increased on average by $324.

Figure 3B shows a progressive differential increase in auto debt balances of 5/1 ARM borrowers, reaching about $300 in the eighth quarter after the reduction in mortgage payments. As in Figure 2B, the figure plots the quarterly interactions with a 5/1 mortgage-type dummy to capture the differential change in auto debt over the period. Consistent with our prior results, the figure also indicates no differential change in the average level of auto debt balances of 5/1 ARM and 7/1 ARM borrowers prior to the rate reset.

We next investigate whether the increase in auto debt among borrowers experiencing the reduction in mortgage payments can be explained by an increase in new outstanding auto loans. Such new car loans can be identified in our data using the monthly evolution of auto debt balances. In particular, a substantial increase in outstanding auto debt in a given month is indicative of a new auto financing transactions occurring in that month. After identifying such instances in our data, we investigate the evolution of the probability of new auto financing among borrowers with 5/1 and 7/1 ARMs.

Figure 4A indicates a differential increase in the average probability of new auto financing of 5/1 ARM borrowers during the two years after the reset. Consistent with this pattern, Column (6) of Table 2B indicates that 5/1 ARM borrowers experience a differential 1.2 percentage point increase in new auto loan financing during the first two years of reduction in their mortgage payments.

Figure 4B presents the estimated differential change in the quarterly probability of new auto financing of 5/1 ARM borrowers prior to and after the rate reset. We find no evidence of differential changes in the probability of new auto financing in the quarters preceding the reduction of mortgage payments. Consistent with our prior results, the estimates in Figure 4B indicate a progressive differential increase in the probability of new auto financing among borrowers experiencing a reduction in their mortgage payments. Two years after the reduction in mortgage payments, 5/1 ARM borrowers are significantly more likely to purchase a new car, with an estimated increase in the probability of new auto financing of 0.52% constituting an 11% relative increase in the probability of buying a new car.

Overall, the above evidence suggests that borrowers experiencing a reduction in mortgage payments increase their durable (auto) consumption. Using monthly auto debt payments as a proxy for monthly auto consumption, our results suggest that two years after a rate reset, the value of household durable consumption increased on average by 10% of the extra liquidity generated by the mortgage payment reductions over the two-year period. However, this estimate should be interpreted with caution since we do not observe other forms of auto financing (e.g., using cash) in our data.

Furthermore, our analysis also establishes that reducing monthly mortgage payments enhances the overall credit standing of borrowers. In particular, we find that 5/1 mortgage-holders have significantly less demand for credit and statistically significantly higher credit scores two years after the rate reset (see Columns (7) and (8) of Table 2B and Appendix A2). We observe that new credit inquires of 5/1 ARM borrowers initially rise in relative terms after the rate reset and then subsequently fall, suggesting that the extra liquidity encouraged borrowers to finance new car purchases. Subsequently, however, these borrowers relied less heavily on other consumer debt, such as new credit card borrowing, for consumption smoothing and other purposes.

Finally, we also investigate the impact of rate reductions on the speed of repayment of household mortgage debt. In unreported results, we find no evidence of significant accelerated repayment of mortgage debt due to the downward rate reset, as the vast majority of borrowers continue to follow their *scheduled* mortgage payments. Likewise, we do not find a significant effect of mortgage payment reductions on the repayment of outstanding student debt.

IV.D Response Heterogeneity

The above analysis focused on the average response of borrowers to mortgage payment reductions, finding that extra liquidity is used to pay down revolving debt and to increase durable consumption. However, less wealthy and liquidity constrained borrowers may be especially sensitive to changes in income or consumption commitments. In this section, we analyze borrowers' responses to mortgage payment reductions across available measures of liquidity constraints and wealth.

We use a borrower's credit card utilization rate as a direct measure of liquidity constraints, which is considered to be far superior to earlier survey-based proxies of perceived credit constraints (see, e.g., the discussion in Gross and Souleles 2002). For robustness, we also use FICO scores as a direct measure of creditworthiness since borrowers with lower credit score levels generally experience more limited access to credit and face higher borrowing costs. We note that our empirical proxies of borrowers' creditworthiness and liquidity constraints are highly correlated with outstanding revolving debt. Borrowers with above median credit utilization (below median credit score) have on average about $15,842 ($12,476) more outstanding credit card debt compared with borrowers with below the median.

To proxy for the borrower's wealth level we use the combined loan-to-value (CLTV) ratio of outstanding mortgage debt. Borrowers with less housing equity can be thought of as being relatively less wealthy compared to similar borrowers with more housing equity. We note that borrowers with above median CLTV in our sample have very little equity -- less than 5% of current home value on average as of month 60 -- and many of these borrowers are underwater on their homes (i.e., have negative estimated housing equity). In contrast, borrowers with below

median CLTV, on average, have a sizeable amount of positive equity left in their homes (more than 20% of current home value).

Tables 5A and 5B investigate how the consumer response to mortgage payment reduction varies across the credit utilization rate and CLTV ratios. The regression specifications here interact the difference-in-differences terms (5/1 ARM, loan age > 60, and the interaction of the two), as described in equation (1), with an indicator for whether these credit characteristics was above or below the median prior to the rate reset.

The results suggest that borrowers with above-median credit utilization rates used on average about 40% to 50% of additional liquidity (about $597 to $814) in the first year of the rate reduction to repay their revolving debt and about one-third of the additional liquidity ($1,116 out of about $3,500) over the two-year period. This implies that the "savings rate" of these households from additional liquidity drops from 50% in the first year to about 20% in the second year of rate reduction.[10] In contrast, we find no evidence that borrowers with below-median utilization rates "save" significant amounts of additional liquidity by repaying their debts, despite facing a similar reduction in mortgage payments to more indebted borrowers. We find a similar pattern when we split the sample by FICO score as homeowners with lower FICO scores paid down relatively more debt, especially revolving debt, during the two years after their mortgage rate reset (see Appendix A4).

Our results suggest that this debt deleveraging process may constrain the durable consumption response of these borrowers to rate reductions. As we observe from Table 5 and Appendix A3 and A4, borrowers with above-median credit utilization rates and borrowers with below-median FICO scores experience smaller increases in their auto debt levels following the reduction in their mortgage payments compared with more creditworthy borrowers. On the other hand, borrowers with higher CLTV ratios but low credit utilization do not appear to use significant amounts of extra liquidity to repay their credit card debts. Interestingly, we also find that these borrowers experience a much larger increase in auto debt as long as they are not heavy users of credit card debt: about $343 to $440 overall, which amounts to up to 12% of the value of the

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[10] Similar results hold in a specification without interaction terms for above-median CLTV (see Appendix A3).

extra liquidity due to rate reductions. These borrowers also experience a much greater relative increase in the absolute probability of a new auto finance transaction following the mortgage rate decrease, about 2.5 percentage points overall.

These results suggest that more-constrained and more-indebted borrowers pay down *more* of their consumer debts than their less-constrained counterparts in response to a decrease in mortgage payments. To further explore this effect, we turn our attention to two subsamples of the relatively most constrained and least creditworthy borrowers, the top quartile of borrowers based on their credit utilization rates and the bottom quartile of borrowers based on their credit score. As shown in Table 4, borrowers in the top quartile of credit utilization rates allocate about 70% of extra liquidity generated by mortgage payment reductions in the first year toward repaying their credit card debt. Consistent with our prior results, borrowers' propensity to use additional liquidity to repay their debts progressively declines over time as they repay their debts. Rather than simply consuming the full amount, these constrained borrowers allocate about 30 to 40% of extra liquidity towards revolving credit debt repayment over a two year period. As the proportion of savings going toward debt repaying declines, these results support the view that heavily indebted households initially prioritize relaxing their credit constraints and paying down their most expensive debts.

IV.E Robustness and Extensions

In this section we discuss a number of robustness checks we performed regarding the nature of our findings. For brevity reasons, several of these results are discussed but not reported. First, we verify that our findings are not an artifact of differential prepayment and refinancing patterns across the two groups of borrowers, which could induce relative changes in the quality of borrowers around the rate resets. First, we note that in the case of rate reductions such concerns may be less important, as lower rates deter prepayment.[11] Second, we note that the prepayment patterns of borrowers with these two types of loans generally follow similar patterns. Furthermore, we confirm that our results hold in subsamples of loans that display very low

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[11] See Tracy and Wright (2012), who explain that in the case of mortgage payment reductions through rate resets, one would not expect to see a spike in prepayments in the treated group. They argue that this downward pressure on payments results in a relatively constant sample composition around reset dates.

refinancing probability around the reset rate. For example, we note that despite our focus on agency loans, our sample includes a significant number of mortgages with high current CLTV ratios (see Appendix A5). We find similar results when we restrict our attention to such borrowers with high CLTV ratios who face limited refinancing opportunities, as evidenced by their low prepayment speeds.[12]

In Appendix A6 we provide results from an even more rigorous approach to addressing concerns related to differential prepayment. First, we estimate a model of prepayment by month 48 (prior to our window of observation for the rest of our analysis) using loan and borrower characteristics at origination, such as income, FICO score, LTV, interest rate, and loan amount. We then predict a prepayment propensity based on the results of this regression (not shown). As a test of whether our results are affected by differential prepayment, we restrict our sample to only those loans present as of month 48 that have below-median prepayment propensity. As Appendix A6 shows, our results are consistent in terms of signs and magnitudes for all of our key results.[13] Even in a sample of loans with low probability of prepayment, interest rate declines lead to reductions in mortgage delinquency, credit card debt, and credit utilization, and increases in auto debt and new auto financing.

Second, one could be concerned that some of our results are affected by the selection of borrowers (potentially on unobservables) into different product types (5/1 ARM versus 7/1 ARMs). As we discussed above, we do not find any evidence of differential patterns in evolution of credit outcomes between these two groups of borrowers prior to the reset rate, yielding support to our empirical design. In addition, we note that our results also hold when we match the loans in these groups more closely on characteristics observable at origination. Finally, 5/1 ARMs loans resets occur at different time periods in our sample due to variation in origination dates. Exploiting reset timing variation only within the sample of 5/1 ARMs reveals similar effects of rate resets on outcomes.

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[12] Borrowers with agency loans could also take advantage of the Home Affordable Refinancing Program, HARP, which started in 2009. However, initial restrictions on the extent of negative equity allowed would prevent many loans in our sample from refinancing. In addition, higher guarantee fees for less-creditworthy borrowers and other institutional factors may have significantly limited the reach of the program during the period of our study.

[13] We note that the estimated magnitude of the revolving debt repayment is smaller in this sample relative to the one based on overall data. This is due to a relatively smaller fraction of borrowers with significant amount of revolving debt in this sample compared to the overall data. Once we take this into account we do find very similar estimated changes in revolving debt repayment as in our overall sample.

Third, most of our specifications investigate the differential evolution in the cumulative level of a given credit outcome (e.g., revolving balance or auto debt). For robustness, we also estimated our specifications with the quarterly (or monthly) changes in the outcome variables as the dependent variable and find very similar results.[14]

Fourth, we verify that our findings also hold beyond agency mortgages. Using BlackBox-Equifax data that provides mortgage performance and credit records for borrowers with non-agency loans, and employing a similar empirical strategy to a sample of more than 50,000 non-agency adjustable-rate mortgages, we broadly find similar qualitative effects. However, the estimated magnitudes of some of the effects are different: for example, we find a larger increase in auto finance transactions due to rate reductions in the non-agency sample relative to the average effect in our main agency-based mortgage data (see Appendix A7). Our findings are consistent with contemporaneous work by Di Maggio et al. (2014) that also investigates the effects of rate reductions in a sample of non-agency borrowers and finds similar results. These differences in the estimated magnitudes of the effects among agency and non-agency borrowers can be explained by the differences in the borrower characteristics, loan amounts, and contract terms across the two groups of borrowers.[15]

Finally, our estimates report an average effect due to rate decreases across loans originated between 2003 and 2007, although we control in all of our specifications for quarterly origination cohort fixed effects. We note, however, that our results are qualitatively unchanged when we perform our analysis in subsamples based on narrow ranges of origination dates.

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[14] See, for example, Appendix A7, which presents the estimated quarterly differential changes in the outstanding auto debt balance of 5/1 ARM borrowers relative to the revolving debt balance of 7/1 ARM borrowers in the three quarters preceding the first reset date of 5/1 ARMs and the eight quarters following the reset date.

[15] To apply a similar empirical strategy in the BlackBox-Equifax data, we need to confine our attention to a fairly small sample of mostly Alt-A non-agency loans (about 50,000 of loans compared to about 350,000 agency loans in our main sample). These loans are commonly given to borrowers who buy more expensive homes relative to the population average and are much less likely to use them as their primary residence than the national average (e.g., these are often investment or second home purchases). As these loans carry much larger balances than the ones in our data and often do not feature amortization of principal amount after their first reset date, the effect of reset on the level of reduction in mortgage payments in the non-agency sample is more than four times as large as in our main agency sample – i.e., a monthly average reduction in mortgage payments of about $650 compared to about $150 among agency loans.

IV.F Implications for the Consumption Response to Mortgage Rate Reduction

To directly investigate the connection between consumption and mortgage rate reductions, we would need individual consumption data linked to mortgage data, which we do not have access to. This problem is common to the household finance literature, which instead often infers the consumption response to various events from changes in consumer debt (see Gross and Souleles 2002). Such inferences, however, face a number of well-known challenges. For example, a lack of data regarding checking or savings accounts of households or stocks/401(k) accounts complicates inferences about a borrower's saving rate. Keeping such caveats in mind, we will use our estimates regarding consumer debt patterns to infer some characteristics of the consumption response to mortgage rate reductions.

Our estimates point to a meaningful increase in durable consumption following a reduction in mortgage payments. This finding is consistent with studies that document an increase in durable consumption by households financed with collateralized lending following a positive income shock (see, for example, Aaronson, Agarwal, and French 2012).

Our results from earlier subsections also imply that less-creditworthy borrowers who carry significant revolving debt balances initially saved about 70% of additional liquidity from mortgage payment reductions in the form of repayment of credit card debt, thus allocating at most 30% of extra liquidity for spending purposes. Consistent with this observation, we also document weaker relative increases in financing of new durable consumption among these borrowers.

These findings may seem puzzling at first in light of the existing literature that generally documents a significantly higher propensity to spend from additional income among more-credit-constrained and less-wealthy households (e.g. Johnson et al. 2006; Agarwal et al. 2007; Parker et al. 2013).[16] First, we note that most of this literature focuses on the household response to a one-time increase in income, such as a tax rebate. In contrast, the additional liquidity in our

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[16] We note that in contrast to these papers, using survey techniques, Shapiro and Slemrod (2003) find that those households that are more likely to be constrained (i.e., lower income) are those that are more likely mostly to save, rather than mostly to spend, the tax rebate.

setting results from a lower cost of servicing debt, received in monthly installments over the life of the loan—rather than in lump sum up-front. In this regard, life-cycle models of optimal household behavior indicate that the timing and persistence of income shocks can crucially affect the response in the cross-section of households.[17]

Second, our results do not imply that the propensity to spend among more-creditworthy households is necessarily higher compared with less-creditworthy ones. Instead, our results suggest that less-creditworthy households initially allocated at most 30% of extra liquidity from rate reductions for spending purposes and appear to be less prone (at least initially) to use it for financing of new durable spending. As we do not observe the overall asset position of more-creditworthy households, these households may display an even smaller overall consumption response.

Finally, we note that if we take higher CLTV ratios as a proxy for lower household wealth, we find that the durable consumption of borrowers with less wealth responds more strongly to reduction in mortgage payments compared with wealthier households. This effect is consistent with standard household life-cycle models (Zeldes, 1989; Carroll and Kimball 1996; Carroll 1997) that predict that households with lower wealth levels should exhibit larger marginal propensities to consume out of income shocks than households with more wealth. However, as discussed above, this response is significantly reduced if households carry substantial amounts of revolving debt, as these households initially allocate a significant part of their extra liquidity to repay their debts. Given that credit card debt often bears the highest interest rate that most households face, such behavior may not be surprising; this margin of adjustment could be the most natural response for highly indebted consumers.[18] Overall, this evidence points to a more

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[17] For example, in a setting with stochastic income, Zeldes (1989) shows that households facing more income risk may initially have a lower propensity to spend from an increase in current and *future* income compared with households with lower income risk. This dampened response occurs because while the spending of households subject to more risk optimally over-responds to changes in current income, it "under-responds" to changes in their expected *future* income relative to safer households. The latter effect can dominate the former one, which may result in the relatively lower consumption response to an increase in current and *future* income among less-creditworthy households, which face more income risk.

[18] For example, in 2013 the average credit card account carried an interest rate of about 13 percentage points (Bankrate.com), which is more than three times as large as newly reset mortgage interest rates in our sample. In addition, the U.S. tax system provides an incentive to prioritize repayment of credit card debt as interest payments on credit cards, unlike those on mortgage-related debt, are not tax deductible.

nuanced interaction between measures of wealth and liquidity constraints and consumer response to mortgage payment reductions.

We conclude this section by noting that models of household behavior predict differential responses to anticipated and unanticipated windfalls. In the case of an adjustable rate reset, the timing of the reset should be perfectly anticipated by homeowners, but the direction and magnitude of the reset requires information about how interest rates have evolved since the date of mortgage origination. We note that the information about the precise value of the index to which a mortgage is resetting is not available until just before the mortgage reset date. Moreover, work by Bucks and Pence (2008) has shown that ARM borrowers are particularly poorly informed about the features of their mortgage contract related to rate resets. Survey evidence suggests that 20% answer "don't know" when asked about their original interest rate, and even larger fractions are unaware of the index their ARM is linked to, as well as per-period and lifetime interest rate caps and floors.

Based on our figures (and additional estimates not shown), our evidence suggests that there is no pre-treatment responsiveness to rate resets, with no differential improvements in any aspect of the credit portfolio occurring prior to month 61. Indeed, the improvements in 5/1 ARM homeowners' credit positions occur only gradually during the first two years after the first rate reset. This finding is consistent with research showing a delayed response of liquidity-constrained households to anticipated changes in their income or cost of debt.[19] However, even among less-credit-constrained homeowners, we find no evidence of anticipatory behavior.

V. Regional Evidence

In this section we explore the impact of mortgage rate declines on regional outcome variables such as house prices, durable consumption (auto sales), and employment. The main challenge when attempting to infer such a connection is that interest rate movements affect borrowers in all regions. We address this challenge by exploiting regional heterogeneity in the share of

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[19] For example, Stephens (2008) documents a significant consumption response to making final payments on a car loan, which suggests that some homeowners may be liquidity constrained and thus unable to respond in advance.

adjustable-rate loans across regions. We first discuss our empirical design and then present our findings.

V.A Empirical Design

Because the fraction of adjustable-rate mortgages in a region is relatively persistent across regions, and was determined prior to the rate declines that occurred during the recent crisis, we can use variation in this ex-ante measure of program exposure to trace out the effects of these rate declines on different economic outcomes. We compare outcomes in regions that had a relatively higher concentration of adjustable-rate loans—and therefore were also regions more likely to benefit from mortgage rate reductions—to otherwise similar regions with a relatively lower concentration of adjustable-rate loans.

To account for general trends in economic outcomes over the recent period, we focus on the *relative* change in the evolution of economic outcomes during the period of rate declines in the zip codes with a high share of ARMs relative to the corresponding change in the zip codes with a lower share of ARMs. Our identification assumption is that in the absence of declining interest rates, and controlling for a host of observable risk characteristics, the economic outcomes in zip codes with a higher ARM share would have a similar evolution as those with a lower ARM share, up to a constant difference. This approach is similar to that used by Mian and Sufi (2010) in evaluating the effects of the "Cash for Clunkers" program, and by Agarwal et al. (2012), who evaluate the broader consequences of debt relief programs using regional variation in exposure to the Home Affordable Modification Program (HAMP). As in other regional studies that use a difference-in-differences strategy, we will not be able to attribute any economy-wide effects to declining interest rates.

It is worth emphasizing a key limitation of our empirical design—namely, that zip codes with a larger share of adjustable rate mortgages could be different on observable and unobservable dimensions from those with a lower share. For example, part of the observed differences in outcomes across zip codes over time may not only reflect greater exposure to interest rate declines but also the unobservable differences in the profiles of borrowers in these regions.

We take a number of steps to address this concern. First, we focus only on zip codes that are relatively similar on key observables prior to the rate declines by matching the high- and low-exposure groups (e.g., zip codes with higher and lower share of ARMs, respectively) using a propensity score methodology and isolating the portion of the propensity score distribution with "common support." This approach employs a set of matching covariates, including zip-code-level averages of the FICO score of borrowers, interest rates, LTV, and delinquency rates at the beginning of our sample period. We obtain a sample of 1,000 zip codes (from an initial sample of about 10,000 zipcodes), each having at least 100 mortgage borrowers, equally split between high- and low-exposure groups, after this matching exercise (see Figure 5 for the geographical distribution of these zip codes). Second, in our analysis we control for many other characteristics of these zip codes to account for any remaining observable differences. Finally, we note that our analysis allows for differences in the evolution in outcomes across zip codes with higher and lower shares of ARMs that are not due to interest rate declines, as long as these differences are, controlling for other observables, roughly constant over time during our sample period.[20]

Our empirical strategy to explore the impact of the rate declines on regional outcome variables relies on zip-code-level data. We focus on the sample period from mid-2006 through the end of 2012. As shown in Figure 7A, from mid-2006 through mid-2007 there were only minimal changes in the major interest rate indices. Afterward, however, these rate indices experienced a substantial decline, reaching record low levels around mid-2009 and remaining low thereafter. We expect borrowers in regions with a larger ARM share to be more exposed to declining interest rates through automatic rate resets.

To obtain information regarding mortgage characteristics in a zip code, we collect individual loan-level information from two databases. The first source is the BlackBox database, which provides a comprehensive, dynamic dataset with information for more than 90% of all privately (non-agency) securitized mortgages in the United States. The second source is the LPS database maintained by Black Knight Financial Services, which provides similar dynamic information on the vast majority of agency and bank-held loans. Combining these two datasets gives us almost

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[20] We also verify the robustness of our analysis in the overall sample of zip codes -- not just matched ones--by directly instrumenting for the intensity of mortgage rate reductions in a region with our measure of ex ante exposure to rate reductions (ARM share). We find similar inference as the one we discuss in the paper.

complete coverage of mortgage loans in the United States. These datasets allow us to compute zip-code-level characteristics for variables such as average borrower FICO credit scores, zip code ARM share, and average mortgage interest rates.

We complement these datasets with the Equifax Credit Trends database, which contains zip-code-level consumer credit characteristics. In addition, we collect zip-code-level demographic information (e.g., median income, percentage of households with a college degree) from the Census Bureau's American Community Survey, house price indices from Zillow, and employment data from the Census Bureau's ZIP Business Patterns database.[21]

We first verify that the matched zip codes in our sample are indeed similar on observables. Table 5A compares the characteristics of zip codes in the period preceding the decline in interest rate indices (mid-2006 to mid-2007). To facilitate the comparison of zip code characteristics we split the matched sample into high exposure zip codes (those with above median share of ARMs) and low exposure zip codes (those with below median share of ARMs).

As we note from Table 5A, the observable characteristics are quite similar across the high- and low-exposure zip code groups. The high-exposure zip codes have very similar mean mortgage rates, credit scores, mortgage LTV ratios, unemployment rates, percentages of individuals with a college degree, and percentages of married households with children. It is worth noting that not only the means but the computed standard deviations of the two groups are quite similar on these dimensions. These patterns are also visible when we examine the evolution of FICO credit scores, LTV ratios, and interest rates in the high- and low-exposure regions in the pre-treatment period (see Figure 6) as well as the kernel densities of these variables (not shown). However, high-exposure zip codes have a larger mortgage delinquency rate (2.81% versus 2.23% in low exposure zip codes). Importantly, as Figure 6A shows, the delinquency rate in high- and low-exposure zip codes followed similar trends in the period preceding the decline in interest rates.

Next, we verify that borrowers residing in zip codes with a higher ARM share are indeed more exposed to interest rate declines. As Table 5A indicates, despite our relative balance on

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[21] We approximate the number of employees in each industry in a zip code by multiplying the number of establishments of a given employment size class by the median number of employees within the size class.

observables, there remains significant variation in the fraction of loans that are ARMs in our matched sample. The low-exposure zip codes have a mean ARM-share percentage of 17.3%, compared with a mean percentage share of 35.2% in the high-exposure zip codes.

Figure 7B plots the average mortgage rates in the high- and low-exposure zip codes. We observe little difference in average mortgage interest rates prior to the major decline of interest rate indices, but a significant relative decline of average mortgage rates in high-exposure zip codes that after the decline of the overall level of interest rate indices. This relative decline of mortgage rates occurs progressively (with visible differences emerging after 2008:Q1) as ARMs reset to lower rate levels at various calendar dates, depending on their origination date and type.[22] Hence, as more time passes since the decline of interest rate indices, a larger fraction of ARMs reset to lower rates resulting in bigger differences across the high and low exposure zip codes.[23]

To verify this pattern more formally, Table 5B confirms a strong association between the zip-code-level ARM share and the extent of interest rate declines in a zip code between 2007:Q4 and 2012:Q4. The estimate implies that a 10% absolute increase in the zip-code ARM share is associated with a 20-basis-point reduction in average mortgage rates. The magnitude of this association is largely unaffected by the inclusion of a variety of control variables capturing the observable characteristics of zip codes. Furthermore, the size of this estimate is also reasonable, as the market interest rates to which ARMs are indexed declined by more than 400 basis points during the treatment period. However, as we discussed above, ARMs reset only periodically and caps and floors may limit the extent of rate fluctuations, so we would expect only a partial (and not instantaneous) pass-through of interest rate reductions to borrowers with ARMs.

V.B Impact on Mortgage Delinquencies, Foreclosures, and House Prices

We now turn to the impact of these rate declines on regional economic measures. First we verify that, consistent with our loan-level results, zip codes with a larger share of ARMs experience a relative decline in delinquencies and foreclosures. Using our matched sample, we estimate a

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[22] ARMs usually carry fixed rates during the first few years of their maturity (e.g. initial 2, 3, 5 or 7 years)

[23] We verify that the relative decline in mortgage rates across zip codes is largely driven by the reset of ARMs that were originated prior to the decline of interest rate indices (i.e., the finding is not driven by origination of new loans after the decline of interest rate indices).

regression with the change in the zip-code quarterly mortgage delinquency rate between the period of interest rate declines (2007:Q3 through 2012:Q4) and the period preceding the rate declines (2006:Q2 through 2007:Q2) as the dependent variable. Table 6A shows that, consistent with our loan-level analysis in Section IV, zip codes with a larger ARM share experienced a relative decline in mortgage delinquency growth rate during the period of declining interest rates.[24]

An alternative way to illustrate these findings is to exploit only the differences between high- and low-exposure regions. Figure 8A plots the mean quarterly mortgage delinquency growth rate in high- and low-exposure zip codes, including a vertical dashed line to mark the beginning of divergence of mortgage interest rates across zip codes following a decline in interest rate indices (2008:Q2). As we observe from Figure 8A, while the difference between high- and low-exposure zip codes remained stable in the period preceding the rate decline, we observe a relative reduction in the mortgage delinquency growth rate in high-exposure zip codes compared with low-exposure ones when mortgage interest rates declined (after 2008:Q1).

Next, we examine the change in the house price growth in regions classified on the basis of their exposure to interest rate declines. Several recent papers argue that foreclosures create downward pressure on house prices (Campbell et al. 2011; Mian, Sufi, and Trebbi 2011). With the sizeable effect of interest rate declines on delinquency and foreclosures in high ARM share zip codes we found above, our empirical setting should allow us enough statistical power to detect house price effects as well.

Figure 8B shows that while the difference in quarterly house price growth between high and low exposure zip codes remained stable during the period of relatively constant rates, the gap between these zip codes groups grows during the period of rate declines. The estimates in Table 6B confirm that zip codes with a larger share of ARMs experienced a relative increase in house price growth. A 10% absolute increase in the high-exposure share, which is associated with about a 20-basis-point average reduction in zip-code mortgage rates, is associated with about a

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[24] In results not shown, we also find similar results when we consider the foreclosure rate: zip codes with a larger share of ARMs saw a relative decline in the foreclosure growth rate during the period of interest rate declines.

0.25% increase in quarterly house price growth.[25] In sum, zip codes with significant exposure to the decline in interest rate indices saw a meaningful relative increase in house price growth.

V.C Impact on Durable Consumption and Employment

Finally, we investigate the association between mortgage rate declines, durable consumption and employment. Unlike in the credit record, where we could only infer auto purchases from significant increases in auto debt, we can measure auto purchases directly at the zip code level.[26] Figure 6C shows the time-series evolution of the annual auto sales growth rate in high and low exposure zip codes. As we observe, zip codes with more ARMs experienced a relative increase in new auto sales growth rate compared to zip codes with fewer ARMs after the decline in level of interest rate indices. The estimates in Table 6C confirm this inference. A 10% absolute increase in the high-exposure share is associated with a 0.37% increase in quarterly auto sales growth. This result is consistent with our micro-level findings, and confirms on a regional level that monetary policy had a significant impact on durable purchases.

Next we turn our attention to employment. Figure 8C plots the time-series evolution of the annual growth in employment at the zip code level in high and low exposure zip codes, while Columns (1)-(3) of Table 7 provide the regression results. The figure shows that employment growth rates in high and low exposure zip codes followed similar patterns prior to the relative decline in mortgage rates (with no statistically significant difference in Column 3 of Table 7). However, during the period of relative decline in mortgage rates in high exposure zip codes (2009-2012), we document a relative increase in the employment growth rate in these regions.

We next investigate which sectors can account for the relatively higher growth rate of employment in high-exposure zip codes after the major decline in interest rate indices. Column (4) of Table 7 repeats the above analysis for employment growth in restaurant and grocery stores, a proxy for the local non-tradable sector. Column (5) shows the corresponding results for

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[25] It is, of course, possible that part of this house price effect reflects a change in the composition of transacted properties due to the relatively lower intensity of foreclosure sales in the high-exposure zip codes. To assess the robustness of our results to this concern, in results not shown we repeat this exercise using the CoreLogic house price index, which excludes distressed transactions. Our inferences remain unchanged.
[26] The data on auto purchases is from R. L. Polk & Company (see Mian, Rao, and Sufi 2013).

employment growth in the sector consisting of industries classified as producing tradable goods and services.[27] As we observe, high-exposure zip codes experienced a significant relative increase in employment growth in the non-tradable sector during the period of rate declines. In contrast, we observe no relative change in the growth of the tradable sector between high- and low-exposure zip codes. This finding is reassuring, as we should not expect to find a significant association between relative employment growth in the tradable sector, which reflects broader economic conditions, and the local (zip-code-level) differential improvement in household balance sheets.

Overall, our findings at the regional level corroborate those of Mian and Sufi (2014), who present evidence that adverse shocks to household balance sheets can account for a large fraction of the decline in U.S. employment from 2007 to 2009. Consistent with this view, our results suggest that a relative improvement in household balance sheets due to mortgage rate declines can have a significant positive impact on local (non-tradable) employment growth, at least in the near term.

VI. Discussion and Concluding Remarks

We find that the large interest rate declines due to monetary policy changes by the Federal Reserve had a direct and substantial impact on household balance sheets and local economies where consumers and regions were relatively more exposed to rate declines. Consumers who experienced reductions in their debt service costs due to rate declines reduced their credit card debt, purchased new automobiles, and were less likely to be delinquent on both secured and unsecured debt. These choices had significant impact on foreclosures, house prices, and employment in regions that were more exposed to interest rate declines.

Our results, along with contemporaneous work by Di Maggio et al. (2014), support the view that policies aimed at reducing mortgage rates can have a meaningful impact on macroeconomic

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[27] To classify industries as either non-tradable or tradable industries, we closely follow Mian and Sufi (2014). Specifically, retail- and restaurant-related industries are taken as non-tradable, while industries that appear in the global trade category are considered tradable.

conditions by improving household balance sheets. This evidence is consistent with Agarwal et al. (2012), who find that mortgage modification programs, when used with sufficient intensity, may meaningfully impact a range of economic outcomes. However, Agarwal et al. (2012) also show that modification programs face a range of barriers to implementation related to the industrial organization of the mortgage finance industry. In that sense, by reducing the mortgage rates of ARM borrowers, low interest rate polices may achieve similar effects to mortgage modification programs for these borrowers more quickly (at least in the near term).[28]

By automatically reducing mortgage rates when markets rates are low, ARMs can also help alleviate other frictions in the mortgage refinancing market. First, rate resets allow refinancing of borrowers regardless of the extent of their housing equity or creditworthiness. Second, they can help reduce frictions due to the limited competition in the loan refinancing market (see Scharfstein and Sunderam 2013). Third, by automatically reducing mortgage rates, ARMs may help alleviate the barriers to loan renegotiation due to securitization (Piskorski et al. 2010; Agarwal et al. 2011) and lender concerns regarding borrowers' strategic behavior (Mayer et al. 2014). Finally, existing research provides evidence of significant inertia and inattention in mortgage refinancing decisions by borrowers (e.g., Keys, Pope, and Pope 2014; Andersen et al. 2014). As ARM contracts do not require the active participation of borrowers in the process of rate reduction, they can help alleviate the adverse effects of such factors for mortgage refinancing.[29]

Our results also highlight the potential limits of monetary policy to quickly stimulate household consumption through lower mortgage rates. In particular, our evidence suggests that credit-constrained households carrying significant credit card debt balances allocate a substantial part (up to 70%) of the liquidity provided by lower mortgage payments to paying down their unsecured debt. Consequently, this debt deleveraging process can significantly dampen the initial consumption response of these borrowers. Our findings also indicate that a sizable part of the initial stimulus provided by lower mortgage rates may have been transferred to the banking

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[28] Fuster and Willen (2013) highlight the potential benefits of ARMs for implementation of low interest rate polices.
[29] See Piskorski and Tchistyi (2010) who highlight benefits of ARMs in an optimal dynamic contracting framework.

sector through the repayment of consumer debt.[30] One implication of these findings is that in order to stimulate household consumption, government policies may also consider directly targeting the cost of servicing credit card and other higher-interest debts.

Finally, it is important to reiterate a few limitations of our results. First, we focus on the effect of low interest rate policies on household balance sheets that operate through the reduction of mortgage rates on outstanding loans, leaving other channels aside (e.g., through a decline in credit card payments, easier refinancing abilities, etc.). Second, due to the nature of our empirical design, we are not able to comment on any economy-wide effects introduced by interest rate declines. Finally, we cannot comment on the broader welfare implications of low interest rate policies. Doing so would require a proper assessment of the overall value of such polices, including their potential long-term costs and distributional consequences.

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[30] In this regard, our results are similar to those in Hsu, Matsa, and Melzer (2014), who find that expansions of unemployment insurance also increased loan repayment. Thus, countercyclical programs of both fiscal and monetary types have been shown to produce indirect benefits to the banking sector.

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Table 1: Summary Statistics

This table presents summary statistics for the full sample, the 5/1 ARM sample, and the 7/1 ARM sample, for the dataset as of month 48 (Panel A) and in the month in which the loans are 60 months of age (Panel B), one month prior to the reset date for the 5/1 ARM sample. Panel C show the distribution of FICO credit score, outstanding revolving debt balances, and credit utilization in the 5/1 ARM sample, and the 7/1 ARM sample for the loans of 60 months of age. Source: Authors' calculations using data from the large secondary market participant.

Panel A: Summary Statistics for Loans in Month 48

	Full Sample		5/1 ARMs		7/1 ARMs	
	Mean	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Original Rate	5.05	0.71	5.02	0.75	5.12	0.60
Current Rate	5.05	0.71	5.02	0.75	5.12	0.60
Margin	2.48	0.31	2.48	0.32	2.48	0.28
Current Mortgage Payment	1,013	441.89	1,012	444.79	1,014	434.95
Number of Student Loans	0.42	0.80	0.41	0.80	0.42	0.81
Number of Recent Credit Inquiries	1.86	2.05	2.00	2.08	1.76	1.98
Revolving Debt	12,426	19,149	12,642	19,427	11,901	18,483
Delinquent Revolving Debt	0.036	0.21	0.04	0.22	0.03	0.20
Revolving Utilization	24.26	26.25	24.99	26.74	22.55	24.97
Auto Debt	9,147	14,262	9,223	14,361	8,995	14,026
Origination FICO	725.76	53.86	724.42	53.96	728.95	53.51
Current FICO	727.07	78.09	724.40	79.52	733.38	74.21
Origination Combined LTV	74.00	17.75	74.15	17.93	73.64	17.31
Mortgage Delinquency Rate	0.02	0.18	0.026	0.025	0.015	0.15
Number of Loans	348,259		244,765		103,494	

Table 1 [continued]

Panel B: Summary Statistics for Loans in Month 60 (one month before 5/1 ARMs reset)

	Full Sample		5/1 ARMs		7/1 ARMs	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Original Rate	5.04	0.72	5.02	0.76	5.10	0.60
Current Rate	5.04	0.72	5.02	0.76	5.10	0.60
Margin	2.48	0.31	2.48	0.32	2.49	0.28
Current Mortgage Payment	1,010	443	1,010	447	1,008	434
Number of Student Loans	0.41	0.81	0.41	0.81	0.42	0.82
Number of Recent Credit Inquiries	1.85	2.02	1.90	2.06	1.74	1.92
Revolving Debt	12,846	18,430	13,040	18,819	12,413	17,536
Delinquent Revolving Debt	0.05	0.18	0.05	0.18	0.04	0.16
Revolving Utilization	25.40	78.13	26.46	92.75	23.09	25.17
Auto Debt	8,463	21,144	8,465	21,922	8,459	19,361
Origination FICO	725.00	54.39	723.28	54.54	728.78	53.85
Current FICO	725.25	77.24	721.74	78.89	732.91	72.91
Origination Combined LTV	73.89	17.81	74.13	17.97	73.34	17.45
Mortgage Delinquency Rate	0.04	0.20	0.04	0.00	0.03	0.17

Panel C: Distribution of Credit Scores and Revolving Debt Balances for Loans in Month 60 (one month before 5/1 ARMs reset)

	p25	p50	p75	p90
	Overall Sample			
Current FICO	688.75	747.00	785.67	801.00
Revolving Debt Balance	2,273	5,956	16,200	33,488
Utilization Rate	5.43	14.47	37.77	67.40
	5/1 ARMs			
Current FICO	683.75	743.00	784.00	800.50
Revolving Debt Balance	2,303	6,145	16,665	34,102
Utilization Rate	5.60	15.33	39.87	69.55
	7/1 ARMs			
Current FICO	698.80	755.20	788.50	802.00
Revolving Debt Balance	2,215	5,589	15,190	32,031
Utilization Rate	5.11	12.84	33.27	61.96

Table 2: Baseline Difference-in-Differences Regressions for the Treatment Effect of Mortgage Payment Reduction

This table presents difference-in-difference OLS specifications to examine the differential outcomes for 5/1 ARM contracts relative to 7/1 ARM contracts after the 5/1 contracts' first reset date. Panel A presents the estimated relative change in outcomes during the first year after the reset, while Panel B presents similar results for the period of two years after the first reset (but before the 7/1 rate reset). The coefficient of interest, *Treatment*, is the estimated change in the difference between outcomes of 5/1 ARM and 7/1 ARM contract types during the period after the reset date. Thus, this coefficient captures the differential effect of the mortgage rate decline (due to a reset) on outcomes of mortgages subject to a reset (5/1 ARM contracts) relative to outcomes of mortgages that did not experience a change in interest rate (7/1 ARM contracts). The specifications include a rich set of observable characteristics as control variables including loan age and mortgage product dummies, rate at origination, FICO credit score, CLTV, quarter-year origination fixed effects and state fixed effects. Standard errors clustered by quarter of origination are in parentheses.

Panel A: One Year after Mortgage Payment Reduction

	Monthly Interest Rate	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing	Recent Credit Inquiries	Current Credit Score (FICO)
Treatment	**-1.14**	**-125.08**	**-0.006**	**-218.37**	**91.97**	**0.004**	**0.041**	**-0.57**
	(0.30)	**(24.52)**	**(0.004)**	**(135.40)**	**(54.84)**	**(0.002)**	**(0.021)**	**(0.82)**
Number of Loans	348,259	348,259	348,259	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.557	0.226	0.069	0.052	0.037	0.024	0.081	0.069

Panel B: Two Years after Mortgage Payment Reduction

	Monthly Interest Rate	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing	Recent Credit Inquiries	Current Credit Score (FICO)
Treatment	**-1.75**	**-163.54**	**-0.018**	**-616.31**	**324.19**	**0.012**	**-0.099**	**5.68**
	(0.14)	**(10.91)**	**(0.01)**	**(135.42)**	**(88.36)**	**(0.004)**	**(0.017)**	**(1.14)**
Number of Loans	348,259	348,259	348,259	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.891	0.251	0.064	0.048	0.037	0.034	0.083	0.07

Table 3: Heterogeneous Treatment Effects of Mortgage Payment Reduction - By Above Median Credit Utilization Rate and CLTV

This table presents heterogeneous treatment effects based on the rate of credit utilization and CLTV for the difference-in-difference OLS specifications to examine the differential outcomes for 5/1 ARM contracts relative to 7/1 ARM contracts after the 5/1 contracts' first reset date. Panel A presents the estimated relative change in outcomes during the first year after the reset, while Panel B presents similar results for the period of two years after the first reset (but before the 7/1 rate reset). The coefficient *Treatment* reports the estimated change in the difference between outcomes of 5/1 ARM and 7/1 ARM contract types during the period after the reset date. The coefficient *Treatment × (Utilization>M)* is the interaction term of treatment effect with a dummy that takes value of 1 if the borrower has an above median credit utilization rate and is zero otherwise. The coefficient *Treatment × (CLTV>M)* is the interaction term of treatment effect with a dummy that takes value of 1 if the loan has an above median CLTV. The specifications include a rich set of observable characteristics as control variables, including rate at origination, FICO credit score, CLTV, quarter-year origination fixed effects, state fixed effects, loan age, mortgage product, *Utilization>M* and *CLTV>M* dummies, as well as their appropriate interaction terms with other control variables.

Panel A: One Year after Mortgage Payment Reduction

	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing	Current Credit Score (FICO)
Treatment	**-113.84**	**-0.001**	**244.43**	**-15.06**	**0.002**	**-0.773**
	(23.27)	(0.00)	(108.54)	(66.47)	(0.003)	(0.29)
Treatment × (Utilization>M)	**-13.43**	**-0.006**	**-835.68**	**-151.30**	**-0.004**	**-0.98**
	(7.39)	(0.00)	(162.51)	(50.65)	(0.002)	(1.02)
Treatment × (CLTV>M)	**-19.189**	**-0.008**	**-223.38**	**258.77**	**0.009**	**2.407**
	(8.58)	(0.00)	(130.39)	(87.98)	(0.003)	(0.40)
Number of Loans	348,259	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.233	0.074	0.254	0.044	0.042	0.469

Panel B: Two Years after Mortgage Payment Reduction

	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing	Current Credit Score (FICO)
Treatment	**-160.03**	**-0.003**	**147.89**	**81.83**	**0.014**	**1.135**
	(9.00)	(0.00)	(175.74)	(124.62)	(0.004)	(0.72)
Treatment × (Utilization>M)	**-4.115**	**-0.020**	**-1116.89**	**-69.90**	**-0.003**	**5.061**
	(5.60)	(0.01)	(170.45)	(136.51)	(0.004)	(1.01)
Treatment × (CLTV>M)	**1.002**	**-0.013**	**-59.09**	**343.75**	**0.011**	**3.549**
	(5.23)	(0.00)	(249.51)	(149.39)	(0.005)	(1.06)
Number of Loans	348,259	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.257	0.07	0.232	0.043	0.004	0.451

Table 4: Treatment Effect of Reduction in Mortgage Payments on Debt Deleveraging

Borrowers in the Top Quartile of Credit Utilization Rates and the Bottom Quartile of Credit Scores

This table presents the OLS estimates for the change in the difference of outstanding revolving debt balances of borrowers with 5/1 ARM relative to borrowers with 7/1 ARM contract types during the period after the reset date. Panel A presents outcomes one year after the first rate reset, while Panel B presents similar results two years after the first reset (but before the 7/1 rate reset). The sample consists of borrowers in the top quartile of credit utilization rates and the bottom quartile of credit scores, respectively. The specifications include a rich set of observable characteristics as control variables, including rate at origination, FICO credit score, CLTV, quarter-year origination fixed effects and state fixed effects. Standard errors clustered by quarter of origination are in parentheses.

Panel A: One Year after Mortgage Payment Reduction

	Top Quartile Credit Utilization	Bottom Quartile Credit Score
Relative Change in Revolving Debt in the First Year	-$1285 (321.40)	-$1206 (280.65)
As % of Reduction in Mortgage Payments during the First Year	70.6%	65.1%

Panel B: Two Years after Mortgage Payment Reduction

	Top Quartile Credit Utilization	Bottom Quartile Credit Score
Relative Change in Revolving Debt over Two Years	-$1548 (337.85)	-$1257 (287.04)
As % of Reduction in Mortgage Payments over Two Years	40.0%	31.7%

Table 5: Regional Evidence: Zip Code Summary Statistics, Mortgage Interest Rate, and ARM Share

Panel A presents summary statistics of key variables as of mid-2007 in high exposure (above median ARM share in the sample of matched zip codes) and low exposure (below median ARM share in the sample of matched zip codes) zip codes. The variable *ARM Share* is the percentage of outstanding mortgages that are of ARM type in a zip code. Panel B reports OLS estimates of regressions where the dependent variable is the mean change in the mortgage interest rates (in percentage terms) in a zip code during the 2007:Q4 to 2012:Q4 period. Column (2) adds a set of zip code level characteristics (Zip Code Controls) including the pre-estimation period average zip code mortgage LTV ratios, interest rates, delinquency rate, demographic variables capturing a profile of the zip code population (annual unemployment rate, median income, total number of households, percentage of individuals with a college degree, and percentage of households that are married with children), and the average FICO credit score of households. Column (3) adds state fixed effects. The estimates are expressed in percentage terms; standard errors are in parentheses.

Panel A: Summary Statistics for High and Low Exposure Zip Codes

	High Exposure Zip Codes		Low Exposure Zip Codes	
	Mean	S.D.	Mean	S.D.
FICO	714.8	23.2	716.0	18.9
LTV	64.5	7.29	68.1	7.00
Interest Rate	6.64	0.57	6.68	0.48
Mortgage Delinquency Rate	2.81	3.09	2.23	1.83
Unemployment Rate	6.04	1.55	5.91	1.47
Median Income	58.42	14.13	52.77	14.38
Percentage of Individuals with College Degree	31.4	10.1	29.5	9.42
Percentage of Households that are Married Couples with Children	21.9	5.13	21.6	5.13
Consumer Credit Score	3.37	0.41	3.35	0.35
ARM Share	35.2	7.62	17.3	4.51

Panel B: Zip Code ARM Share and Change in a Zip Code Mortgage Interest Rate

	(1)	(2)	(3)
ARM Share	-0.0198	-0.0176	-0.0174
	(0.0005)	(0.0006)	(0.0008)
Zip Code Controls	No	Yes	Yes
State FE	No	No	Yes
Number of Zip Codes	1000	902	902
R-Squared	0.568	0.759	0.800

41

Table 6: Mortgage Delinquency, House Price, and Auto Sales Growth and the Zip Code ARM Share

Panel A of this table reports OLS estimates of regressions where the dependent variable is the change in the quarterly mortgage delinquency growth rate in a zip code between the period of interest rate declines and the period preceding the rate declines. Panel B shows the corresponding estimates for the quarterly house price growth rate. Panel C shows the results for the quarterly auto sales growth. The variable *ARM Share* is the percentage of mortgages that are of ARM type in a zip code. Column (2) adds a set of zip code level characteristics. Column (3) adds state fixed effects. The estimates are expressed in percentage terms; standard errors are in parentheses.

Panel A: Change in the Mortgage Delinquency Growth Rate and the Zip Code ARM Share

	(1)	(2)	(3)
ARM Share	**-0.657**	**-0.579**	**-0.269**
	(0.048)	**(0.067)**	**(0.092)**
Zip Code Controls	No	Yes	Yes
State FE	No	No	Yes
Number of Zip Codes	1000	902	902
R-Squared	0.156	0.305	0.426

Panel B: Change in the House Price Growth Rate and the Zip Code ARM Share

	(1)	(2)	(3)
ARM Share	**0.0319**	**0.0251**	**0.0258**
	(0.005)	**(0.006)**	**(0.005)**
Zip Code Controls	No	Yes	Yes
State FE	No	No	Yes
Number of Zip Codes	1000	902	902
R-Squared	0.035	0.313	0.497

Panel C: Change in the Auto Sales Growth Rate and the Zip Code ARM Share

	(1)	(2)	(3)
ARM Share	**0.085**	**0.088**	**0.037**
	(0.008)	**(0.013)**	**(0.018)**
Zip Code Controls	No	Yes	Yes
State FE	No	No	Yes
Number of Zip Codes	1000	902	902
R-Squared	0.089	0.154	0.282

Table 7: Employment Growth and the Zip Code ARM Share

This table reports OLS estimates of regressions where the dependent variable is the average annual employment growth rate in a zip code. The variable *ARM Share* is the fraction of mortgages that are of ARM type in a zip code. The variable ARM Share × (09-12) is the interaction term of this variable with the dummy variable that takes a value of 1 for the employment growth rate in 2009-2012 period and is zero otherwise. Column (1) shows the results with the basic set of controls consisting of *ARM Share*, *09-12* dummy, and *ARM Share × (09-12)* interaction term. Column (2) adds a set of zip code level characteristics (Zip Code Controls) in the period preceding the decline in interest rate indices including the average zip code mortgage LTV ratios, interest rates, historical house price growth, socio-economic variables capturing a profile of the zip code population, and the average FICO credit score of households. Column (3) adds state fixed effects. Column (4) shows results where the dependent variable is the average annual employment growth rate in a zip code in the restaurant and grocery sector (non- tradable sector). Column (5) shows results where the dependent variable is the average annual employment growth rate in a zip code in the tradable sector. The estimation period: 2007-2012. The estimates are expressed in percentage terms; standard errors are in parentheses.

	All Industries Employment Growth Rate (1)	All Industries Employment Growth Rate (2)	All Industries Employment Growth Rate (3)	Restaurant and Grocery Employment Growth Rate (4)	Tradable Sector Employment Growth Rate (5)
ARM Share	-0.0557***	-0.0873***	-0.00559	0.00643	0.0693
	(0.0131)	(0.0166)	(0.0219)	(0.0425)	(0.304)
ARM Share × (09-12)	0.0902***	0.0891***	0.0891***	0.0711**	-0.0018
	(0.0185)	(0.0186)	(0.0183)	(0.0351)	(0.253)
Zip Code Controls	No	Yes	Yes	Yes	Yes
State FE	No	No	Yes	Yes	Yes
Number of Zip Codes	1000	902	902	829	878
R-Squared	0.0999	0.123	0.173	0.0648	0.0555

Figure 1: The Impact of Rate Resets: Mortgage Interest Rates and Scheduled Mortgage Payments

Panels (a) and (b) of this figure show the average interest rates and monthly payments, respectively, by loan age for 5/1 ARM and 7/1 ARM loans in our sample. Loans must be active as of month 48, see text for additional sample restrictions. The loans have very similar average rates and monthly payments prior to month 61, when the 5/1 ARM loans reach the end of their fixed period and experience their first rate reset. The 5/1 ARM loans again reset in month 73, while the 7/1 ARM loans are fixed at the origination rate for seven years, and only reset upon reaching month 85. The two vertical dashed lines mark the timing of the first reset of 5/1 ARMs and the second reset. Source: Authors' calculations using data from the large secondary market participant.
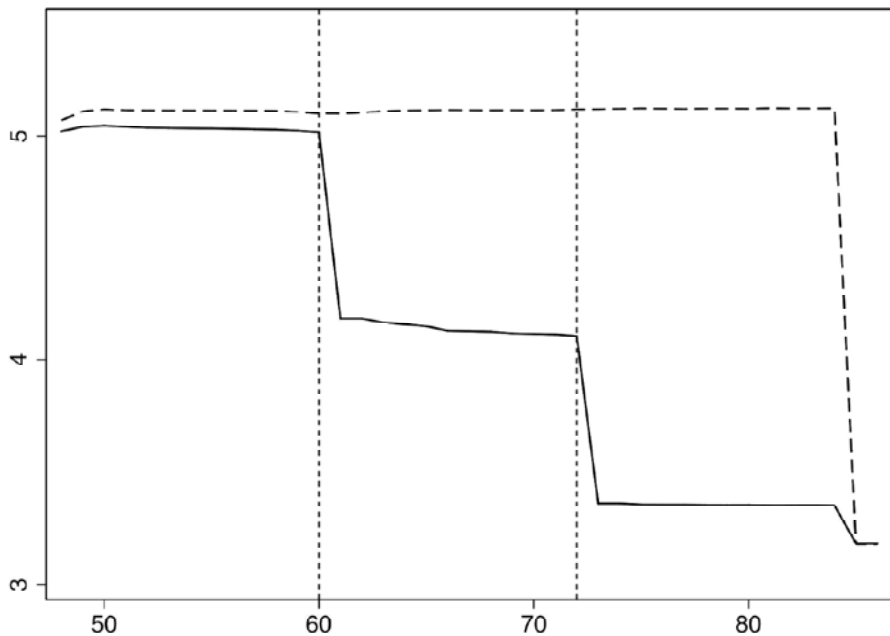
(a) Interest Rates
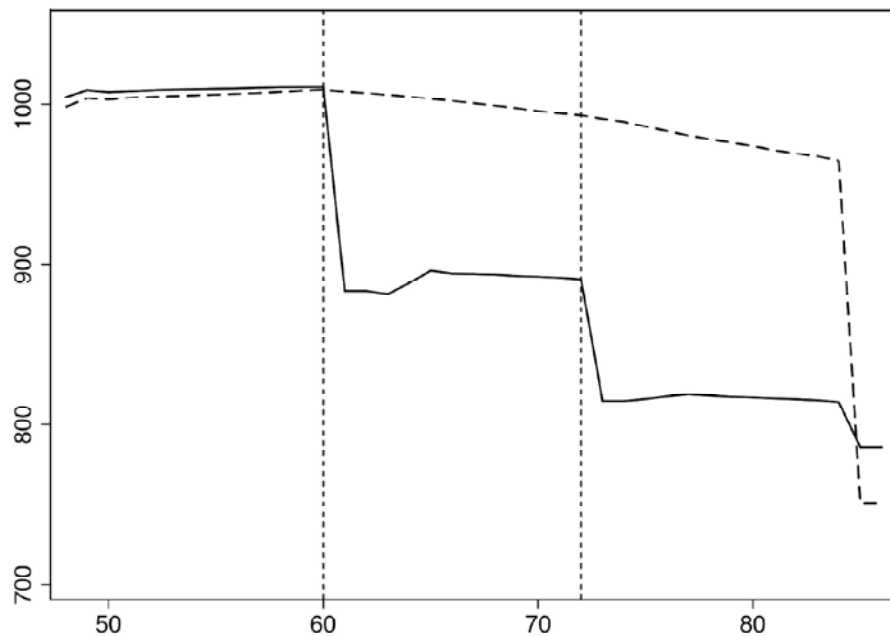
(b) Monthly Mortgage Payments

Figure 2: Impact of Mortgage Payment Reduction on Revolving Debt Balance

Panel (a) of this figure plots the average outstanding revolving debt balance of borrowers (in $) over the mortgage life (in months). The dashed line in panel (a) shows the results for 7/1 ARM contracts while the solid line shows the results for 5/1 ARM contracts. Panel (b) shows the estimated quarterly cumulative differential change in the outstanding revolving debt balance of 5/1 ARM borrowers relative to the revolving debt balance of 7/1 ARM borrowers in three quarters preceding the first reset date of 5/1 ARMs and eight quarters following the reset date along with the 95% confidence bounds around these estimates. The two vertical dashed lines mark the timing of the two reset dates of 5/1 ARMs, which result in a substantial reduction of mortgage payments for 5/1 ARM borrowers. Borrowers have similar trends in the outstanding revolving debt with no statistically significant difference until the 5/1 ARM loans reach the end of their fixed period (at month 60) and experience their first rate reset (the first vertical line). The interest rates of 7/1 ARM loans are fixed at the origination rate for seven years, and only reset upon reaching month 85. By this time, the average outstanding revolving debt of 5/1 ARM borrowers has declined significantly relative to those of 7/1 ARM borrowers. Source: Authors' calculations using data from the large secondary market participant.
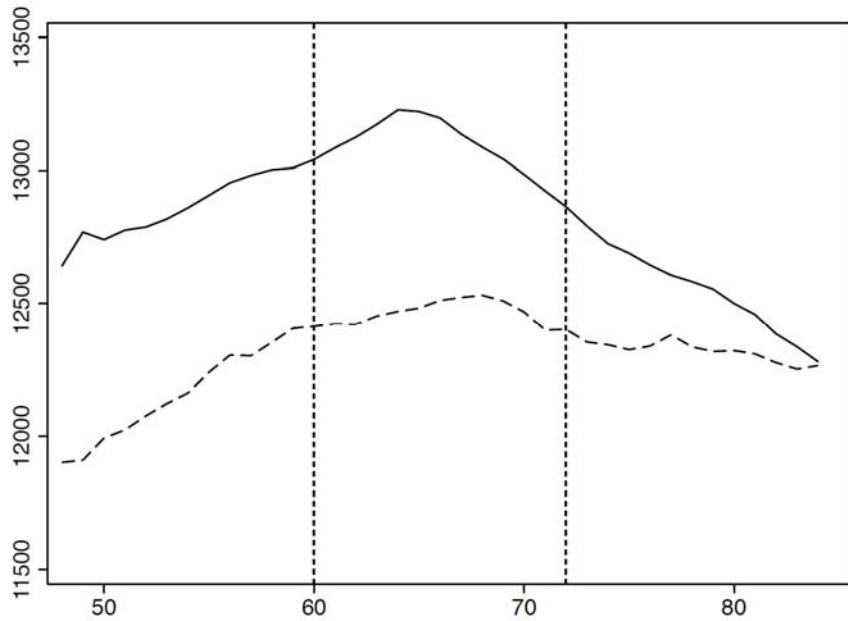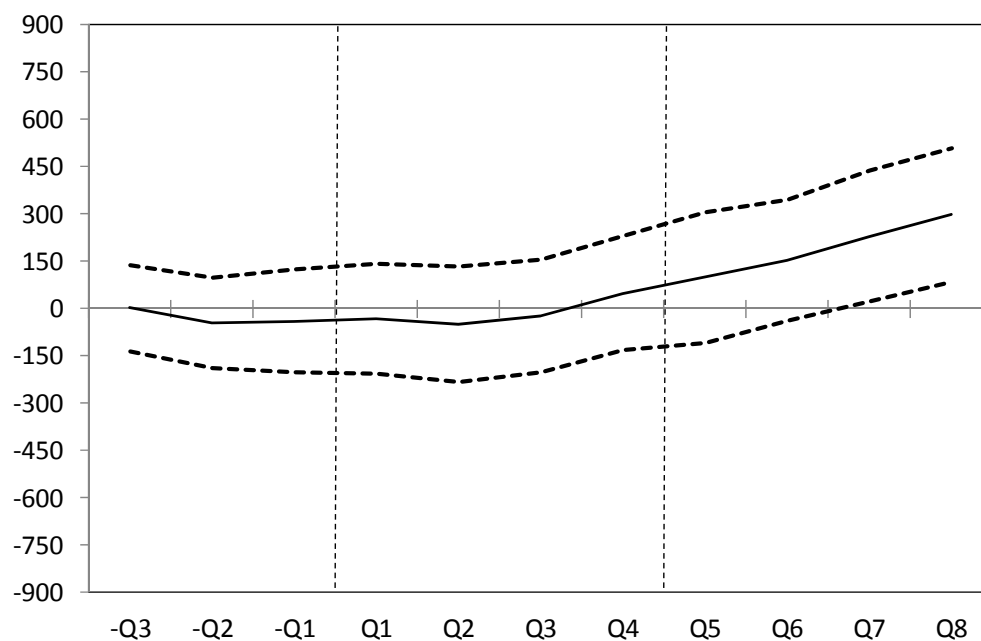

(a) Revolving Debt Balance (Monthly)
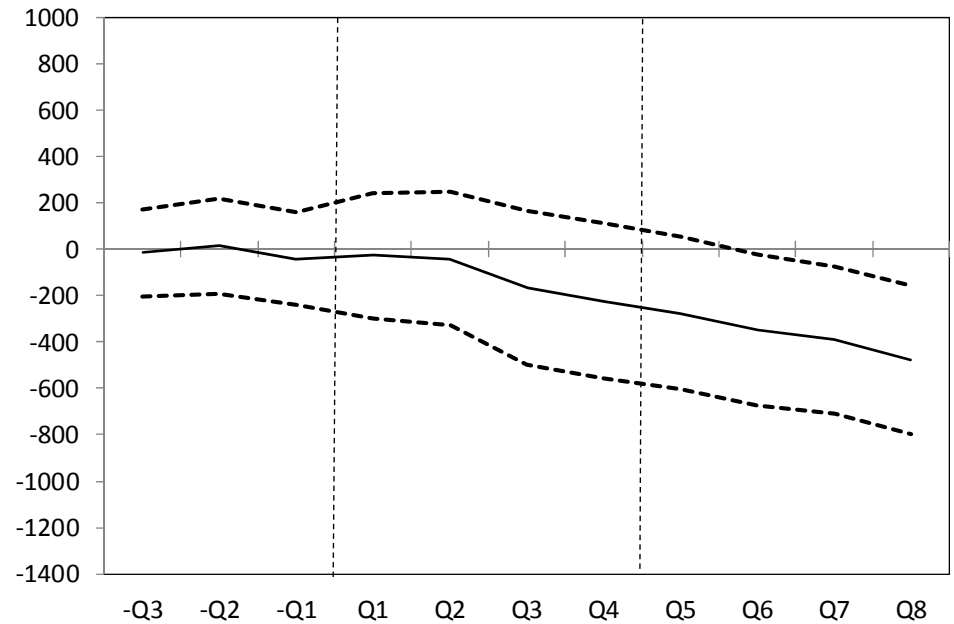
(b) Cumulative Quarterly Differential Change in the Revolving Debt Balance

Figure 3: Impact of Mortgage Payment Reduction on Durable Consumption (Auto) Financing

Panel (a) of this figure plots the average outstanding auto debt balance of borrowers (in $) over the mortgage life (in months). The dashed line in panel (a) shows the results for 7/1 ARM contracts while the solid line shows the results for 5/1 ARM contracts. Panel (b) shows the estimated quarterly cumulative differential change in the outstanding auto debt balance of 5/1 ARM borrowers relative to the auto debt balance of 7/1 ARM borrowers in the three quarters preceding the first reset date of 5/1 ARMs and eight quarters following the reset date along with the 95% confidence bounds around these estimates. The two vertical dashed lines mark the timing of the two reset dates of 5/1 ARMs, which result in a substantial reduction of mortgage payments for 5/1 ARM borrowers. Borrowers have similar trends in the outstanding auto debt with no statistically significant difference until the 5/1 ARM loans reach the end of their fixed period (at month 60) and experience their first rate reset (the first vertical line). The interest rates of 7/1 ARM loans are fixed at the origination rate for seven years, and only reset upon reaching month 85. By this time, the average outstanding auto debt of 5/1 ARM borrowers has increased significantly relative to those of 7/1 ARM borrowers. Source: Authors' calculations using data from the large secondary market participant.
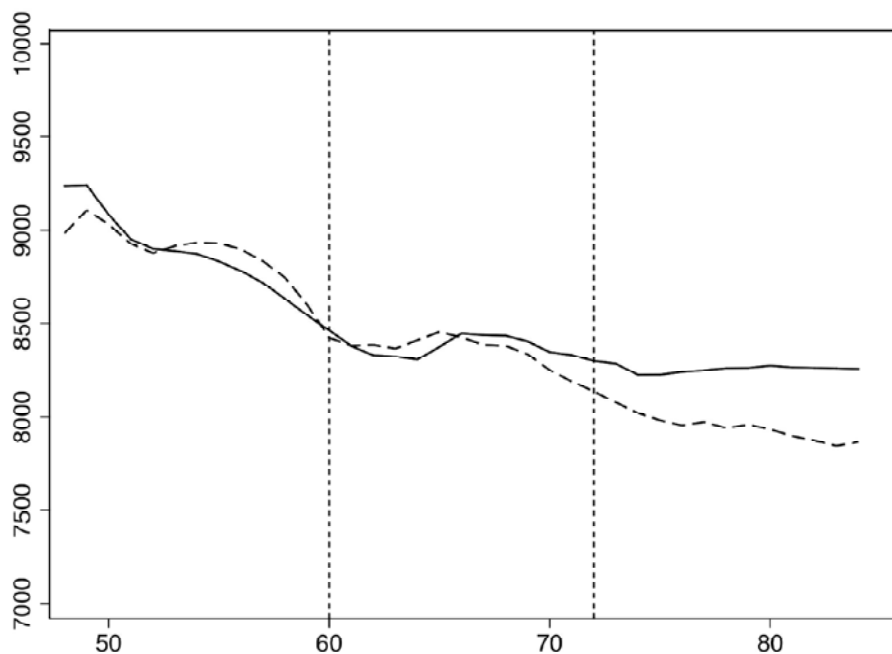
(a) Auto Debt Balance (Monthly)

(b) Cumulative Quarterly Differential Change in Auto Debt Balance

Figure 4: Impact of Mortgage Payment Reduction on Quarterly Probability of New Durable Consumption (Auto) Financing

Panel (a) of this figure plots the average quarterly probability (in %) of obtaining new auto financing by the borrower during four quarters preceding the first reset date of 5/1 ARMs and eight quarters following the reset date. The dashed line in panel (a) shows the results for 7/1 ARM contracts while the solid line shows the results for 5/1 ARM contracts. Panel (b) shows the estimated cumulative differential change in the quarterly probability of 5/1 ARM borrowers obtaining new auto financing relative to 7/1 ARM borrowers in the three quarters preceding the first reset date of 5/1 ARMs and eight quarters following the reset date along with the 95% confidence bounds around these estimates. The two vertical dashed lines mark the timing of the two reset dates of 5/1 ARMs, which result in a substantial reduction of mortgage payments for 5/1 ARM borrowers. We observe a similar trend in the probability of auto loan financing in the two groups of borrowers with no statistically significant difference until the 5/1 ARM loans reach the end of their fixed period (at month 60) and experience their first rate reset (the first vertical line). The interest rates of 7/1 ARM loans are fixed at the origination rate for seven years, and only reset upon reaching month 85. By this time, the average quarterly probability of new auto financing of 5/1 ARM borrowers experienced a significant differential increase relative to those of 7/1 ARMs borrowers. Source: Authors' calculations data from the large secondary market participant. Source: Authors' calculations using data from the large secondary market participant.

(a) Quarterly Probability of New Auto Financing   (b) Differential Change in the Quarterly Probability of New Auto Financing

Figure 5: Geographic Distribution of Zip Codes

This figure presents the geographic distribution of zip codes in our matched sample across the United States (panel a) and in California (panel b). In addition, the figure displays the percentage of loans in a zip code which are of ARM type (the zip code ARM share).

Panel A: Distribution of Zip Codes across the United States
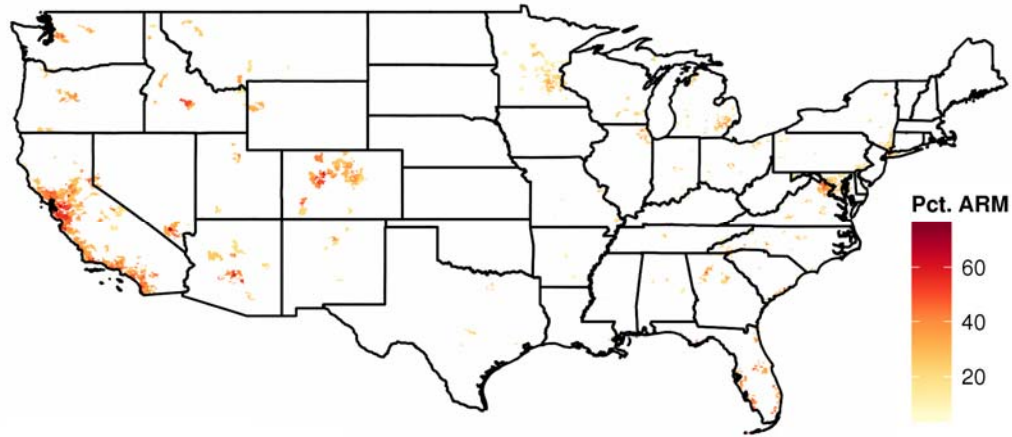
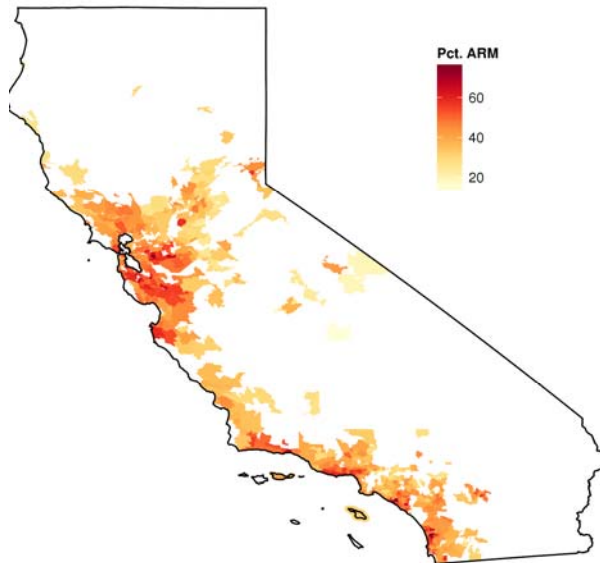**Panel B: Distribution of Zip Codes in California**

Figure 6: Evolution of Observables in High and Low Exposure Zip Codes

The figure shows the evolution of the mean origination FICO credit score (panel a), current mortgage interest rate (panel b), and origination LTV ratio (panel c) of outstanding mortgages in high and low exposure zip codes prior to the decline in interest rate indices. The high and low exposure groups are defined based on the share of loans that are ARMs in a zip code. The high exposure group is represented by the solid line and the low exposure group is represented by the dashed line.
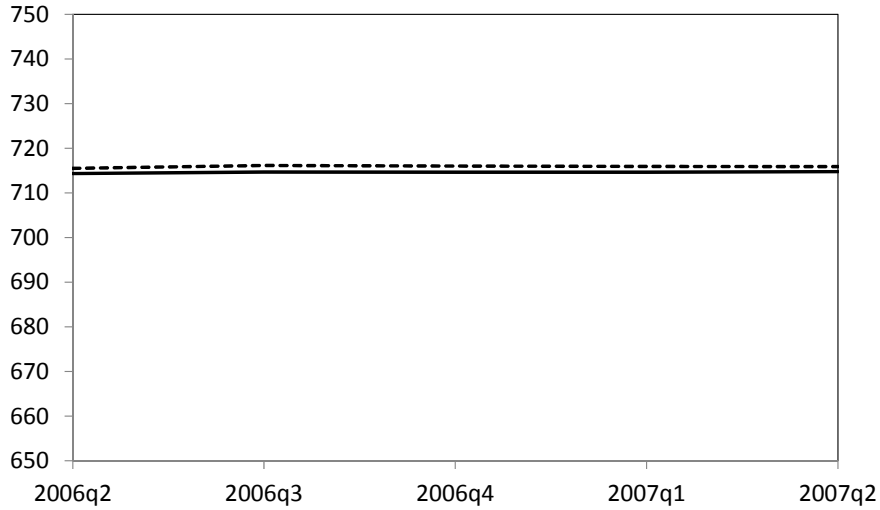

(a) FICO Credit Score
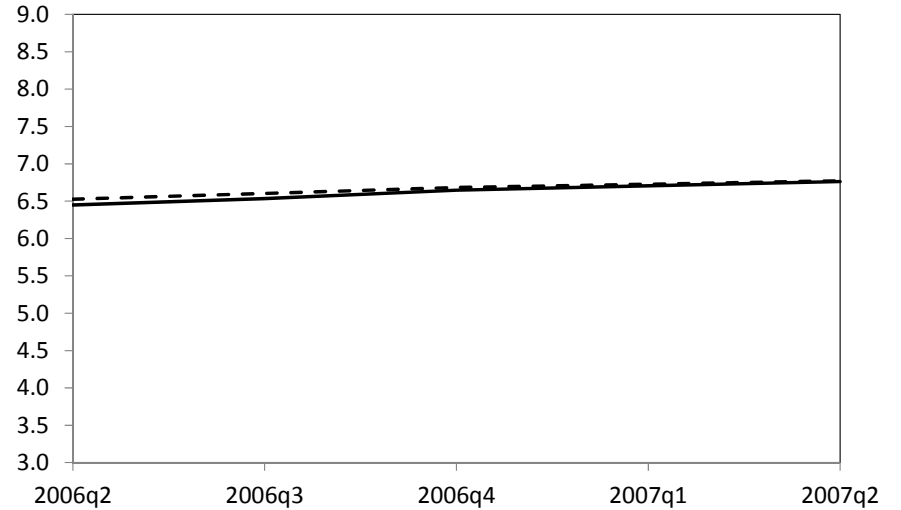
(b) Mortgage Interest Rate

(c) LTV Ratio

49
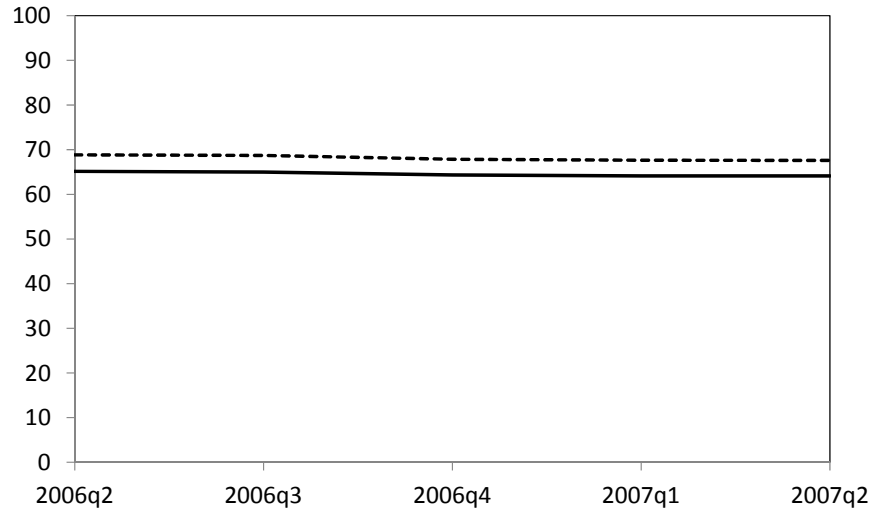
Figure 7: Interest Rate Indices and Mean Zip Code Mortgage Interest Rates in High and Low Exposure Zip Codes

This figure presents the evolution of index interest rates (panel a) and the evolution of average zip code mortgage interest rates (panel b). The high and low exposure groups in panel (b) are defined based on the share of loans that are ARMs in a zip code. In panel (b), the high exposure group is represented by the solid line and the low exposure group is represented by the dashed line. The first vertical dashed line (at 2007:Q2) marks the period of the beginning of the rapid decline in interest rate indices, while the second (at 2008:Q1) marks the beginning of the period when we start observing the divergence in mortgage interest rates across high and low exposure zip codes.
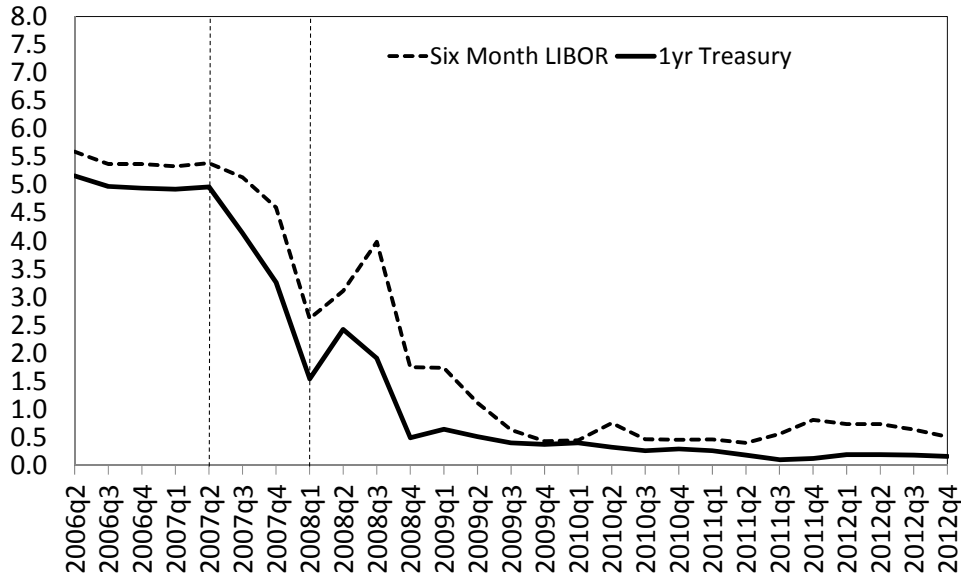

(a) 6-month LIBOR and 1-year Treasury
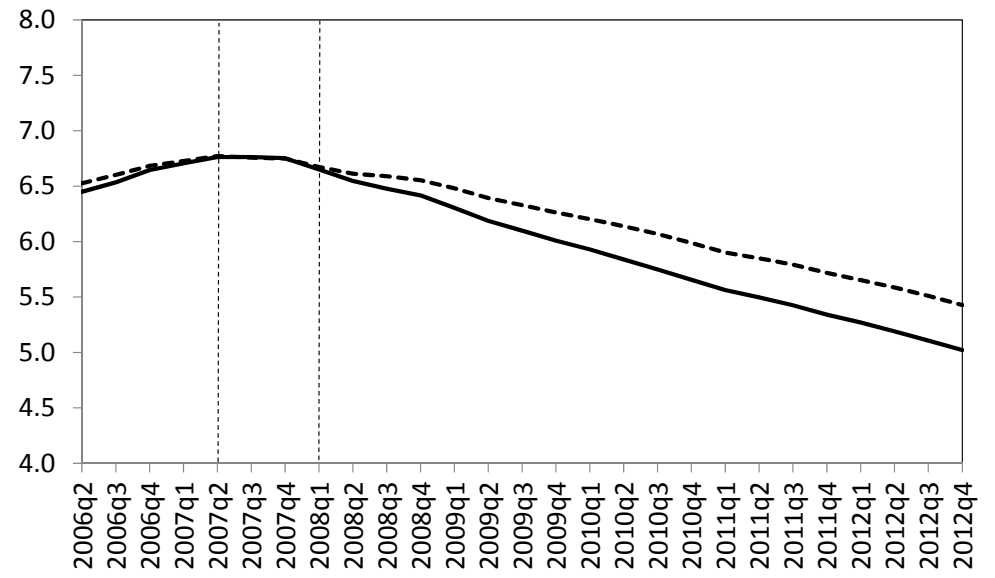
(b) Zip Code Mortgage Interest Rates

Figure 8: Mortgage Delinquency, House Prices, Auto Sales, and Employment in High and Low Exposure Zip Codes

The figure shows the average quarterly growth rate (in %) of the mortgage delinquency rate (panel a), the average quarterly house price growth rate (panel b), the annual auto sales growth rate (panel c), and the annual employment growth rate (panel d) in high and low exposure zip codes. The high and low exposure groups are defined based on the share of loans that are ARMs in a zip code. The high exposure group is represented by the solid line and the low exposure group is represented by the dashed line. The vertical dashed line marks the beginning of the period when we start observing the divergence in mortgage interest rates across high and low exposure zip codes following the decline in the interest rate indices.
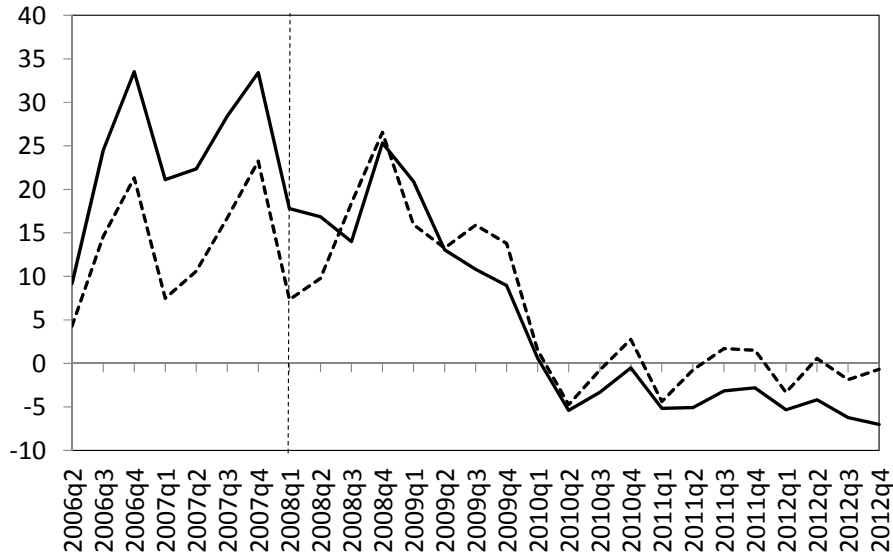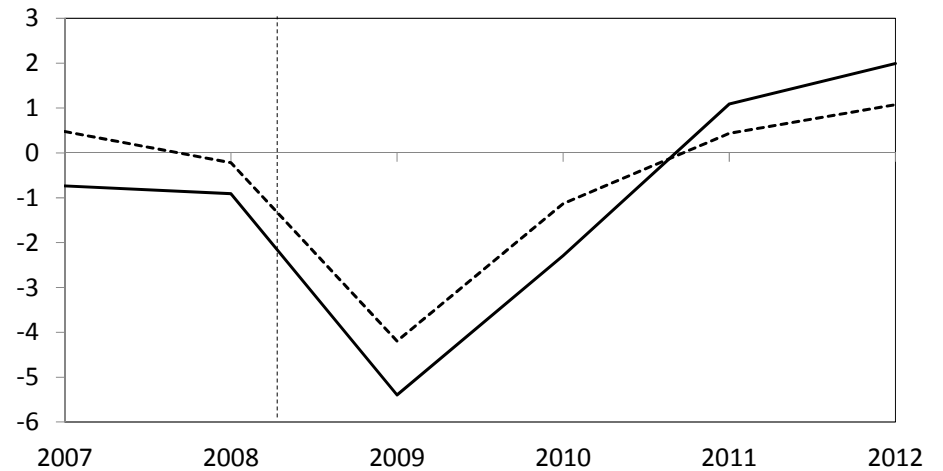

(a) Mortgage Delinquency Growth
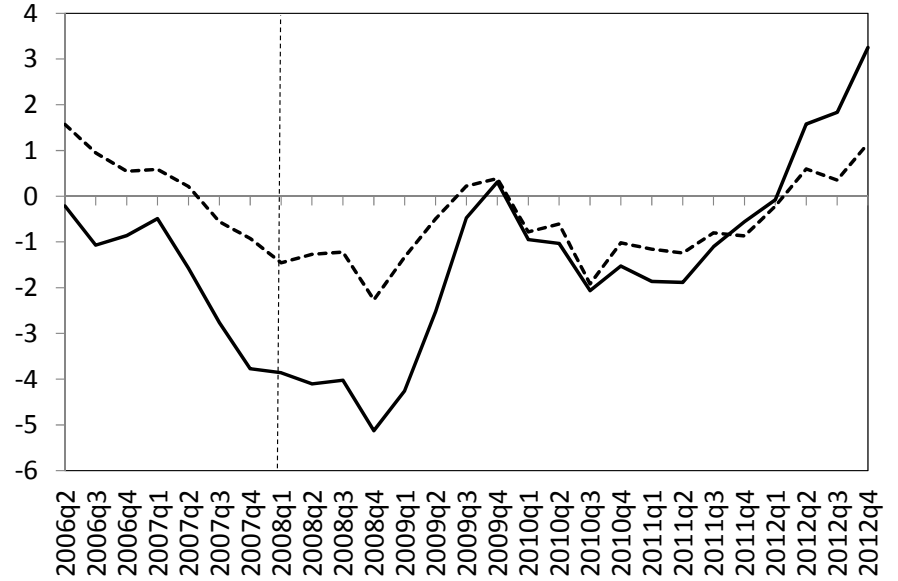
(b) House Price Growth
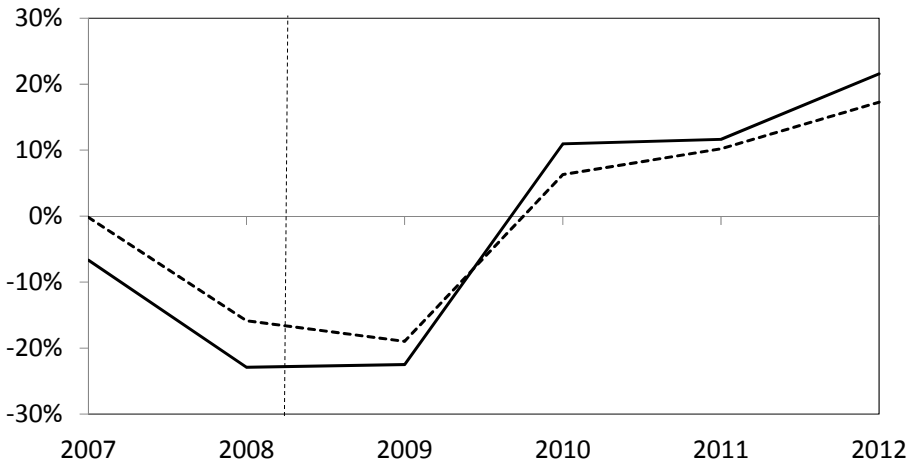
(c) Auto Sales Growth

(d) Employment Growth

Appendix

A1: Impact of Mortgage Payment Reduction on the Delinquency Rate of Mortgages, Revolving Debt, and Auto Debt

This figure plots the average cumulative monthly delinquency rate for mortgages (panel a), revolving debt (panel b), and auto debt (panel c). The dashed line shows the results for 7/1 ARM contracts while the solid line shows the results for 5/1 ARM contracts. The two vertical dashed lines mark the timing of the two reset dates of 5/1 ARMs, which result in a substantial reduction of mortgage payments for 5/1 ARM borrowers.
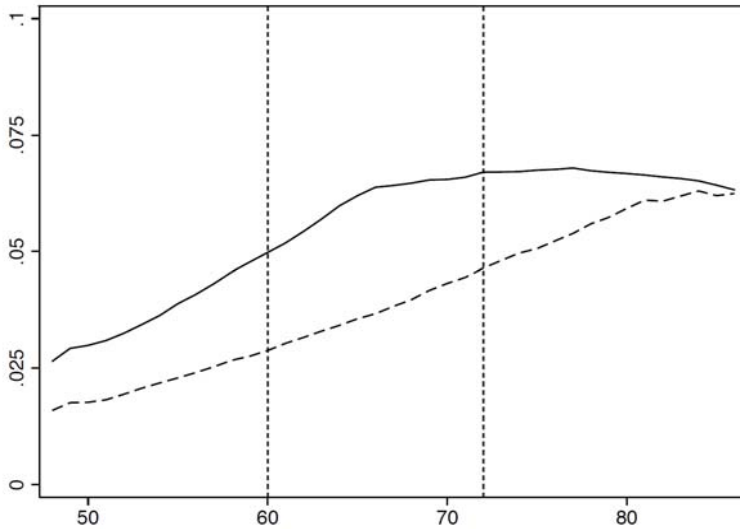
(a) Mortgage Delinquency Rate
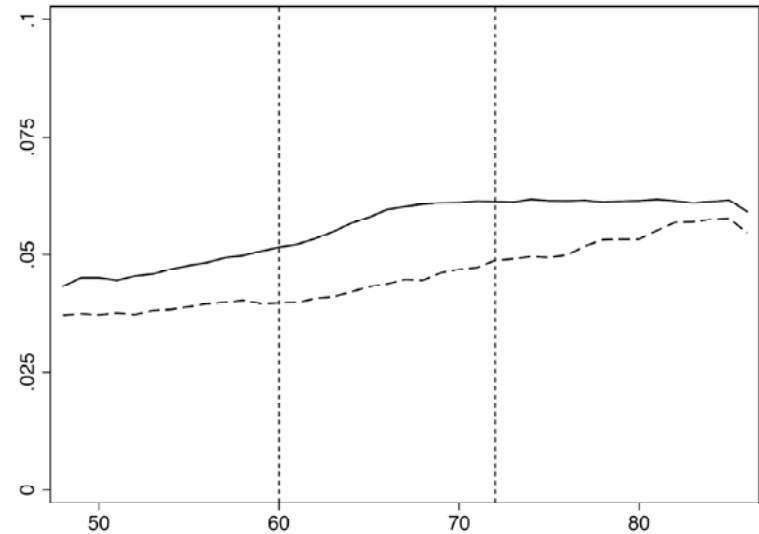
(b) Revolving Delinquency Rate
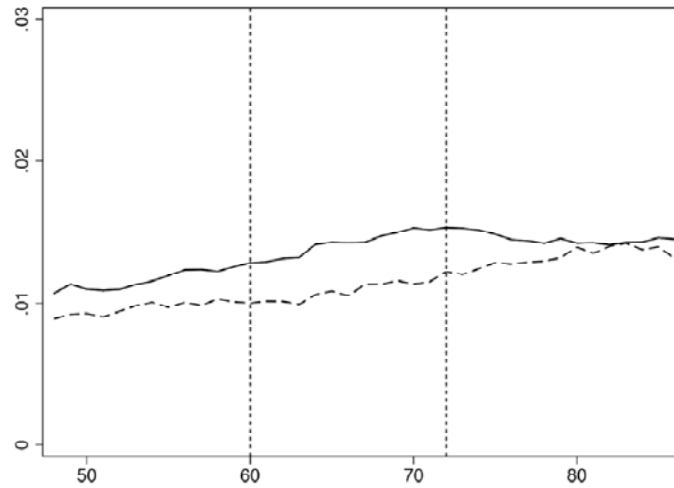
(c) Auto Delinquency Rate

A2: Impact of Mortgage Payment Reduction on Credit Inquires, Credit Utilization Rate, and Consumer Credit Score

This figure plots the evolution of the average of recent credit inquires (panel a), credit utilization rate (panel b), and FICO consumer credit score (panel c). The dashed line shows the results for 7/1 ARM contracts while the solid line shows the results for 5/1 ARM contracts. The two vertical dashed lines mark the timing of the two reset dates of 5/1 ARMs, which result in a substantial reduction of mortgage payments for 5/1 ARM borrowers.
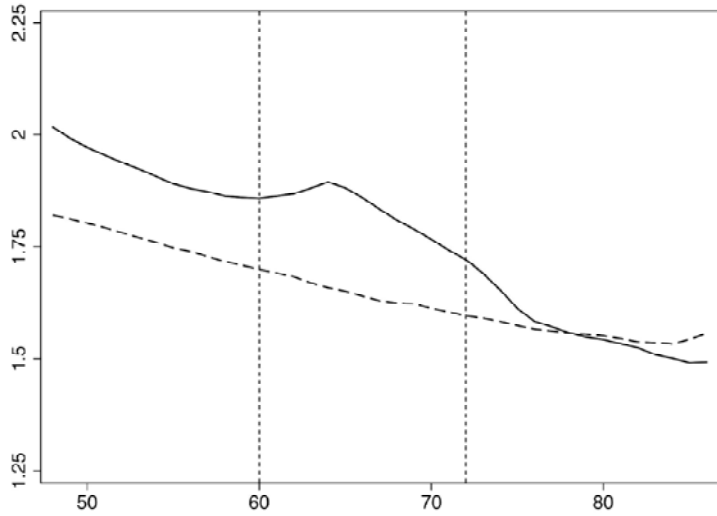

(a) Recent Credit Inquiries
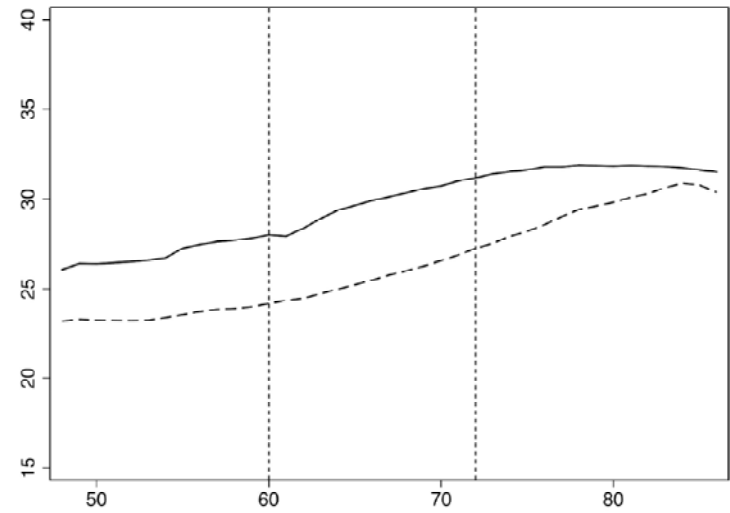
(b) Credit Utilization Rate

(c) FICO

54
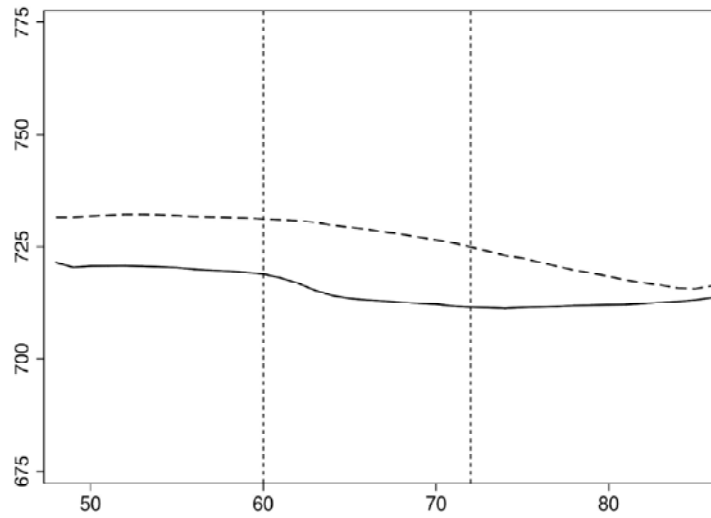
A3: Heterogeneous Treatment Effects - By Above/Below Median Credit Utilization Rate

This table presents heterogeneous treatment effects based on credit card utilization rates for the difference-in-difference OLS specifications to examine the differential outcomes for 5/1 ARM contracts relative to 7/1 ARM contracts after the 5/1 contracts' first reset date. Panel A presents outcomes one year after the first rate reset, while Panel B presents similar results two years after the first reset (but before the 7/1 rate reset). The coefficient of interest is the interaction between 5/1 ARM contract type, the "post" period after the reset date, and whether the borrower had an above median utilization rate prior to reset. The specifications include a rich set of observable characteristics as control variables, including interest rate at origination, FICO credit score, CLTV, quarter-year origination fixed effects, state fixed effects, loan age, mortgage product, *Utilization>M* dummies, as well as their appropriate interaction terms with other control variables. Standard errors clustered by quarter of origination are in parentheses.

Panel A: Heterogeneous Treatment Effects One Year after Reduction in Mortgage Payments

	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing
Treatment	**-117.53**	**-0.003**	**21.56**	**62.07**	**0.006**
	(23.44)	**(0.001)**	**(81.582)**	**(54.98)**	**(0.003)**
Treatment × (Utilization>M)	**-16.212**	**-0.007**	**-867.48**	**-116.70**	**-0.004**
	(8.16)	**(0.001)**	**(169.873)**	**(53.40)**	**(0.005)**
Number of Loans	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.227	0.074	0.254	0.044	0.027

Panel B: Heterogeneous Treatment Effects Two Years after Reduction in Mortgage Payments

	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing
Treatment	**-159.74**	**-0.007**	**136.35**	**179.984**	**0.014**
	(9.32)	**(0.00)**	**(92.798)**	**(100.50)**	**(0.004)**
Treatment × (Utilization>M)	**-4.673**	**-0.022**	**-1131.61**	**-25.5**	**-0.003**
	(6.08)	**(0.01)**	**(174.90)**	**(141.12)**	**(0.004)**
Number of Loans	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.252	0.069	0.232	0.043	0.08

A4: Heterogeneous Treatment Effects - By Above/Below Median FICO Score

This table presents heterogeneous treatment effects based on FICO Scores for the difference-in-difference OLS specifications to examine the differential outcomes for 5/1 ARM contracts relative to 7/1 ARM contracts after the 5/1 contracts' first reset date. Panel A presents outcomes one year after the first rate reset, while Panel B presents similar results two years after the first reset (but before the 7/1 rate reset). The coefficient of interest is the interaction between 5/1 ARM contract type, the "post" period after the reset date, and whether the borrower has below median FICO score prior to reset, shown in the seventh row of in bold. The specifications include a rich set of observable characteristics as control variables including rate at origination, FICO credit score, CLTV, quarter-year origination fixed effects, state fixed effects, loan age, mortgage product, *FICO<M* dummies, as well as their appropriate interaction terms with other control variables. Standard errors clustered by quarter of origination are in parentheses.

Panel A: Heterogeneous Treatment Effects One Year after Reduction in Mortgage Payments

	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing
Treatment	**-115.66**	**-0.001**	**310.680**	**177.076**	**0.005**
	(23.13)	**(0.00)**	**(90.795)**	**(67.00)**	**(0.003)**
Treatment × (FICO<M)	**-19.734**	**-0.012**	**-899.851**	**-293.164**	**-0.004**
	(7.89)	**(0.01)**	**(154.962)**	**(76.38)**	**(0.002)**
Number of Loans	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.227	0.0810	0.147	0.042	0.028

Panel B: Heterogeneous Treatment Effects Two Years after Reduction in Mortgage Payments

	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing
Treatment	**-157.38**	**-0.003**	**72.617**	**322.019**	**0.012**
	(9.21)	**(0.00)**	**(157.102)**	**(99.16)**	**(0.004)**
Treatment × (FICO<M)	**-8.616**	**-0.030**	**-970.88**	**-251.808**	**-0.003**
	(5.92)	**(0.01)**	**(234.58)**	**(126.94)**	**(0.001)**
Number of Loans	348,259	348,259	348,259	348,259	348,259
Adjusted R-squared	0.252	0.076	0.134	0.041	0.04

A5: Distribution of CLTV Ratios

This table shows distribution of current CLTV ratios (by the percentile of distribution) as of month 48, 60, 72, and 84 of the loan's life for all loans originated in 2006-2007 period in our sample (Panel A) as well as for 5/1 ARMs (Panel B) and 7/1 ARMs (Panel C).

Panel A: Distribution of CLTV Ratios (All Loans)

Month	10th	25th	Median	75th	90th
48	66.0	82.0	98.7	123.4	158.2
60	70.0	86.3	105.6	135.1	171.3
72	69.9	86.3	106.2	134.6	168.2
84	65.7	81.4	99.7	125.5	152.7

Panel B: Distribution of CLTV Ratios (5/1 ARMs)

Month	10th	25th	Median	75th	90th
48	66.8	82.7	99.1	124.4	160.9
60	70.8	86.5	106.1	136.3	174.0
72	70.3	86.3	106.4	135.3	169.2
84	65.7	80.9	99.4	125.2	152.6

Panel C: Distribution of CLTV Ratios (7/1 ARMs)

Month	10th	25th	Median	75th	90th
48	62.9	79.5	97.3	119.2	148.8
60	66.8	85.3	104.3	130.5	163.6
72	68.0	85.9	105.9	132.4	164.1
84	65.1	83.0	102.2	126.7	152.8

A6: Impact of Mortgage Payment Reduction in a Sample of Borrowers Unlikely to Prepay

This table presents results for the difference-in-difference OLS specifications to examine the differential outcomes for 5/1 ARM contracts relative to 7/1 ARM contracts after the 5/1 contracts' first reset date. The sample is restricted to only those loans with estimated below-median propensities to prepay (based on a prediction from a regression of which loans prepay by their 48th month). Panel A presents outcomes one year after the first rate reset, while Panel B presents similar results two years after the first reset (but before the 7/1 rate reset). The coefficient of interest, *Treatment*, is the estimated change in the difference between outcomes of 5/1 ARM and 7/1 ARM contract types during the period after the reset date. Thus, this coefficient captures the differential effect of mortgage rate decline (due to a reset) on outcomes of mortgages subject to a reset (5/1 ARM contracts) relative to outcomes of mortgages that did not experience a change in interest rate (7/1 ARM contracts). The specifications include a rich set of observable characteristics as control variables including loan age and mortgage product dummies, rate at origination, FICO credit score, CLTV, quarter-year origination fixed effects and state fixed effects. Standard errors clustered by quarter of origination are in parentheses.

Panel A: One Year after Mortgage Payment Reduction

	Monthly Interest Rate	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing	Recent Credit Inquiries	Current Credit Score (FICO)
Treatment	**-1.01**	**-109.80**	**-0.005**	**-22.30**	**146.58**	**0.002**	**0.045**	**-0.24**
	(0.31)	**(22.57)**	**(0.004)**	**(102.44)**	**(52.19)**	**(0.003)**	**(0.022)**	**(0.85)**
Number of Loans	174,129	174,129	174,129	174,129	174,129	174,129	174,129	174,129
Adjusted R-squared	0.520	0.187	0.056	0.070	0.042	0.004	0.084	0.367

### Panel B: Two Years after Mortgage Payment Reduction

	Monthly Interest Rate	Monthly Mortgage Payment	Mortgage Delinquency Rate	Revolving Debt Balance	Auto Debt Balance	Probability of New Auto Financing	Recent Credit Inquiries	Current Credit Score (FICO)
Treatment	**-1.58**	**-146.97**	**-0.013**	**-247.81**	**173.79**	**0.010**	**-0.106**	**5.00**
	(0.14)	**(9.83)**	**(0.005)**	**(95.607)**	**(62.66)**	**(0.002)**	**(0.019)**	**(1.26)**
Number of Loans	174,129	174,129	174,129	174,129	174,129	174,129	174,129	174,129
Adjusted R-squared	0.891	0.210	0.051	0.066	0.041	0.004	0.085	0.351

A7: Impact of Mortgage Payment Reduction on New Durable Consumption (Auto) Financing among Agency and Non-Agency Borrowers

Panel (a) of this figure shows the estimated quarterly differential *change* in the outstanding auto debt balance of 5/1 ARM *agency* borrowers relative to the auto debt balance of 7/1 ARM borrowers in the three quarters preceding the first reset date of 5/1 ARMs and eight quarters following the reset date along with the 95% confidence bounds around these estimates. The two vertical dashed lines mark the timing of the two reset dates of 5/1 ARMs, which result in a substantial reduction of mortgage payments for 5/1 ARM borrowers. Borrowers have similar trends in the change of outstanding auto debt balance with no statistically significant difference until the 5/1 ARM loans reach the end of their fixed period (at month 60) and experience their first rate reset (the first vertical line). The interest rates of 7/1 ARM loans are fixed at the origination rate for seven years, and only reset upon reaching month 85. By this time, the quarterly change in auto debt of 5/1 ARM borrowers has experienced a significant increase relative to those of 7/1 ARM borrowers. Panel (b) shows the estimated quarterly differential *change* in the outstanding auto debt balance of *non-agency* 5/1 ARM in the three quarters preceding the first reset date of 5/1 ARMs and eight quarters following the reset date along with the 95% confidence bounds around these estimates. The sample in panel (a) is our main dataset on about 350,000 agency borrowers while the sample in panel (b) consists of about 50,000 non-agency Alt-A ARM borrowers from BlackBox-Equifax database. As we observe we find larger differential increase in auto balance after rate reduction in the non-agency sample relative our main agency-based mortgage data. These differences can be explained by differences in the borrower characteristics, loan amounts, and contract terms across these two samples of borrowers (see Section IV.E for more discussion).

(a) Quarterly Differential Change in Auto Debt Balance
Borrowers with Agency Mortgages
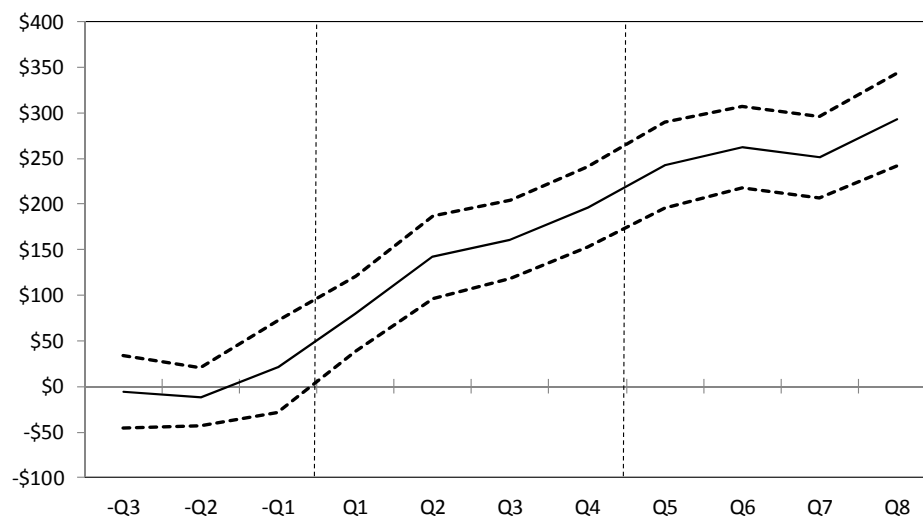
(b) Quarterly Differential Change in Auto Debt Balance
Borrowers with Non-Agency Mortgages