

Monetary Policy Pass-Through: Household Consumption and Voluntary Deleveraging *

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Abstract

Did households benefit from the expansionary monetary policy adopted by the Federal Reserve? To address this question we investigate how indebted households' consumption and saving decisions were affected by anticipated changes in monthly interest payments: we focus on borrowers with adjustable rate mortgages originated between 2005 and 2007 featuring an automatic reset of the interest rate after five years. We show that at the moment of the interest rate adjustment the monthly payment due from the average borrower fell by \$900, resulting in an increase in disposable income totaling tens of thousands dollars over the remaining life of the mortgage. We uncover three important patterns. First, in the wake of the reduction in monthly payment, the average household increases monthly car purchases by 40 percent. Second, this expansionary effect is attenuated by the borrowers' voluntary deleveraging, as a significant fraction of the increased income is deployed to accelerate debt repayment. Third, the marginal propensity to consume is significantly higher for liquidity-constrained borrowers and for those that had experienced a larger decline in housing wealth. To complement these findings, we employ county-level data to provide evidence that consumption responded more forcefully to a reduction in short-term interest rates primarily in counties with a larger fraction of adjustable rate mortgage debt. Since households with non-adjustable interest rates did not benefit from the reduction of interest rates, our results shed light on the role of debt rigidity in diminishing the effectiveness of monetary policy.

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1 Introduction

Six years after the financial crisis, we still observe many debt-burdened households, widespread unemployment and relatively low growth, despite the highly expansionary monetary policy adopted by the Federal Reserve. Therefore, it is not a surprise that there is disagreement among economists, as well as policy makers, about the effectiveness and appropriateness of monetary policy after the financial crisis. In this paper, we provide household-level evidence on the pass-through of lower interest rates to households and investigate the extent to which their need to deleverage dampened the effectiveness of monetary policy.

The conventional wisdom has it that monetary policy should affect firms' investment and households' consumption by reducing the cost of external finance. However, a number of contractual frictions might limit the extent to which changes in monetary policy actually affect debt service and the cost of finance for households and firms. When the terms of debt contracts are rigid, as in the case of most fixed-rate mortgage contracts, changes in interest rates have little direct effect on consumption and investment decisions for already indebted households: only potential new borrowers or those able to refinance their mortgages will be affected. In fact, during recent years banks were unwilling to refinance mortgages on "underwater" homes that were worth less than the amount still owed on them. This may have limited the pass-through of lower interest rates to households, and therefore the ability of expansionary monetary policy to stimulate households' consumption.

If borrowers' marginal propensity to consume is greater than that of lenders, a decline in interest rates results in a positive income shock that should increase consumption, to an extent that depends on the magnitude and the persistence of its effect (i.e. the period of time in which monthly payments are likely to remain at lower levels), and boost economic activity.¹ However, this consumption response can be dampened by an increase in precautionary saving, leading households to engage in *voluntary deleveraging*. The higher the household's debt level, the more it should be expected to deleverage.² We provide evidence of both effects. Hence, the effectiveness of lower interest rates is as much about the indebtedness of homeowners as it is about an increase in their housing wealth and a drop in their debt servicing costs.

To isolate the borrowers' consumption response to the change in interest rates, the key identification challenge is that the decision to refinance their mortgage might be correlated

¹See [Mian and Sufi \(2012b\)](#), for instance, for evidence on the importance of this aggregate demand channel and its role in explaining the increase of unemployment in the U.S. during the Great Recession.

²A similar mechanism is proposed by [Guerrieri and Lorenzoni \(2011\)](#), which studies the effects of a credit crunch on consumer spending and show that after an unexpected permanent tightening of consumers' borrowing capacity, the most indebted consumers tend to readjust towards lower levels of debt.

with households' characteristics or geographical factors, which might conceal the effect of the interest rate cut. For instance, households' with a bad credit history may be unable to refinance; the same may apply to liquidity-constrained households, which cannot pay the closing costs of their pre-existing mortgage.³ Similarly, households living in counties where the housing market has experienced a more severe crash are less likely to refinance, due to the high loan-to-value ratios, as most banks require twenty percent equity in the house. These households' consumption response to the drop in interest rates would be accordingly muted.

To overcome these difficulties, we exploit the anticipated changes in monthly payments of borrowers with adjustable rate mortgages (ARMs) originated between 2005 and 2007, with an interest rate fixed for the first 5 years, which is then automatically adjusted at the end of this initial period. A drop in interest rates benefits these borrowers automatically with no need to refinance. And the reduction is sizeable: the ARMs originated in 2005 benefited from an average reduction of 3 percentage points in the reference interest rate in 2010.

The key to our identification strategy is the ability to exploit the timing of the interest rate adjustment. Effectively, we compare borrowers who will experience the interest rate adjustment at different point in time. This allows us to control for the endogeneity of the refinancing decision and to focus on the effects of the cut in monthly payments on their consumption behavior. To this end, we collect information on the balance of all their liabilities, such as credit cards and auto loans, and other revolving or installment debts. To investigate whether the refinancing resulted in faster deleveraging, we analyze data on the households' repayment behavior for both installment and revolving loans. Furthermore, by restricting attention to households with this type of mortgage, we limit potential concerns about the households' characteristics driving the choice between fixed-rate and adjustable-rate mortgages.⁴

First, we study the monthly payment for households with 5-year ARMs and show that, when the interest rate was reset, the monthly payment fell sharply on average by \$900. The payments tend to stay constant before the reset month, as well as afterwards, suggesting that indeed the monthly payments featured a significant, permanent step decrease as a function

³For instance, [Hurst and Stafford \(2004\)](#) shows that the households that engage in home equity extraction are more likely to have experienced an unemployment shock or to have limited initial liquid assets to draw upon. [Agarwal et al. \(2013\)](#) also point out that the incentives might depend on the size of the mortgage, as they estimate the spread between the current and the refinancing interest rate that justifies refinancing at 1.1 to 1.4 percentage points for mortgages between \$100,000 and \$200,000. [Campbell \(2006\)](#) discusses these issues in greater detail.

⁴[Campbell and Cocco \(2003\)](#) show that unconstrained households prefer ARMs when inflation risk is large relative to real interest rate risk, while credit-constrained households might opt for them when they have low risk aversion; however, they are unattractive to risk-averse credit-constrained households with a high debt-to-income ratio.

of the interest rate. We control for borrowers' characteristics as well as county-time fixed effects, which capture any unobserved time-varying variation at the county level, and allow for different trends for each different origination cohort. Exploiting the change in monthly payments, we document three main findings.

First, we find a positive consumption response to a drop in monthly payments. We measure consumption in two different ways. First, we identify the instances in which households purchase a car by applying for an auto loan, which constitutes our main measure of consumption of durable goods. Second, we employ information from revolving store credit cards as a measure of other forms of consumption, such as purchases at store chains like Best Buy or Macy's. Using both measures, we show that the households that experience a drop in monthly mortgage payments increase their consumption significantly in the quarter after the change. Since the change in the mortgage payments was anticipated, we observe a slight but statistically significant increase in the quarter before the change, but the households' consumption expenses spike in the quarter after the reset and remain significantly higher for two years. Specifically, households increase their consumption of durables on average by 40% (or \$150 per month), controlling for household, month and county-time fixed effects, as well allowing for heterogeneous trends for each origination cohort and for different mortgage sizes. In other words, a borrower with a mortgage resetting in January 2010 (after interest rates were reduced) will consume significantly more in the first quarter of 2010 than a borrower with a reset at a different point in time, say June 2010. The amount invested in durable goods, and also the probability of purchasing a new car, spikes after the reduction in the interest rate. Similar results are obtained with our second measure of consumption derived from retail credit cards.

We then turn to the analysis of households' deleveraging. We observe all the payments made towards mortgages and all the other debts, e.g. equity loans and home equity line of credit. We show that they use a significant fraction of the increase in disposable income to repay their debts faster. In terms of economic magnitude, borrowers tend to employ more than 15% of the additional income to repay their debts, which is equivalent to saying that they more than double their efforts to deleverage after the interest rate reset. This suggests that, although the monetary policy implemented starting in 2008 had a significant effect on households' debt service costs, their consumption response was attenuated by the high level of debt accumulated during the boom years and their desire to deleverage.

We complement these results by analyzing the behavior of borrowers with different loan-to-value ratios (LTV) and show that there is a significant difference in their consumption behavior. Specifically, borrowers with above-median LTV increase their consumption almost twice as much as other borrowers. This suggests that, as shown by [Zeldes \(1989a\)](#) and

[Aiyagari \(1994\)](#), the most credit-constrained borrowers are those that react most strongly to the income shock. But interestingly borrowers with lower LTV are those that invest more in deleveraging. This confirms the intuition that the borrowers with low or intermediate LTV ratios are the ones that can benefit the most from deleveraging, being closest to building equity in their homes, while deeply underwater homeowners benefit much less. We also find that low-income households tend to consume significantly more and deleverage less than high-income ones.

Finally, we investigate the implications of our findings for the aggregate economy. To estimate the effect of monetary policy on county-level aggregate consumption, we exploit the geographical variation in the presence of adjustable-rate mortgages: ARMs have been more popular in some parts of the U.S. than others. Specifically, zip codes in California and Florida – and in general in coastal areas – have had higher levels of ARM origination. We accordingly complement our data sources with data coming from a private data provider, Lender Processing Services (LPS), on the ARMs originated at the zip code level. This allows us to construct a measure of how much each region is exposed to the changes in monetary policy.

First, we show that the fraction of outstanding ARMs as of 2006 is a significant predictor of the monetary policy interest rate pass-through in 2007-13. In other words, the average mortgage rate in regions with a higher fraction of ARMs reacts more to the decline in interest rates. Then, by looking at quarterly car sales between 2007 and 2013, we show that changes in the interest rates tend to have a disproportionately larger effect on durable goods consumption in counties with a greater fraction of ARMs. These results remain significant even when we control for local house prices, the elasticity of housing supply, the fraction of subprime borrowers, and county and time fixed effects. These results suggest that relative debt rigidity – viz. the responsiveness of loan contracts to interest rate changes – plays an important role in the transmission of monetary policy to the real economy. Moreover, this empirical strategy allows us to capture the local general-equilibrium response to interest rate changes, as the effects that we estimate can be seen as the sum of the direct increase in car purchases by borrowers holding ARMs, and the indirect increase by all the other households in the same area who benefit from the resulting increase in local demand. However, admittedly our methodology falls short of estimating the aggregate general-equilibrium effect, such as an economy-wide multiplier of interest rate policy; for instance, we do not observe the lenders' response to such changes in interest rates.

1.1 Related Literature

[Bernanke and Gertler \(1995\)](#) show that households' expenditures on durable goods and residential investment are the components of GDP that respond most forcefully to changes in monetary policy. However, very few empirical studies analyze the impact of monetary policy on households' consumption behavior at the disaggregated level.⁵ Moreover, households' consumption reaction to monetary policy can be driven by a valuation channel and an income channel.⁶ Our first contribution is to use household-level data to fill this gap by investigating the role of the income channel of monetary policy in shaping households' consumption and saving behavior.

Recent papers have investigated the channels through which monetary policy impacts on banks' lending decisions and risk-taking behavior. For instance, [Jimenez et al. \(2014\)](#) show that a lower overnight interest rate induces less capitalized banks to lend to riskier firms. [Jimenez and Ongena \(2012\)](#) show that tighter monetary policy and worse economic conditions substantially reduce lending, especially by banks with lower capital or liquidity ratios. Finally, [Maddaloni and Peydró \(2011\)](#) find that low short-term interest rates soften standards for household and corporate loans, an effect that is amplified by monetary policy rates that remain too low for too long.⁷ We complement these studies by uncovering the impact of low interest rates on households' consumption and saving decisions. The novelty of our approach is to document that the prolonged period of low interest rates boost households' consumption both at the individual and the aggregate level, but that the effect is attenuated by the households' incentives to deleverage.⁸

Hence, our paper is related to the work that measures the size of the household consumption responses to fiscal stimulus policy or tax rebates. For instance, [Souleles et al. \(2006\)](#) and [Parker et al. \(2013\)](#) focus on the episodes of 2001 and 2008 respectively, in which the U.S. Treasury scheduled payments based on the last two digits of individual Social Security numbers. They exploit this randomized timing of the receipt of payments to conclude that households spend approximately 25 percent of rebates on nondurables in the quarter that they are received, relative to the control group of households that do not receive the rebate

⁵Evidence of financing constraints at the household level has been widely documented by, among others, [Zeldes \(1989a\)](#), [Jappelli and Pagano \(1989\)](#), [Campbell and Mankiw \(1989\)](#), and [Carroll and Dunn \(1997\)](#).

⁶See [Doepke and Schneider \(2006\)](#) for evidence regarding the valuation channel.

⁷Other relevant papers in this literature include [Bernanke and Blinder \(1988\)](#), [Christiano and Eichenbaum \(1992\)](#), [Kashyap and Stein \(2000\)](#), [Stein \(2012\)](#) and [Williamson \(2012\)](#).

⁸For other papers on the effects of unconventional monetary policy see [Swanson and Williams \(2012\)](#), [Romer and Romer \(2013\)](#), [Krishnamurthy and Vissing-Jorgensen \(2011\)](#), [Krishnamurthy and Vissing-Jorgensen \(2012\)](#), and [Gagnon et al. \(2011\)](#). Recent papers by [Doepke and Schneider \(2006\)](#), [Coibion et al. \(2012\)](#) and [Sterk and Tenreyro \(2014\)](#) have also investigated the redistributive implications of monetary policy for the aggregate economy.

in that same quarter. There is also evidence of interesting dynamic effects. For instance, [Agarwal et al. \(2007\)](#) analyze the tax rebate of 2001 and show that consumers initially saved some of it, by increasing their credit card payments and thereby paying down debt, but that their spending increased again soon afterwards. This uncovers an important liquidity mechanism, which is confirmed by our results on the heterogeneous marginal propensity to consume of borrowers facing different wealth shocks.⁹ Recently, [Mian and Sufi \(2014\)](#) examine households' borrowing and spending behavior resulting from rising house prices from 2002 to 2006. [Mian et al. \(2013\)](#) estimate, instead, the elasticity of consumption with respect to net housing worth, during the 2006-2009 period, employing the unequal geographic distribution of wealth losses across the United States.

In contrast to most of the literature which focuses on anticipated shocks, [Agarwal and Qian \(2013\)](#) study how households respond to an unanticipated income shock. Specifically, they study the effect of the Growth Dividend Program, which consisted in a one-time cash payout of \$1.17 billion ranging from \$78 to \$702 to 2.5 million Singaporeans. They find that for each dollar received, consumers on average spent 80 cents during the ten months after the announcement. [Jappelli and Padula \(2014\)](#), instead, study the effect of a change in the severance pay for public employees in Italy, which entailed substantial losses for future generations of public employees and can be considered as an unanticipated income shock. They find that each euro reduction in severance pay reduces the average propensity to consume by 3 cents and increases the wealth-income ratio by 0.32.

Other related papers in this literature include [Jappelli and Pistaferri \(2010\)](#), [Kaplan and Violante \(2011\)](#), [Hsieh \(2003\)](#), [Shapiro and Slemrod \(2003b\)](#), [Shapiro and Slemrod \(2003a\)](#), [Souleles \(2002\)](#) and [Stephens Jr \(2008\)](#). [Jappelli and Pistaferri \(2010\)](#) develop a theoretical framework that has several predictions for consumption response to unanticipated and anticipated income shocks depending on their persistence and the degree of completeness of credit and insurance markets. Specifically, they argue that while consumption should not respond to anticipated but should respond to unanticipated income changes. Recently, [Kaplan and Violante \(2011\)](#) propose a quantitative framework, where households can hold two assets: a low-return liquid asset (e.g., cash, checking account, etc.) and a high-return illiquid asset that carries a transaction cost (e.g., housing or a retirement account). They show that this model yields consumption responses to fiscal stimulus payments that are in line with the empirical evidence. [Hsieh \(2003\)](#) provides evidence of consumption smoothing employing the Alaska permanent fund, while [Shapiro and Slemrod \(2003b\)](#) and [Shapiro and Slemrod](#)

⁹[Bertrand and Morse \(2009\)](#) also use the 2008 tax rebate, studying the behavior of borrowers who use payday loans. They find that only the low-to-middle users of payday lending services (measured in terms of frequency of use in the prior year) retire debt in the pay cycles that follow the receipt of the tax rebate.

(2003a) provide further evidence on the tax rebate in 2001 and Souleles (2002) analyze the effects of the Reagan tax cuts. Finally, Stephens Jr (2008) examines the consumption reaction to predictable increases in discretionary income, following the final payment of a vehicle loan, to investigate whether households "smooth" consumption in response to predictable changes in income.

In sum, we contribute to this literature in two ways. First, whereas the existing literature focuses on the effects of fiscal policy through tax rebates, our study highlights the role that monetary policy can play in shaping consumers' behavior through mortgage payments and housing wealth. Second, the magnitude of the average income shock per households is significantly larger than any other previous study considered. In fact, our estimates do not rely on a one-time shock, but on an average effect of about \$900 per month.

Finally, our paper also highlights the important role played by frictions in the mortgage market. While the previous literature on monetary policy has focused on price rigidities, we highlight the importance of debt rigidities in the transmission of monetary policy. This also connects our study to recent papers by Calza et al. (2013), Scharfstein and Sunderam (2013) and Keys et al. (2014). Calza et al. (2013) analyze the relationship between the structure of housing finance and the monetary transmission mechanism in several industrialized countries. They show that the size of the effect of a monetary policy shock is significantly related to indicators of flexibility in the mortgage markets and that residential investment is significantly more responsive to policy innovations in countries with a variable-rate mortgage structure. Scharfstein and Sunderam (2013) show that the strength of the housing channel of monetary policy is reduced in areas with more highly concentrated mortgage lending. Keys et al. (2014), instead, examine the reasons behind the failure to refinance for households in the U.S., even when this would lead to significant savings. Specifically, they compute that the median household that is holding on to a mortgage with too high an interest rate would have saved approximately \$45,000 (unadjusted) over the remaining life of the loan by refinancing. Moreover, they argue that the failure to refinance was too widespread to be explained simply by more conservative underwriting standards in the wake of the crisis.

We complement these papers by showing how households less subject to such frictions, due to an automatic adjustment of the interest rate, responded to the positive monetary policy shock.¹⁰ We are able to do so by employing an identification strategy similar to that proposed by Fuster and Willen (2013), who employs these changes to monthly mortgage payments to shed light on borrower's default behavior and show that the reduction of the

¹⁰Also related is the mechanism proposed by Iacoviello (2005). He develops and estimates a monetary business cycle model with nominal loans and collateral constraints tied to real estate values as in Kiyotaki and Moore (1997). He shows how positive demand shocks, which reduce the real value of borrowers' outstanding debt obligations, are amplified and propagated over time.

payment significantly reduces the hazard of becoming delinquent.

The remainder of the paper is organized as follows. Section 2 provides details on the data sources and summary statistics. Section 3 explains the research design and how it is made operational. Section 4 describes and interprets the main results on the households' marginal propensity to consume. Section 5 presents evidence suggesting heterogeneous MPC among households facing different liquidity constraints. Section 6 discusses a number of robustness checks and Section 8 concludes.

2 Data and Summary Statistics

We take advantage of two main source of information, one on the characteristics of the mortgages and one on households' balance sheets. Specifically, we collect data on mortgage loans originated every month from 2005 to 2013 through Blackbox Logic, a private company that provides a comprehensive, dynamic dataset with information on 21 million privately securitized Subprime, Alt-A, and Prime loans. These loans account for about 90% of all privately securitized mortgages from that period. This dataset allows us to keep track of the information on the mortgages and the borrowers at origination, such as the loan type, the initial interest rate, the initial FICO score and the amount of the loan, but more importantly it provides us with monthly updates about, for instance, the status of each mortgage, the monthly payments, the current balance and other important information. Furthermore, since we know the borrowers' location we can employ the zip-code house prices and the information about the current balance on the mortgage to construct a current loan-to-value ratio for each borrower.

These loans are then matched with credit bureau reports from Equifax. Equifax provides us with detailed households' balance sheets, specifically, the monthly information on all the loans that a borrower has, such as credit cards, auto loans, mortgages, and home equity line of credit, but also on his current FICO score. The two datasets allow us to construct our main variables of interest. First, we can precisely identify the mortgages that should be affected by changes in monetary policy. Specifically, we focus on prime five-year ARMs originated between 2005 and 2007, which are among the most common categories within the ARMs. We also employ the second-largest category, ten-year ARMs, as control group to provide an additional robustness check in Section 6. Second, we can accurately measure the change in the mortgage monthly payment as we observe the borrowers' mortgage payments each month. By observing this balance sheet information over time, we can also estimate how much of the income shock will be utilized by the borrower to pay down debt. Finally, we can construct a measure of consumption for each borrower. In particular, we can measure

the consumption of durable goods, proxied by the change in auto loans. We also supplement this with another measure of consumption coming from the balance of the borrowers' store credit cards (e.g. Best Buy card, Macy's card, etc.) to provide further evidence on the households' consumption response.

To be clear, these measures underestimate the increase in consumption resulting from the decline in interest rates, because they cannot capture purchases made by cash, check or other means not recorded in Equifax. At the same time, we cannot observe the decision of the households to save part of the reduction in the monthly payment in their checking or saving accounts. Yet, this only makes the significant portion of the positive income shock that we are able to account for all the more striking.

Let us start by describing the main variable of interest. Figure 1 shows the distribution of the changes in the monthly payment at the time of the interest rate adjustment for our sample of ARMs. In other words, the average monthly positive disposable income shock is about one thousand dollars which, as we will show in the next section, corresponds to half the monthly payment. However, depending on the size of the loan, some borrowers' monthly payment goes down by more than three thousand dollars. We take account of this heterogeneity by analyzing the behavior of households subject to a different intensity of the treatment.

This change in the monthly payment is triggered by the automatic reduction of the mortgage rates. In our sample, mortgage rates are computed as a fixed spread over an index. Since these are all prime borrowers, the spread is relatively low with a range of 2 to 4 percentage points. Most of the loans are indexed to 6-month LIBOR, the second largest group comprised is indexed to 1-year LIBOR, and finally a fraction are indexed to the 1-year Treasury bill rate. Figure 2 shows the cumulative distribution function for the change in the mortgage rate between the origination and the date of the adjustment. The average decline in the interest rates is about 3.3 percentage points. Moreover, considering our sample period for the post-adjustment period 2010-2012, the majority of these loans will enjoy these lower interest rates for a prolonged period of time.

We can now turn to our main measure of consumption: car purchases. Figure 3 is a representation of the way in which we are able to identify car purchases through two examples drawn from our sample. We plot the balance of the auto loans and the measure of new car purchase that we use in our analysis. The left panel describes the case in which the borrower has bought a car before the beginning of our sample, and starts paying down his auto loan over time. This explains why our measure stays constant at zero for the whole period, while the blue dots trace the decreasing auto loan balance. The right panel, instead, represents the more relevant case in which a consumer has bought two cars. These events

correspond to a clear spike in his auto loan balance. Our measure of car purchase is equal to the change in the auto loan balance at the time of purchase.

Figure 4 complements the previous description by showing the average monthly expenditure on car purchase for the period 2006-2012. It starts from its highest level at the beginning of our sample, at about \$400 per month spent, and declines to \$250-\$300 during the Great Recession. The bottom graph shows, instead, the average probability of a car purchase in a month, which is between 1.3% and 2.1%. These data will be useful in interpreting the magnitude of our consumption response.

Before discussing the summary statistics, we also plot the average monthly partial mortgage prepayment in Figure 5. This captures the amount allocated by the borrower to repay the mortgage. It is \$40 during the pre-adjustment period 2007-2010, but then rise to \$120 in the later years in our sample. This increase reflects the fact that starting in 2005, a significant fraction of these households benefited from the adjustment to the interest rate and, as we will show in the next section, they allocate on average an additional \$60 to repay their mortgages.

Table 1.A reports the summary statistics for the main variables. We consider both 5-year and 10-year ARMs, since the latter will be used as an additional control group in Section 6. Our sample comprised prime borrowers with an average FICO score of 736, an average original mortgage balance of \$357k, and an initial loan-to-value ratio of 77%. The interest rate averages 6.4% at origin and it declines to 3% after the adjustment, with a corresponding decrease in the average monthly payment from \$1.900 to \$915. We also computed that the average monthly expenditure on new cars by these borrowers was \$319 and their monthly probability of purchasing a new car 1.5%. Next we can compare these characteristics with the 10-year ARMs. The main difference is that 10-year ARMs tend to be larger, with an average mortgage size of \$536k and a monthly payment of \$2.700, but the borrowers' consumption and saving behavior is very similar.

To analyze the aggregate effects of changes of interest rates on the county-level consumption we use a dataset from R. L. Polk & Company (Polk) that records all new car sales in the United States.¹¹ Beginning in 2002, for each new car purchased in the United States, the dataset identifies whether the car was purchased by a private consumer (a retail purchase), a firm (commercial purchase), or by the government. It also gives the county, year and quarter in which the car was registered.

The lower panel of Table 1.A shows information about the key control variables that we use in Section 7 to capture county-level heterogeneity. We collected information on median income, population, household leverage, inequality as captured by the Gini coefficient,

¹¹This same data has been previously used by [Mian et al. \(2013\)](#).

poverty rate, fraction of African-American and, more importantly for our analysis, the fraction of ARMs in 2006. The latter exhibits a significant variation: 17% on average, but ranging from 3% to 63%.

For the households' balance sheet information we employ data from LPS. It provides loan-level information collected from the major mortgage servicers in the US, covering about 60 percent of the mortgage market. We use this data to construct the total stock of outstanding mortgage debt in each county, disaggregating the principal balance by whether the mortgage is fixed rate or adjustable rate and combining the principal balances for adjustable and hybrid mortgages. We include both refinances as well as new mortgage originations in order to measure broadly the potential channels through interest rate movements might affect consumption. The main advantage of this dataset over the one we use for the loan-level analysis is broader coverage, because it includes non-securitized loans and loans insured by GSEs. However, we cannot employ this dataset throughout the paper, because it does not contain credit bureau information from which we derive our measures of consumption and prepayment.

We can take advantage of the larger sample in LPS to see whether the borrowers in BlackBox differ from households holding other types of mortgages in any significant way. Table 1.B provides information first on the characteristics of almost 20 million mortgages originated between 2005 and 2008, and then on three main subgroups: borrowers with fixed-rate mortgages, those with adjustable rate mortgages and those with 5-year ARMs (which are not restricted to hybrid mortgages only). Comparing data from Table 1.A with the one provided in Table 1.B we can see that in our sample the borrowers have a somewhat better FICO (736) than the average borrower (703), or borrowers with fixed-rate mortgages (705), but very similar to the sample of 5-year ARMs in LPS (721). The same is true for the interest rate at origination, the initial monthly payment and the loan-to-value ratio. The only important difference between these different types of mortgage holders is the average size of the loan. In LPS we have an average size of \$349k, compared to \$196k and \$239k for fixed-rate mortgages and the average borrower respectively. However, this is very close to what we report in Table 1.A for our sample of 5-year ARMs in BlackBox (\$357k). This evidence reassures us that the main mortgage characteristics of the borrowers who experienced the automatic adjustment of the interest rate mirror those of the more general population of households holding a mortgage in U.S.

3 Research Design

The monetary policy implemented in the aftermath of the crisis could have benefited existing homeowners through the possibility of refinancing at lower interest rates and so boosted aggregate consumption. But a substantial fraction of homeowners were not able to take advantage of the low interest rates due to the collapse in house prices, which resulted in spiking loan-to-value ratios and the consequent inability to refinance. This paper starts with the observation that during the boom period 2004-2006 an important part of the mortgages originated were adjustable rate mortgages.¹² The key feature exploited in our study is that these mortgages entail an interest-only payment for the first 10 years, and an automatic adjustment of the interest rate 5 or 10 years after the origination. In other words, no matter the local house prices, these households would see their mortgages refinanced at much lower interest rates, which would result in a significant reduction in their monthly payment. A crucial factor in our identification strategy is that the monthly payment reduction is a feature of the contract and not an endogenous choice of the borrower.

At the individual level, our identification strategy is designed to exploit the timing of the change in the interest rate and the automatic reset for these ARMs as a positive income shock for households holding these mortgages.¹³ The estimation methodology employed for the individual level is a version of the difference-in-differences estimator (DD). Specifically, in each month t the treatment group includes all the households holding 5-year ARMs who have their mortgages reset in month t , while the control group comprises those with the same type of mortgage, but that did not experience the change in their interest rate. In other words, we estimate the consumption response of the households who experienced a reduction in the interest payment, relative to that of households holding the *same* mortgage, but with a different reset date.

This identification strategy has several advantages. First, by restricting attention to households holding the same ARMs, we avoid picking up some difference in preferences that could drive the choice of an ARM rather than a fixed-rate mortgage. Second, this strategy allows us to exploit the timing of the change, which is unlikely to be correlated with the households' consumption behavior. That is, the assumption is that households whose mortgage is reset in May 2010 are basically comparable to households that will experience their reset, say in December. Third, thanks to the panel nature of our data, we can control for

¹²By 2006 they reached over 12% of all new mortgages and close to 40% in some well-performing markets (see [Krainer and Laderman \(2014\)](#), [Piskorski and Tchisty \(2010\)](#) and [Garmaise \(2013\)](#)).

¹³At the aggregate level, we can exploit the inter-county heterogeneity in exposure to these type of contracts to analyze how the prolonged period of low interest rate has affected households' consumption behavior. This will be explained in greater details in Section 7.

household and time fixed effects in all our specifications, as well as a vector of characteristics that would absorb potential heterogeneity correlated with their consumption and saving behavior.

Moreover, as a further robustness check, we can include county-month fixed effects and cohort-year fixed effects, where cohort is defined as the year of origination.¹⁴ These more conservative specifications correct for two potential confounding effects. First, we allow for heterogeneous trends in different regions, which controls for potential differential responses to the reduction in the interest payment due to changing local economic conditions. For instance, households in counties with a more severe bust and economic recession might show different consumption behavior from those in counties less severely affected.

Second, we allow for heterogeneous trends by cohort of origination, which captures unobserved variation across cohorts that might affect the households' response to the interest rate reset. For instance, mortgages originated in 2007 had higher LTVs than those originated in 2005, as the house prices rose in the meantime and lending standards became laxer. This means that households who purchased a house in 2007, with a higher monthly payment, are affected differentially by the interest rate adjustment, both because of the stronger income shock and because of potential characteristics correlated with their consumption behavior, such as creditworthiness and expectations about future income growth.

Formally, our main specification is the following

$$Y_{i,t,g,\tau} = \sum_{\theta=-8}^8 \beta_{\tau} 1\{\tau = \theta\} + \lambda_i + \eta_{g,t} + \Gamma X_{i,t} + \varepsilon_{i,t,\tau}, \quad (1)$$

where i denotes the households, g the county, t the month or the quarter and τ the quarter since the interest rate adjustment. The main outcome variables $Y_{i,t,g,\tau}$ analyzed in the next section are the increase in consumption of durables, as proxied by the purchase of a car or by purchases made with store credit cards, and the increase in voluntary prepayment of debts. The main coefficients of interest are β_{τ} which capture, for instance, the consumption response to the change in the interest payment one quarter, two quarters or even two years before and after the adjustment of the interest rate. λ_i captures the households fixed effects, whereas $\eta_{g,t}$ is the county-month fixed effects. Finally, $X_{i,t}$ is a vector of borrower's characteristics designed to capture any residual individual heterogeneity not captured by the household fixed effect. This includes the borrower's FICO score, as proxy for his financial constraints or creditworthiness, and the zipcode-level house prices to capture the local economic conditions. Alternatively, instead of controlling for the county-month fixed effect we can control for

¹⁴Since in our specifications we estimate the consumption and saving response with quarterly dummies before and after the interest rate adjustment, we cannot estimate different trends for quarters of origination.

the cohort-year fixed effect. To analyze heterogeneity in the response to the decline in the monthly mortgage payment, we interact $1\{\tau = \theta\}$ with indicators for different types of households. We correct the standard errors to allow for arbitrary heteroskedasticity and we cluster them at the household level.

We start by quantifying the average change in the monthly payment, which will constitute our income shock. Figure 6 shows an event study analysis with time zero being the time of the interest rate reset and the x-axis being quarters before and after the adjustment. In the top graph, we plot the average monthly payment, normalized to zero in the pre-period, which stays constant for the period before the event and drops significantly at the moment of the event. The bottom graph shows the change in the monthly payment once we normalize it by the monthly payment at origination. The magnitude of the drop is very substantial, nearly a thousand dollars on average, or about half the monthly payment. This figure also highlights one important feature of our setting, namely that the reduction in the payment is not temporary, but lasts for the whole post period. This is because even though these ARMs usually reset the interest rate every year after the initial fixed-rate period, the low interest rate regime that set in December 2008 is still in place.

Now we can present our estimation results. Table 2 shows the regression of interest payments on the time dummies for the four quarters before and after the change in the interest rate as in (1). Each coefficient captures the dollar reduction in the interest payment in that quarter for the sample of all 5-year ARMs with a 10-year interest-only payment originated between 2005 and 2007. In Column (1) we control for households and month fixed effects and show that in the quarter after the event there is a significant reduction in the interest payment of about \$1045. Similar estimates are presented for the subsequent quarters. The presence of small changes in the pre-period is due to the possibility of voluntary payment or adjustments by the households. However, coefficient goes from -\$47 to -\$1,044, which highlights how important the change in the interest rate has been for households' balance sheets.

Column (2) confirms similar results controlling for the borrower's FICO score and the log of house prices in the county. Column (3) is a more restrictive specification, as we control for county-month fixed effects as well as household fixed effects. But even when we capture this time-varying heterogeneity at the county level, neither the economic magnitude nor the statistical significance is affected. Our preferred specifications are those in Columns (4) and (5). Column (4) includes households fixed effects and origination cohort-year fixed effects. As is evident from the magnitude and statistical significance of our results, the estimated coefficients are not affected by potential heterogeneity across mortgages originated in different time periods.

The reduction in the monthly payment tends to go down from \$920 in the first quarter after the adjustment to \$720 two years afterward, but this is because that for later quarters the only borrowers on whom we have the data two years after the adjustment are those originated earlier in our sample, and these are mortgages with lower monthly payments than the later cohorts. This is easily taken into account in Column (5): allowing for differential trends depending on the size of the initial monthly payment, the reduction in the monthly payment is very stable at around \$920 for the entire post-adjustment period. Finally, we run a similar specification to the one in Column (4), the only difference being that we normalize the monthly payment by the size of the original payment. Intuitively, the estimated coefficients capture the size of the reduction in percentage points. While there is no economically significant reduction in the monthly payment before the interest rate adjustment, it is reduced by 53 percent in the first quarter after the adjustment and this effect persists for the next two years.

In sum, the automatic reset of the interest rates constituted a major positive disposable income shock for these households. Unlike most of the literature on households' consumption response to income shocks, which focuses on one-time payments, such as tax rebates, of a few hundred dollars, we have the opportunity to investigate a shock of tens of thousands dollars per year.

4 Main Results

We start by investigating the effect of the change in interest payments on the households' consumption behavior and then analyze its effect on their debt-repayment strategy.

4.1 The Consumption Response

We take data on auto loans to capture the purchase of a car in response to the reduction in the monthly mortgage payment. We can track the changes in the auto loan balance to identify all the instances in which households purchased a car using financing.¹⁵

We start our analysis with Figure 7 which shows an event study analysis with time zero as the moment of the interest rate reset and the x-axis showing the quarters before and after the event. The top graph plots the average monthly amount spent on car purchases through an increase in auto loans. It shows that households increase their car consumption starting one year before the interest rate reset, allocating on average \$50 to it. This shows that households were anticipating the mortgage payment reduction and began to increase

¹⁵In Section 6 we complement these results using a different measure of consumption, store credit cards.

their car purchasing before the reset date. Interestingly, however, the effect increases in the subsequent quarters to an average of as much as \$200 one year after the interest rate adjustment. The bottom graph plots the same coefficients normalized by the initial monthly payment. On average, the households that expect the reduction in the monthly payment allocate about 5% of the positive income shock to purchase a car in the quarter before the adjustment, but this effect increases significantly in magnitude in the next quarters to over 20% one year after the adjustment.¹⁶

Table 3 confirms the previous results controlling for several potential confounding effects. Column (1) presents the coefficients controlling for household and month fixed effects. It shows that starting one year before the change in the interest rate, households start spending about \$40 more on durable goods.¹⁷ However, in the quarter after the reset the households more than double their consumption spending to almost \$100, and to \$203 two years after the interest rate adjustment. Column (2) controls for the borrower’s FICO score and the log of house prices in the borrower’s. Both the statistical and the economic magnitude of the estimates are unaffected. Intuitively, higher FICO scores predict higher consumption, because they capture the credit available to these borrowers.

In Column (3) we saturate the model with county-month fixed effects, showing that allowing for differential trends across different counties does not affect our estimates. This is particularly important for this estimation, because households’ consumption decisions can be significantly affected by local economic conditions. For instance, households living in counties worst hit by the financial crisis, such as those that experienced the sharpest declines in house prices or employment, may have a different marginal propensity to consume than households living in less severely affected regions. In Column (4), instead, we introduce origination cohort-year fixed effects. The coefficients are robust to this factor, which shows that the differential conditions at origination, such as the different equity in the house, have no significant impact on our estimates. In fact, households start allocating an additional \$52 to consumption before the interest rate adjustment, increasing to \$93 in the quarter after and \$150 one year after.

Column (5) shows the coefficients for the specification in which we allow for different trends for different quartile of the monthly payment at origination. This captures in a non-linear fashion the possibility that households facing different monthly payments behaved

¹⁶Note that the coefficients are normalized by the initial monthly payment, and we know from Table 2 that the payment falls 50%. Hence, we need to double our point estimate to capture the fraction of the monthly reduction in payment allocated towards car purchases.

¹⁷Lenders are required to disclose information about future interest rate adjustments at least 60 days before it occurs. Moreover, the regulation implemented after the crisis, such as the Truth in Lending Act, extended this to six months. For more information see <http://archive.regulationroom.org/mortgage-protection/issue-posts/for-all-borrowers-adjustable-rate-mortgages/>.

differently. For instance, households with higher monthly payments might have higher incomes and own larger houses, which might also lead them to have different consumption responses to the positive income shock. The magnitude of these effects is particularly large if compared with the data in the top plot of Figure 4. Since we are examining the consumption behavior of households with mortgages originated between 2005 and 2007, we are investigating consumption behavior in the period 2010-2012. Considering the monthly expenditure on cars for that same period, the top panel of Figure 4 shows that it averages \$300 a month. Our estimates suggest that after the interest rate adjustment the households' car purchases increased by at least 30%, and as much as 55%.

In Column (6) we estimate a linear probability model to determine how the likelihood to purchase a car is affected by the change in the monthly payment, which provides us with an estimate of the households response on the extensive margin. It shows that this probability increases by 0.8% a month in the first quarter after the adjustment, rising to 1.3% two years after. This is an economically significant effect, because as shown by the bottom panel of Figure 4, the average monthly probability of buying a car in the 2010-2012 period is about 1.3%. Hence, households increase their monthly probability of purchasing a car by at least 60 percent.

Finally, Column (6) reports the estimated coefficients of monthly car purchases normalized by the size of the original monthly mortgage payment, controlling for household and mortgage cohort-time fixed effects. Households spend 10% of the income shock the first quarter after the interest rate adjustment, but this effect increases over time, reaching 20% one year later.

Interestingly, these effects together show a different reaction of durable consumption from its response to the fiscal stimulus recently identified by [Mian and Sufi \(2012a\)](#). The latter estimate the impact of the 2009 "Cash for Clunkers" program on short and medium-run auto purchases and show that the resulting boost in aggregate demand is quite short-lived. In fact, they find that almost all of the additional purchases under the program were pulled forward from the near future. In our case, instead, the reduction of the monthly payment significantly increased aggregate demand, and we find no evidence of intertemporal substitution. This follows from the absence in the quarters before the interest rate adjustment, of any evidence that households decreased their consumption. Nor do we find that the effect is short-lived; quite the contrary, we find that it increases over time. We believe this is due to the different features of the underlying income shock. Unlike [Mian and Sufi \(2012a\)](#), which examines a one-time subsidy to purchase prices, we consider a shock that is much larger and that persists over a number of quarters. Hence, as we shall show in Section 5, our mechanism is likely to involve wealth and liquidity effects. Moreover, since the shock is less temporary than in

Mian and Sufi (2012a), households do not change just the timing of their consumption but also its level.

More generally, we can compare our estimates with the literature on households' consumption response to income shocks. Among the most recent contributions to this literature, Parker et al. (2013) analyzes the reaction to the Economic Stimulus Act (ESA) of 2008, which consisted in a tax credit of \$300 to \$1200 depending on the household's size. They find that households spent about 12 to 30 percent of their stimulus payments on non-durable consumption goods and another 38 to 60 percent on vehicles, which is only slightly smaller in magnitude than the response to the 2001 tax rebates (see for instance Johnson et al. (2009)). On the one hand, we find a smaller effect (comparing the \$150 spent on vehicles with the estimates provided by Parker et al. (2013)). On the other hand, we find that the radically different source of the income shock means that in our case the effect lasts for up to two years, which makes the overall consumption spending significantly larger. Another significant factor in this comparison is that mortgage interest is tax-deductible, which makes the effective income shock about thirty percent lower, depending on the household's tax bracket. In the next section we provide evidence of one important reason why households might not spend the additional income on consumption: voluntary deleveraging.

4.2 Voluntary Deleveraging

The way in which monetary policy can affect households' behavior depends crucially on precautionary saving. In general, we would expect that if households are liquidity-constrained, a decrease in debt service will be associated with an increase in consumption. But the magnitude of this effect can be a function of their incentive for precautionary saving. That is, the greater the income risk, the smaller the consumption response.¹⁸

To estimate this effect, we record the changes in the debt balance for the households affected by the automatic interest rate reset. This allows us to track down their incentive to allocate the savings to faster repayment of their loans. To be sure, we are not able to capture other forms of saving, such as retirement accounts or savings deposits, so we necessarily underestimate the precautionary incentive. Nevertheless, we believe that given the collapse in house prices and the high loan-to-value ratios for the majority of the mortgages in our sample, repaying their mortgage more rapidly and building equity in their homes might constitute an important way for households to use the additional resources available.

Figure 8 shows an event study analysis with time zero at the interest rate reset and

¹⁸Consistent with this intuition, Agarwal et al. (2007) analyze the 2001 tax rebate and show that consumers initially saved some of the rebate, increasing their credit card payments and so paying down debt, but that their spending increased soon afterwards.

quarters before and after the event on the x-axis. The top panel shows the average monthly amount allocated to voluntary repayment of mortgage principal. We only consider partial prepayment, because full repayment coincides with the house being sold or the mortgage being refinanced. The plot shows that, in contrast to the consumption response presented in Figure 7, even if the change in the monthly payment is anticipated, the borrower does not allocate an economically significant amount of money until the quarters following the interest rate adjustment. Specifically, households allocate on average \$60 per month to a faster repayment of their mortgage, and the amount increase in the following quarters. The bottom panel shows that this corresponds to about 15% of the positive disposable income shock.

Table 4 reports the coefficients estimated using a similar regression to (1), which allows us to supplement the findings of Figure 8 by controlling for several other factors that could distort our results. The dependent variable is the monthly reduction in the mortgage balance; it is computed from BlackBox data. Column (1) controls for household and month fixed effects and shows that borrowers spend about \$60 a month to repay the principal on their mortgage in the first quarter after the reset, but no significant pre-trend (the coefficient for the quarter before the adjustment is insignificant). Column (2) shows that the effect is robust to the FICO score and the county log of house prices. It shows that the FICO score positively predict an increase in borrowers' voluntary deleveraging. Moreover, higher housing prices that are correlated with general economic conditions tend to be correlated with faster deleveraging.

Columns (3) and (4) show the robustness of our results to the inclusion of county-month fixed effects and cohort-year fixed effects. In fact our effect is even larger, reaching almost \$80 two years after the reset. These tests further reassure us that our results are not driven by heterogeneity in county or time of origination factors that might determine the households' saving decisions. The specification in column (5) we allows for different trends for households with different monthly payments. Even here, however, the statistical and economic significance of our estimates remains unaffected. Finally, in Column (6) we estimate a specification similar to that of Column (4) but normalizing the prepayment by the original monthly mortgage payment. We find that on average 10% of the income shock goes to repay the mortgage.

To evaluate these results, we can compare them with the average amount allocated by households to repay their mortgages in the pre-adjustment period (Figure 5). Up to 2010, the first year when any of our sample households benefited from the interest rate adjustment, the average amount devoted to deleveraging was \$40 over the period 2007-2010. This means that after the adjustment, households more than doubled their efforts to reduce their debt

level.

5 Heterogeneous Responses across Households

In this section we analyze the heterogeneity in households' consumption and saving decisions in response to the income shock.

The theoretical literature indicates the types of households that should respond more forcefully to a positive income shock. For instance, [Zeldes \(1989a\)](#) show that an important source of heterogeneity is the tightness of households' liquidity constraint, which can motivate the reaction to an anticipated income shock like ours. Liquidity-constrained households may be unable to increase their consumption until the income shock occurs. A number of studies, such as [Zeldes \(1989b\)](#), [Jappelli \(1990\)](#), [Aiyagari \(1994\)](#), [Jappelli et al. \(1998\)](#), [Kaplan and Violante \(2011\)](#) and [Jappelli and Pistaferri \(2014\)](#) among others, support this hypothesis.¹⁹

We can employ several measures to capture liquidity constraints. First, a cash-flow measure of liquidity is borrower income, which we measure in the pre-adjustment period. Table 6 tests for differences in spending and saving across income groups. Since we need to report the interactions between the time dummies and the income indicator, we restrict attention to one year before, one year and two years after the reset date, and we only report the normalized coefficients, which makes the effect easier to interpret.²⁰ High-income households' income shock is larger, as shown in Column (1), which suggests that households with higher income have larger mortgages, and hence a larger monthly payment, to begin with. Interestingly, Column (2) provides supporting evidence that the more liquidity constrained households tend to have a higher marginal propensity to consume. In fact, low-income households spend 20 percent more of their additional income on car purchases. However, we also find that they have a significantly lower marginal propensity to deleverage (Column (3)) in the first year after the interest rate reset.

Another important gauge of liquidity constraints on homeowners is their loan-to-value ratio (LTV). Table 7 tests for differences in car purchases and mortgage principal prepayment across households with different LTV. "High LTV" is an indicator variable, equal to one for current LTV larger than the median, which is 105 percent.²¹ We measure the LTV in the 24 months up to 12 months before the interest rate adjustment and in all specifications we

¹⁹Given the size of the income shock, its monthly nature and its duration, we believe that the utility costs of not smoothing consumption before and after the interest rate adjustment are not likely to be small. See [Caballero \(1995\)](#), [Parker \(1999\)](#), [Sims \(2003\)](#) and [Reis \(2006\)](#) for studies about this possibility.

²⁰The estimates with quarterly dummies show exactly the same pattern and are available in the online appendix ?? .

²¹Note that this is not the LTV at origination, but the LTV computed by using information on the zip-code level house prices and the current mortgage balance.

control for household fixed effects, origination cohort-time fixed effects and high- and low-LTV-time fixed effects. These capture unobserved heterogeneity at the household level and allow for differential trends across cohorts and households with different loan-to-value ratios.

We find that borrowers with a high LTV experience a monthly income gain only slightly smaller than the other borrowers (Column 1). However, these households have a significantly higher marginal propensity to consume. In fact, high-LTV borrowers spend almost twice as much on durable goods as low-LTV households (Column 2). This suggests that, as shown by [Aiyagari \(1994\)](#), the most constrained borrowers react most sharply to the income shock.

Next, we investigate how saving decisions are affected by LTV. We find that borrowers with higher LTV tend to deleverage less. Intuitively, borrowers who are deep underwater have little incentives to use the reduction of the monthly payment to repay their debt, because they do not expect to be able to build equity in their homes any time soon. In contrast, the households with intermediate LTV can really benefit from the reduction in the interest rate, as a smaller repayment may well get them out from underwater and enable them to build equity.²²

Finally, we can also capture the heterogeneity in households' access to credit with their FICO score, proxying credit availability with the average borrower's FICO score over the period 24 to 12 months before the interest rate adjustment, so that post-adjustment consumption and saving decisions cannot influence this proxy. We divide the sample between borrowers with above- and below-median FICO scores, denoted by the dummy "High FICO". Since we measure durables consumption with leveraged car purchases, we should expect that households with less access to the credit market will spend less on vehicles. Table 9 tests this hypothesis.

In all specifications we include household fixed effects, as well as origination cohort-time fixed effects, but we also modify our baseline specification to allow for heterogeneous time trends between high- and low-score households. Column (1) investigates the reduction in the monthly payment: households with high FICO scores have a monthly payment reduction only 3% larger than those with low FICO, which translates into a net income boost of \$27. However, Column (2) shows that borrowers with high FICO consume 13% more than those with less access to the credit market. This is consistent with the interpretation that low FICO households face higher borrowing costs and poorer access to credit, i.e. auto loans, which presumably result in lower car purchases. This is important to an understanding of how the fiscal multiplier varies when borrowers are more credit-constrained: when leveraged

²²Consistent with this view, [Gross and Souleles \(2002\)](#) show that consumers whose credit card limits get increased increase their debt, and that the effect is larger for consumers near their current limit, which is consistent with binding liquidity constraints. We supplement these results by analyzing the behavior of borrowers with different loan-to-value ratios.

purchases are limited or credit standards tightened, the benefits from low interest rates can be limited for the more constrained borrowers. Column (3) also shows that there are significant differences in the deleveraging behavior of households with different FICO scores, because the more creditworthy deleverage by 30% more than the less creditworthy.

Taken together, our results on the marginal propensity to consume and deleverage in different types of household suggests the importance of liquidity constraints. The reduction in the monthly payments, as a result of the low-interest-rate environment, provided the resources for down payments on leveraged purchases of cars, which would not have been available otherwise. This corroborates the hypothesis that the fiscal stimulus we identify is likely to operate through wealth and liquidity mechanisms. Moreover, since the underlying income shock is not a one-time subsidy to purchase prices (Mian and Sufi (2012a)), or an “economic stimulus payment” (Parker et al. (2013)), households do not appear to engage in intertemporal substitution, but rather to make new purchases made possible by the relaxation of their liquidity constraints.

6 Further Evidence

In this section we present further evidence corroborating our previous findings and testing their robustness.

6.1 Attrition

One potential concern with our estimates is that they might be distorted by some form of attrition. This is an important concern, especially if we consider that our sample period covers the recent crisis and that the hybrid ARMs we consider might have had an even harder time during the Great Recession than less risky mortgage types. In Table 1.B we have compared the characteristics of these ARMs and of the households holding them with those of the larger representative sample of loans in LPS, which includes both fixed-rate mortgages and a more general form of ARMs; we found no significant difference except for mortgage size. In this section, however, we want to examine potential source of attrition within our sample.

We start by reporting in Figure 9 three types of loans that are present in our sample. Specifically, this plot shows the number of loans that remain active throughout the period, the number of loans liquidated (due to foreclosure, bankruptcy or when they are real estate owned), and the number of mortgages that are prepaid or refinanced during the 2008-2012 period. This figure shows that about 40% of the borrowers active in 2008 become delinquent

or pay off their mortgage at some point in time, with the first effect dominating the second. In fact, the number of liquidated loans increase significantly over time from almost zero at the beginning of 2008 to almost 30,000 in July 2012. The number of paid-off loans is significantly lower at about 15,000.

We can provide some insight into what drives this attrition. BlackBox does not report information on current loan to value ratios (CLTV), but we can compute it by using information on the mortgage balance and house prices at zip code level. Figure 10 shows the cumulative distribution for the CLTV for these three categories of loans: active, liquidated and paid-off. What is immediately clear is that paid-off loans have significantly lower CLTV than active and defaulted mortgages. Specifically, one quarter before these loans drop out of our sample the median CLTV is 78%, which corresponds to the vertical line in the graph. This corresponds almost exactly to the common threshold of 80% used by financial institutions in determining the refinancing costs.²³ Moreover, this is significantly higher than the 110% or 115% CLTV of active and defaulted loans respectively.²⁴

This figure suggests two observations. First, the decision to refinance a mortgage is mainly driven by the CLTV, which means that households in counties less affected by the housing bust will have access to this opportunity, while those living in the worst affected regions are unlikely to be eligible for refinancing. Second, the absence of any significant difference between the CLTVs of active and defaulted mortgages is perfectly consistent with the “double trigger” hypothesis that mortgage default depends on the joint occurrence of negative equity and a life event like job loss. Gerardi et al. (2013) show that the strongest predictor of default, in fact, is individual unemployment. Moreover, they also show that only a very small fraction of defaulters have both negative equity and enough assets to make one month’s mortgage payment, which suggests that “strategic” defaults were relatively rare. Similarly, Elul et al. (2010) found that negative equity, illiquidity as measured by high credit card utilization, and unemployment shocks are all associated with higher default risk, and that the latter interacts strongly with CLTV.

In our analysis we only consider active loans, comparing the consumption and savings decisions of borrowers benefiting from the interest rate adjustment at different points in time. We do not consider the households who defaulted or prepaid their loans, as this would clearly bias our results. Our analysis in section 5 of the heterogeneous response to this income

²³Caplin et al. (1997) report that, since the higher borrowing rate associated with higher CLTV is applied to the whole outstanding mortgage balance, not just the incremental equity removed, the additional cost for households refinancing with an initial LTV just above 80% can be as much as 20 percent. See also Hurst and Stafford (2004) for a discussion of this issue.

²⁴Notice also that our measure of CLTV tends to underestimate it. Elul et al. (2010) have access to a measure of total household debt, combined LTV, and they show that for the households with a second mortgage, using only the first-mortgage LTV underestimates their total CLTV by 15 percentage points.

shock provides some speculative insights into how our estimates of the marginal propensity to consume might be generalized to this sample as well. Specifically, since low-income and those credit-constrained households tend to consume a significantly higher fraction of the added income, the exclusion of borrowers who enjoyed the income shock but then defaulted (the majority of those dropping out of our sample) probably biases our results downward.

6.2 Difference-in-Differences Results

In this section, we further test the validity of our identification strategy. One potential concern with the consumption and deleveraging estimates presented in Section 4 is that there might be a mortgage-specific trend that could affect our results. In particular, since it is collinear with the time dummies, in the previous specification we could not control for the age of the mortgage, which might be correlated with the household’s consumption or prepayment behavior. For instance, households might be more inclined to purchase a new car twelve months after they bought a house, or they might have a greater incentive to prepay their mortgage once they have built enough equity in it. Then there might be heterogeneity among households with mortgages of different vintages. In order to correct for this possibility, we consider as control group the mortgages that will have the interest rate reset 10 years after origination, i.e. 10-year ARMs.

This allows us to compare the behavior of the borrowers who experienced a reduction in the monthly payment with that of other borrowers who bought houses during the same period under a similar hybrid mortgage. Table 5 reports coefficient estimates of least square regressions relating the monthly mortgage payment, car purchases and mortgage principal prepayment to the reset 5 years after the origination. In contrast to the previous estimations, this sample includes both 5-year and 10-year ARMs originated between 2005 and 2007 as provided by BlackBox Logic. We report in Columns (1)-(3) the results in dollars, in Columns (4)-(6) the normalized coefficients.

Columns (1) and (4) show a reduction in the monthly payment of \$900 on average, about half of the monthly payment, in the quarter after the interest rate reset, which is comparable to the results reported in Table 2. Columns (2) and (5) analyze consumption decisions: borrowers who experienced a reduction in the monthly payment tend to increase their consumption of cars by about \$145-\$185, or 15%-20% of the income shock, within the first year compared to the borrowers holding a similar mortgage but not experiencing the payment reduction. Finally, Columns (3) and (6) show that borrowers employ about \$60 per month, or 10% of their additional disposable income, to repay their mortgage faster.

One drawback of this alternative specification is that households with different charac-

teristics might be endogenously sorted in different contract types, 10-ARMs versus 5-ARMs. However, in all specifications we include household fixed effects which absorb any fixed variation at the individual level. More importantly, we also allow for differential trends for different loan cohort and types. That is, our estimates do not rely on the assumption that households who decided to purchase a house, for instance, in the first quarter of 2005 with a 10-ARM, will follow a similar trend to the households that purchase one, say in the last quarter of 2006 with a 5-ARM. Finally, since we also include the age of the mortgage as an additional control, these estimates reassure us that we are not capturing any time trend specific to the mortgage vintage.

6.3 Alternative Consumption and Deleveraging Measures

The richness of our data allows us to complement the previous findings by investigating the impact of monetary policy on different measures of consumption and deleveraging. We observe the balance on all the borrower’s revolving accounts and focus on retail credit cards, e.g. credit cards issued by large store chains such as Amazon and Macy’s. Like our measure of car sales, this measure tracks the consumption expenditures of the households by analyzing significant changes, above \$500, in the balance on these accounts. Table 10 shows the coefficient estimates of a least square regression relating the amount spent on retail credit cards with the interest rate reset. In Column (1) we control for household and time fixed effects, as well as loan cohort fixed effects, and show that households tend to increase their expenditures after the interest rate adjustment by almost \$30. Here too we uncover a similar spending pattern, with households starting to increase their consumption one quarter before the interest rate reset and keep consuming more after it. In Column (4), instead, we show that normalizing by the size of the initial monthly payment, this increase corresponds to 3% of the positive income shock. Finally, Column (7) augments the specification by allowing for heterogeneous trends depending on the size of the monthly payment. The results are still statistically significant at the 1% level, but the magnitude is smaller, with an average consumption response of about \$16.

We also find evidence that households’ tendency to deleverage is not restricted to their mortgage balance. In fact, the results presented so far are likely to be an underestimation of the fraction of the positive income shock allocated by borrowers to repay their debts, because they might decide to repay other debts as well. For instance, borrowers might repay the more expensive loans, such as equity loans and home equity lines of credit. We investigate this possibility in Table 10. For brevity, we provide the two most restrictive specifications, those controlling for origination cohort-time fixed effects and monthly payment bin-time

fixed effects, and the estimates normalized by the initial mortgage payment. Columns (2), (5) and (8) test for an increase in payment towards equity loans. They all show that there is indeed a significant increase in prepayment of this type of loans after the interest rate adjustment with an average effect of \$15 per month in the more restrictive specification. Columns (3), (6) and (9) report the results for home equity line of credit. We find that in the quarter after the interest rate reset, borrowers allocate on average about \$20 per month towards the repayment of these lines of credit.

In sum, analyzing a different measure of consumption and the repayment behavior for the case of other two types of debt, we confirm and reinforce the main results presented in Section 4 on households' consumption and deleverage response to the positive income shock.

7 Aggregate Level Evidence

In the previous sections, we have used the sub-sample of hybrid ARMs to limit unobserved heterogeneity and identify more cleanly the effect of interest rate changes on household's consumption and saving decisions. We now turn to county level data to gauge the extent to which these results might be generalized across a broader sample of households, and to better understand their local general equilibrium implications. Admittedly, our methodology cannot estimate the aggregate general-equilibrium effect, such as an economy-wide multiplier of interest rate policy, as for instance we do not observe the lenders' response to such changes in interest rates. Nevertheless, one implication of the previous findings is that the rigidity of mortgage contracts — fixed or flexible — is likely to shape the pass-through of changes in interest rates to real activity at the county level. And in particular, we would expect that a decline in interest rates will likely have a bigger impact on household consumption in those counties that use adjustable rate mortgages more intensively.

To develop tests based on this idea, we augment our data with three additional data sources. First, we aggregate loan level data from LPS, which constitutes a nationally representative sample of mortgages with a 64% coverage of the U.S. mortgage market ([Fuster and Vickery \(2013\)](#)). Second, to correctly estimate the mortgage and the credit card balance at the county level, we employ data from the New York Federal Reserve Consumer Credit Panel, which collects information from a 5 percent representative sample of households in the U.S., and aggregate this information at the county level. Third, we measure consumption of durable goods through the car sales data provided by Polk. This data provider collects information on the sales of new vehicles at quarterly frequency by county.

We start by describing the main variables of interest. Figure 11 illustrates the county-level variation in adjustable-rate mortgages at the peak of the boom in 2006. It shows that

the cross-sectional variation in the fraction of ARMs is not random, as these contracts are relatively more frequent along the coast, where housing costs are generally higher. So it is possible that the variation in the fraction of ARMs could be correlated with some unobserved factors that might explain the transmission of monetary policy to the local economy. We take this possibility into account in our empirical strategy by controlling for several county characteristics. Over our sample period, there is also substantial variation in our measure of local consumption as shown by Figure 12, which plots the year-on-year quarterly change in car sales. As it is evident, the number of cars sold was high and stable in the first half of our sample, but then it sharply decline during the Great Recession to almost half of what it was before, i.e. two million cars. Finally, Figure 13 plots the six-month LIBOR from 2005 to the end of 2013 and shows a decline of about 4.5 percentage points. This confirms that the ARMs indexed to the LIBOR are able to take advantage of a significant reduction in the interest rates.

Table 10 presents our estimation results. We first provide simple correlations for the fraction of ARMs in a county in 2006 and county-level characteristics from the same period in Panel A. This guides us in understanding what the main drivers of higher ARMs origination are and which controls we need to include. Higher-income counties tend to have a higher fraction of ARM debt, which might capture the preference of households with higher incomes to purchase houses with jumbo loans featuring an adjustable interest rate. Likewise, counties with more highly leveraged households—a higher median debt to income ratio—tend to also have a higher fraction of ARM debt. Moreover, ARM debt is more common in counties with greater securitization activity, capturing the greater incentives for risk-taking by banks, and with a higher poverty rate, which might reflect the prevalence of teaser rates and negative amortization mortgages among the more credit-constrained households.

Since during our sample period interest rates were declining, if regions with higher concentration of ARMs also experience a more significant decline in consumption due to these other factors, we might find a spurious correlation between changes in interest rates and aggregate consumption. Moreover, many of these factors could also independently shape the transmission of interest rate movements to household consumption. Higher-income households may have easier credit access, for example, and be better placed to buffer any changes in the cost of credit.

Accordingly, we include these variables linearly in the baseline specifications, or absorb them when using county fixed effects, but we also interact them with the six-month LIBOR. Our sample period extends from 2007 to 2013, and because households can adjust at the margin to changing economic conditions, throughout we use county-level variables observed in 2006 to avoid endogenous responses when measuring the impact of interest rate movements

on county-level economic outcomes.

Panel B of Table 10 shows how the average mortgage interest rate and the average monthly payment in a county can be differentially affected by changes in the LIBOR, depending on the fraction of ARMs. In all columns we control for county level controls, such as the log of median income and population, the debt-to-income ratio as computed in 2006, the change in securitization computed as the change in the fraction of loans securitized over the period 2004-2006, the poverty rate and their interactions with the six-month LIBOR. Moreover, we also include time and county fixed effects, which absorb the impact of aggregate economic shocks that might affect counties simultaneously, and time-invariant county characteristics, such as the elasticity of housing supply. Standard errors are clustered at county level. Columns (1) and (2) investigate the effect on the average interest rate, while Columns (3) and (4) examine the average monthly payment.

We find that as the interest rate declines, counties with a higher fraction of ARMs display a more significant reduction in the average mortgage rate and in their average monthly payments, which suggests higher pass-through of changes in monetary policy and in LIBOR to these counties. The economic magnitude too is substantial, because if we consider the observed decline in interest rates, about 4.5 percentage points from 2007 to 2011, a one-standard-deviation increase in the fraction of ARMs translated into a 9-11 basis points decrease in the average mortgage rate by 2013 and 2-3 percentage points lower average monthly payments.²⁵ Columns (2) and (4) also control for state-specific time trends, which allow for heterogeneous trends across states. For instance, states with a higher concentration of ARMs might react differently to the decline in the interest rates from states with a higher fraction of fixed-rate mortgages. We find that the main coefficient of interest is stable across specifications and always significant at the one percent confidence level.

In sum, the fraction of adjustable rate mortgages is a strong predictor of pass-through of changes in monetary policy to households' mortgages rates and monthly payment. Hence, to the extent that we are able to control for the other variables that are correlated with the fraction of adjustable rate mortgages in a county, we can use the interaction between fraction of adjustable rate mortgages and the LIBOR rate as an instrument for the average mortgage interest rates (or monthly payments) paid by households in that county. This allows us to try to determine whether the results on consumption and deleveraging in section 4 at the individual level could be generalized to the aggregate economy.

Building on our previous results, Table 11 presents the effect of changes in the mortgage

²⁵ Alternatively, for each one percent decline in LIBOR rates, a county in the top decile of fraction of adjustable rate mortgages enjoys 7 bps more decline in their average interest rates than a county in the lowest decile of fraction of adjustable rate mortgages.

interest rate on car sales and on credit card and mortgage balances. We present both the reduced form results as well as the instrument variable estimates. Columns (1)-(3) presents the results of the reduced form, while Columns (4)-(9) focus on the IV results. Columns (1) relate to the effect of changes in the interest rate on quarterly car purchases. We find that a decline in interest rates like that of 2007-2013 leads to a significant consumption response in counties with a higher share of ARMs in 2006. The point estimates suggests that a 10 basis points decline in the average mortgage interest rates of a county is associated with about 2% increase in car sales in that county.

We also use as an alternative measure of consumption the balances of households on credit cards which can be a noisy proxy for the households' consumption. In the New York Consumer Credit Panel, the average household carries only \$800 balance on its credit cards, which is suggestive that on average households use their credit cards as a payment card rather than as a borrowing tool. The result in Column (2) suggests that 10 bps decline in the average mortgage interest rates of a county is associated with about 2.5% increase in balances on credit cards. Since we can only consider the aggregate balance on credit cards, we cannot fully distinguish between durable and non-durable goods. However, this evidence corroborates the hypothesis that aggregate demand responded more forcefully in areas where households could enjoy the reduction in mortgage rates.

Finally, we confirm that the decline in interest rates resulted in a more significant deleveraging in counties with more AMRs in Column (3). In fact, we find that a 10 bps decline in the average mortgage interest rates of a county is associated with about 1.5% decline in mortgage balances.

Columns (4)-(9) present our IV results for the interest rate and the monthly payment. As in the individual level analysis, where we estimate the effect of the change in the mortgage rate and the resulting decline in the monthly mortgage payment on households consumption and saving behavior, at the aggregate level, we can instrument for these variables with the interaction between the index rate (i.e. LIBOR) and the fraction of ARMs. The results are both statistically and economically significant. For instance, a 10 percentage points decline in monthly mortgage payment is associated with an increase of 10% in car sales, a 5% higher delveraging and about 15% higher credit card balances.

To be clear, even though the exclusion restriction is satisfied, we cannot use these elasticities to calculate the aggregate effect of changes in interest rates on households consumption and deleveraging decisions. This is because as long as the fraction of adjustable rate mortgages in a county is correlated with the fraction of lenders that operate in that county, the estimated coefficients only captures the partial equilibrium reaction of borrowers to changes in the interest rates (or monthly payments). However these results can still be used as an

upper bound in estimating the effects of monetary policy on consumption and deleveraging.²⁶

8 Discussion and Concluding Remarks

We have exploited the automatic interest rate adjustment for households with hybrid ARMs to study households' consumption and saving response to the highly expansionary monetary policy of the post-crisis period. Our identification strategy exploits the expected change in monthly payments for borrowers who have adjustable rate mortgages originated between 2005 and 2007 with an automatic reset after five years. Focusing only on this type of mortgage allows us to be sure that issues relating to the selection of different types of contracts, such as FRM versus ARM, cannot contaminate the estimation.

The magnitude of the positive income shock for these households is large indeed: the monthly payment falls on average by \$900 at the moment of the interest rate adjustment. Potentially, this could free up important resources for these indebted and mainly underwater households. We show that households increase their car purchase spending by more than \$150 per month, equivalent to a 40 percent increase compared to the period immediately before the adjustment. Their monthly credit card balances also increase substantially, by almost \$200 a month within the first year after the adjustment. Nor is there any sign of intertemporal substitution or reversal within two years of the adjustment.

However, the economic stimulus of the increase in consumption is attenuated by voluntary deleveraging, because households use 15% of their increase in income to repay their debts faster, almost doubling the extent of this effort.

There exist important differences across households. Those with less access to credit due to bad credit history tend to spend less on durables and to repay their debts more slowly. Underwater mortgages are associated with allocation of a larger part of the income gain to car purchases and with less debt repayment. Low-income households, instead, according to our point estimates exhibit a higher marginal propensity to consume and less deleveraging. These effects underscore the importance of credit-constraint in shaping households' consumption and saving decisions.

Finally, we also show how debt rigidity can determine the aggregate effects of monetary policy transmission, providing evidence that the effects of a decline in the interest rate differ according to the concentration of adjustable-rate mortgages in different areas: the fall in interest rates produces a significantly larger increase in consumption and deleveraging in counties with a higher fraction of ARMs. These results can be useful in informing the

²⁶See Nakamura and Steinsson (2014) and the literature aiming at estimating the fiscal multiplier for a discussion of a similar point.

discussion of the effects that the exit from quantitative easing could have on aggregate consumption through an income channel (see [Hall \(2013\)](#) and [Shin \(2013\)](#)). Our findings also indicate that interest rate or monthly payment reductions can help to ease cash flow and liquidity constraints and should be considered as possible policy responses in times of crisis ([Eberly and Arvind \(2014\)](#)).

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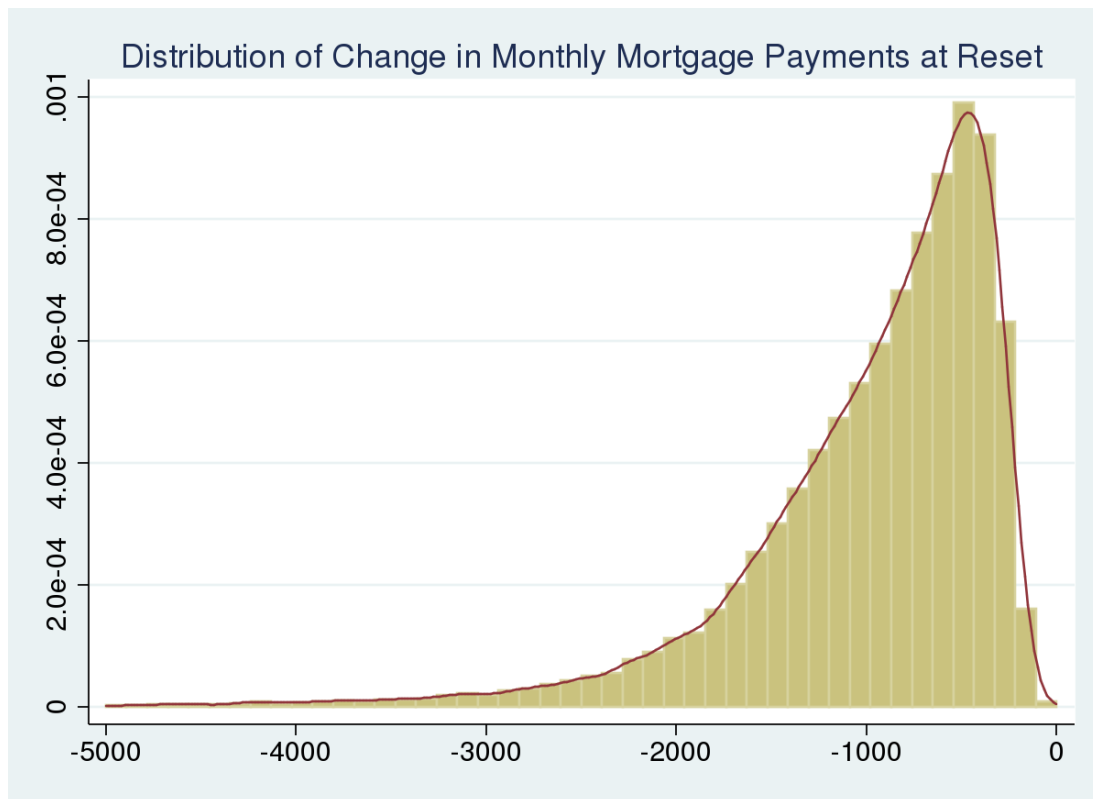


Figure 1 –Change in the Monthly Payment

This figure shows the average change in the monthly payment at the time of the interest rate adjustment, for our sample of hybrid ARMs with an interest-only period of 10 years and a reset date 60 months after origination.

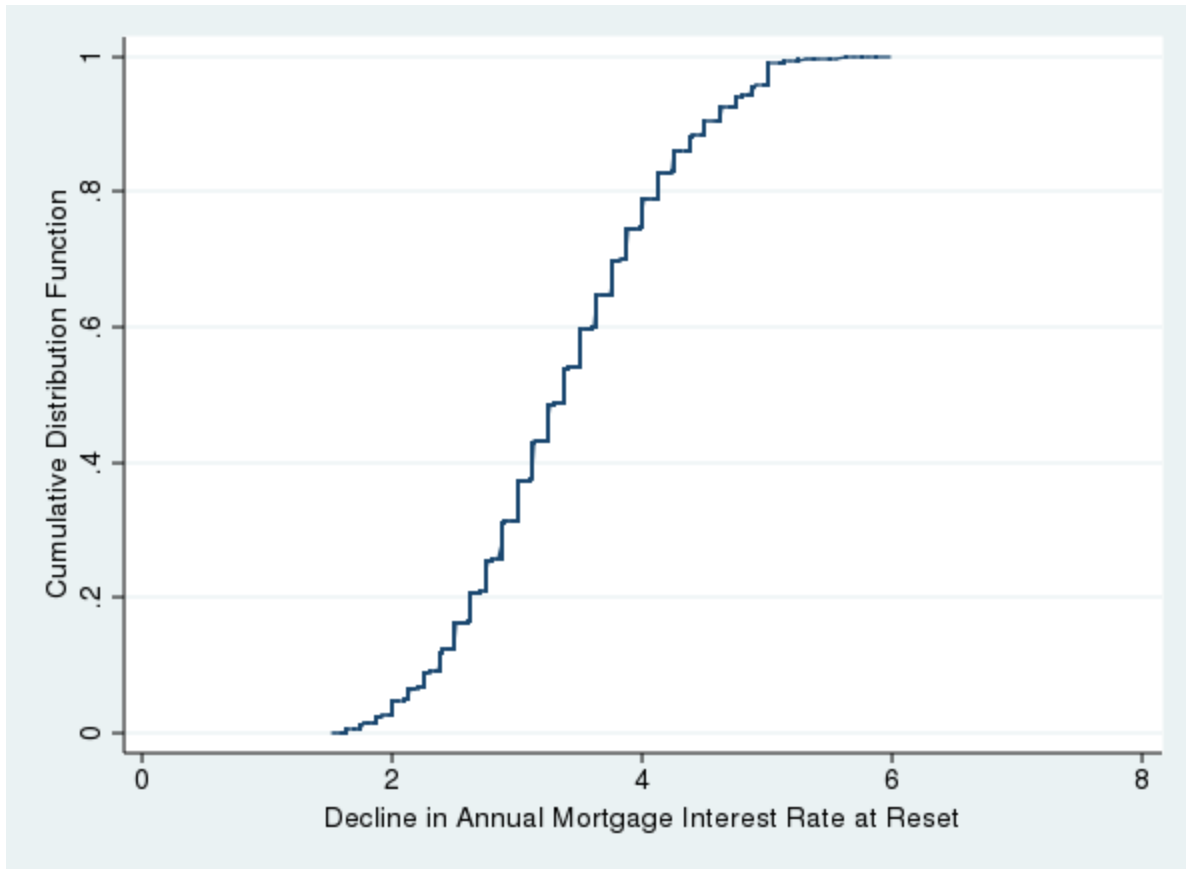


Figure 2 – Change in the Mortgage Interest Rate

This figure shows the cumulative distribution for the change in the mortgage interest rate between origination and the date of the adjustment, for our sample of 5-year ARMs with an interest-only period of 10 years and a reset date 60 months after origination. On average the interest rate declines by 3.3%.

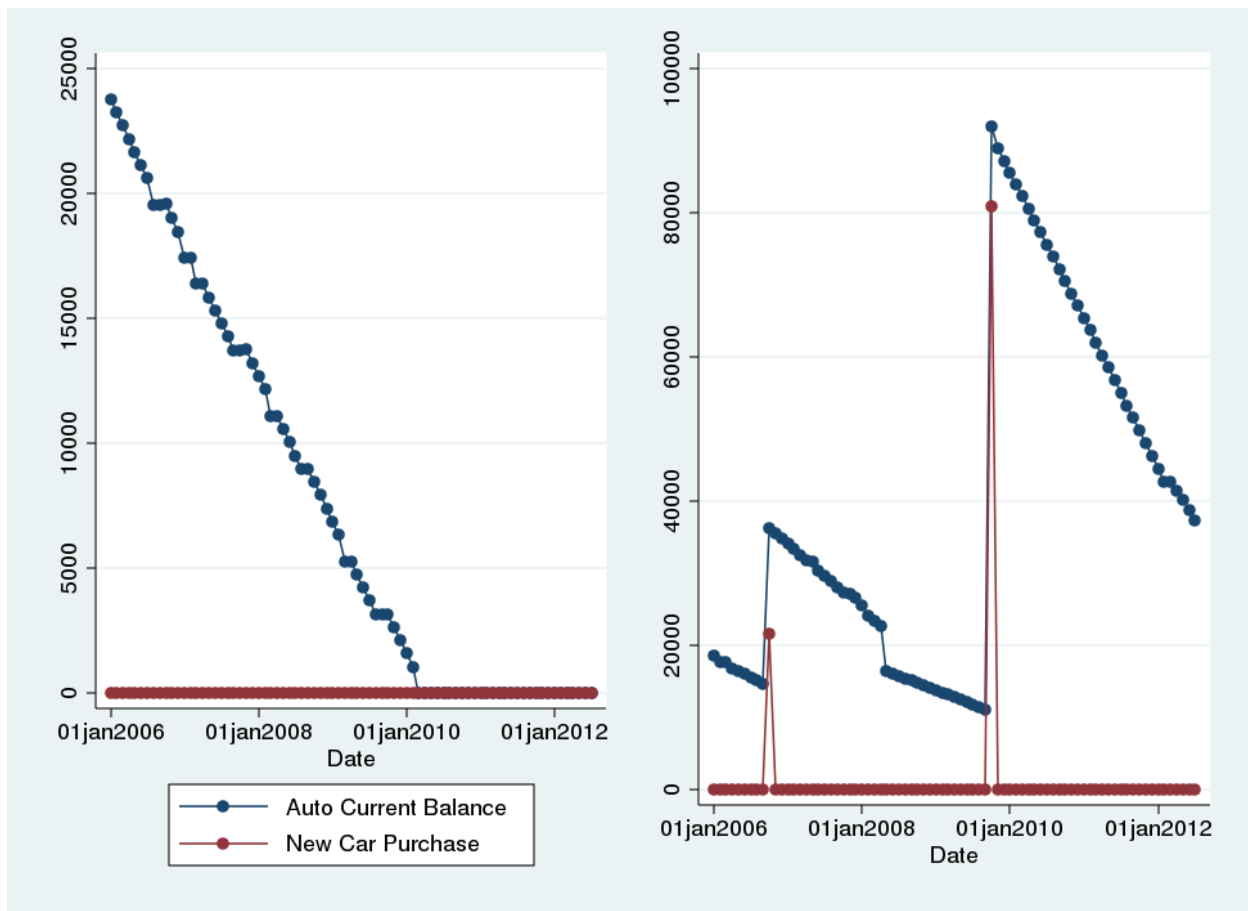


Figure 3 –Households Auto Loan Balances and Construction of Auto Sales Measure

The left panel is an example of individual who purchased her car before January 2006 and did not purchase any car until July 2012. The household in the right panel purchased two cars during the period. We assumed the value of the new car to be equal to the change in the auto loan balance at the time of purchase.

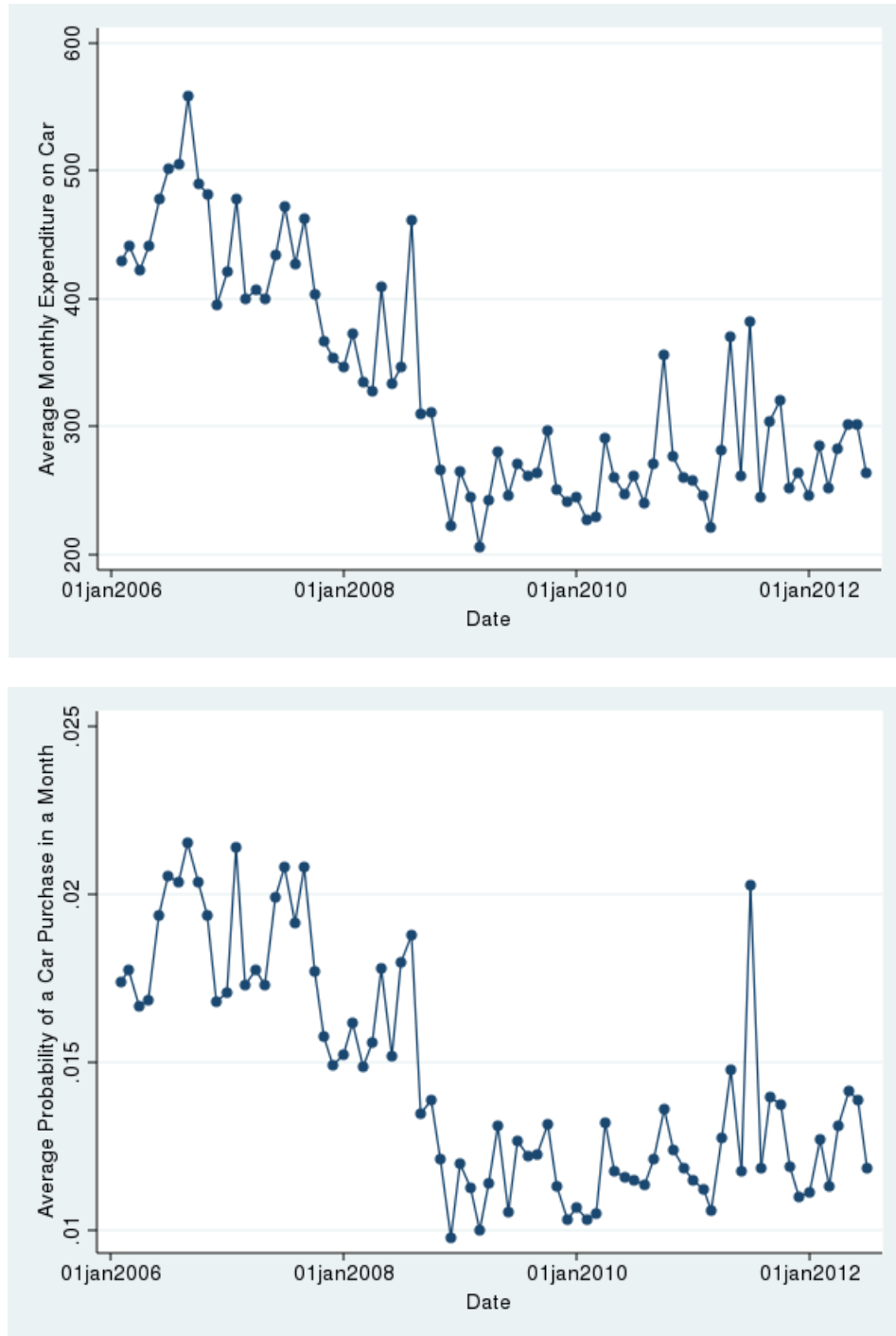


Figure 4 – Car Purchases of Households with 5 ARMs over Time

The top panel shows the average monthly car expenditure from January 2006 to July 2012 for those households who had a 5-year ARM mortgage originated between 2005 and 2007. The bottom panel shows the fraction of these households who purchased a car in each single month.

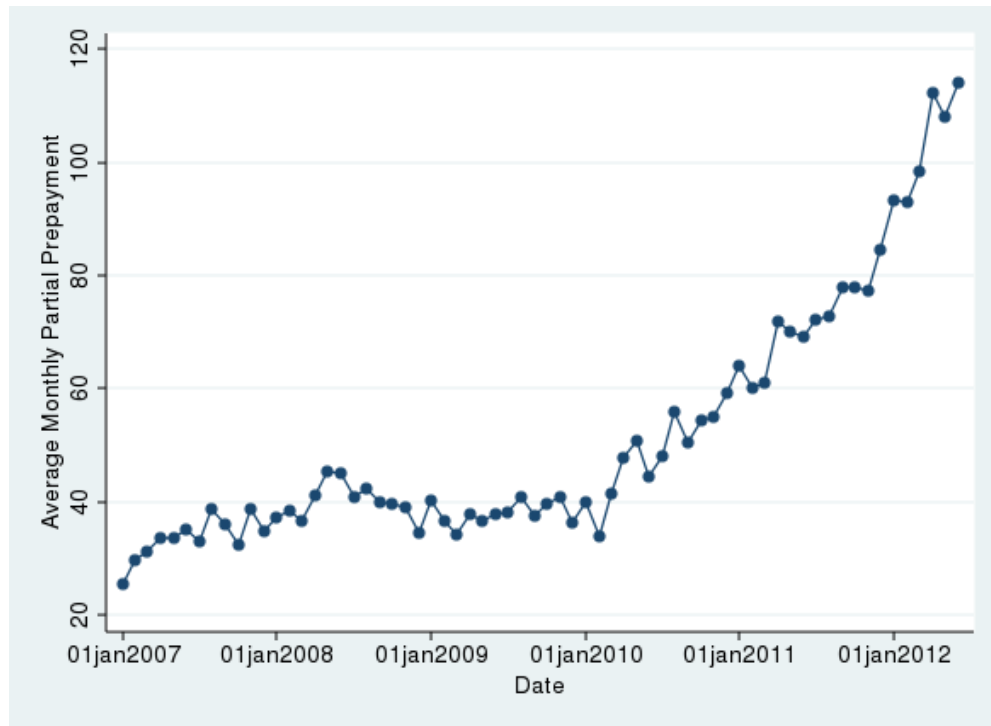


Figure 5 – Mortgage Partial Prepayment

This figure shows the average monthly prepayment of the mortgage for borrowers holding 5-year ARMs originated during the 2005-2007 period.

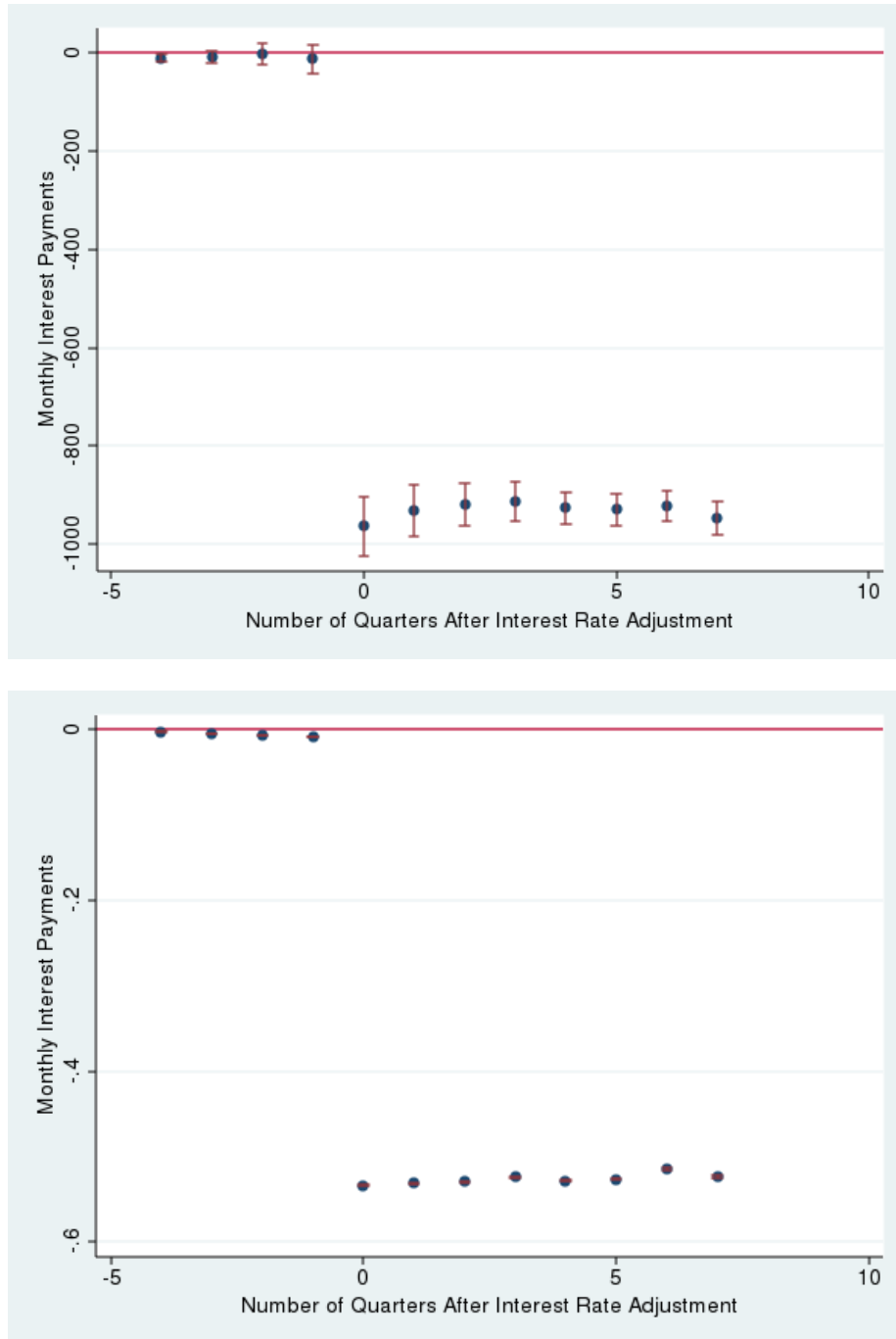


Figure 6 – Reduction in Monthly Payments

Interest rate adjustment and the monthly interest payments for 5-year ARMs originated during the 2005-2007 period. Top panel shows the change in dollars, while the bottom panel normalized it by the size of the monthly payment of the mortgage at the origination.

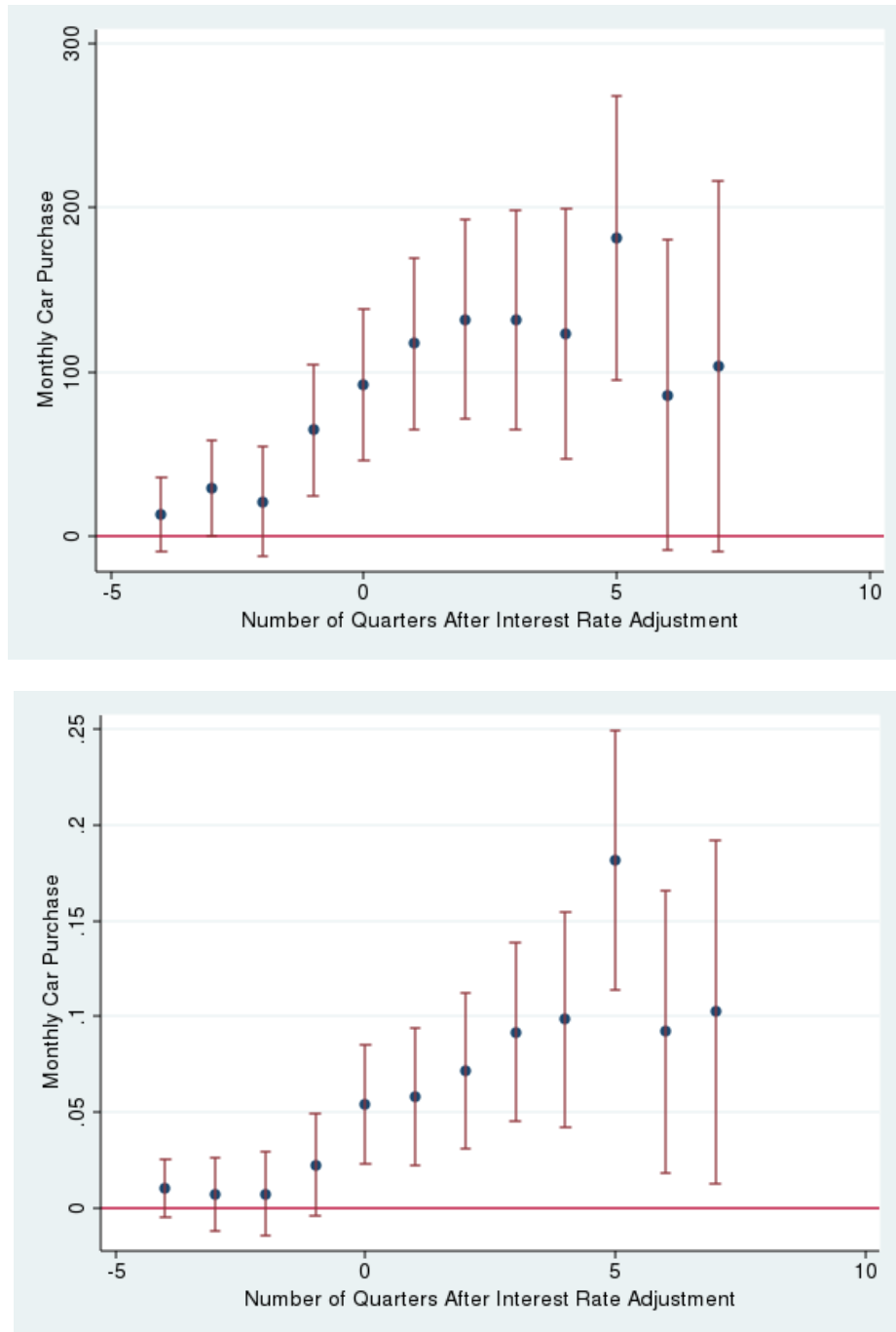


Figure 7 – Car Purchase

Monthly car purchase and interest rate adjustment for 5-year ARMs originated during the 2005-2007 period. Top panel shows the change in dollars, while the bottom panel normalized it by the size of the monthly payment of the mortgage at the origination.

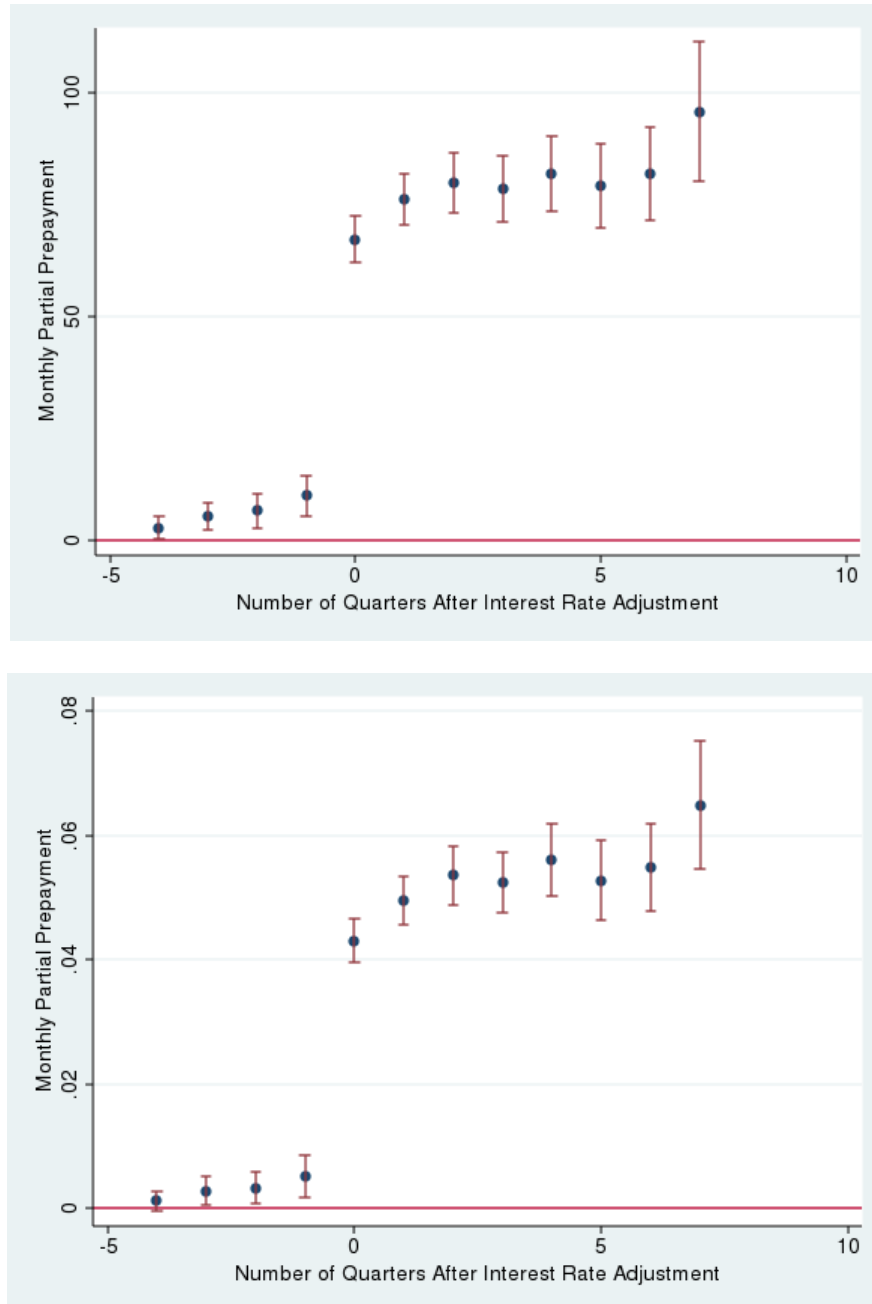


Figure 8 – Deleveraging

Monthly voluntary partial principal repayment and interest rate adjustment for 5-year ARMs originated during the 2005-2007 period. Top panel shows the change in dollars, while the bottom panel normalized it by the size of the monthly payment of the mortgage at the origination.

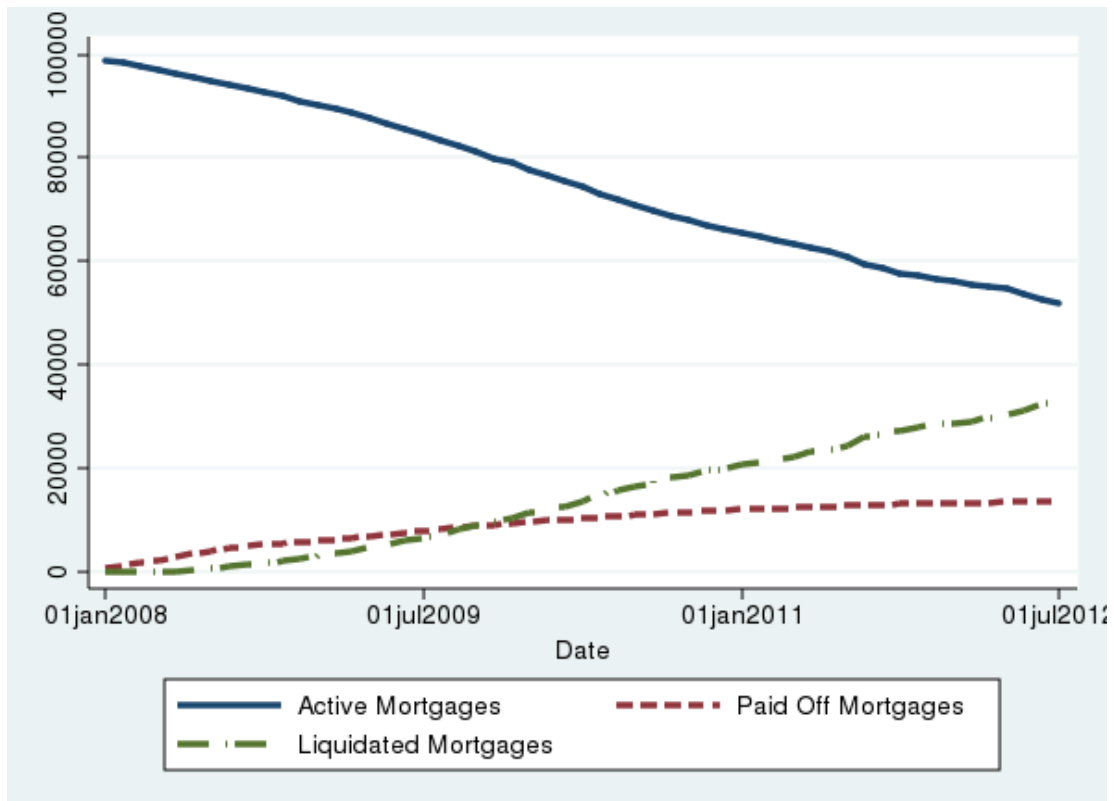


Figure 9 – Attrition

This plot shows the number of active loans (blue solid line), liquidated loans due to foreclosure, bankruptcy or real estate owned (green dash line) and paid off mortgages due to prepayment or refinancing (dash-dot line) over time.

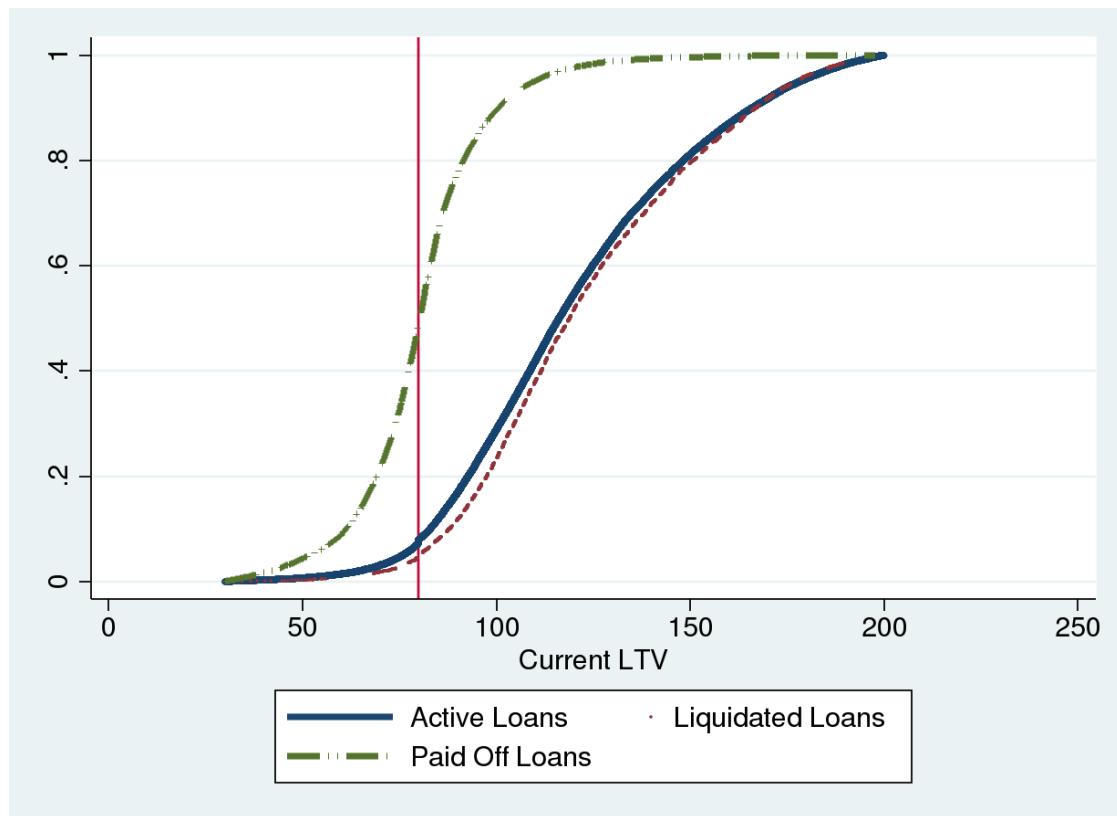


Figure 10 – Attrition and Current LTV

This plot shows the cumulative distribution of the number of active loans, liquidated loans due to foreclosure, bankruptcy or real estate owned and paid off mortgages due to prepayment or refinancing as a function of the current loan-to-value ratio. The vertical line shows a current LTV of 80%, which corresponds to the median of the current LTV for the paid off loans.

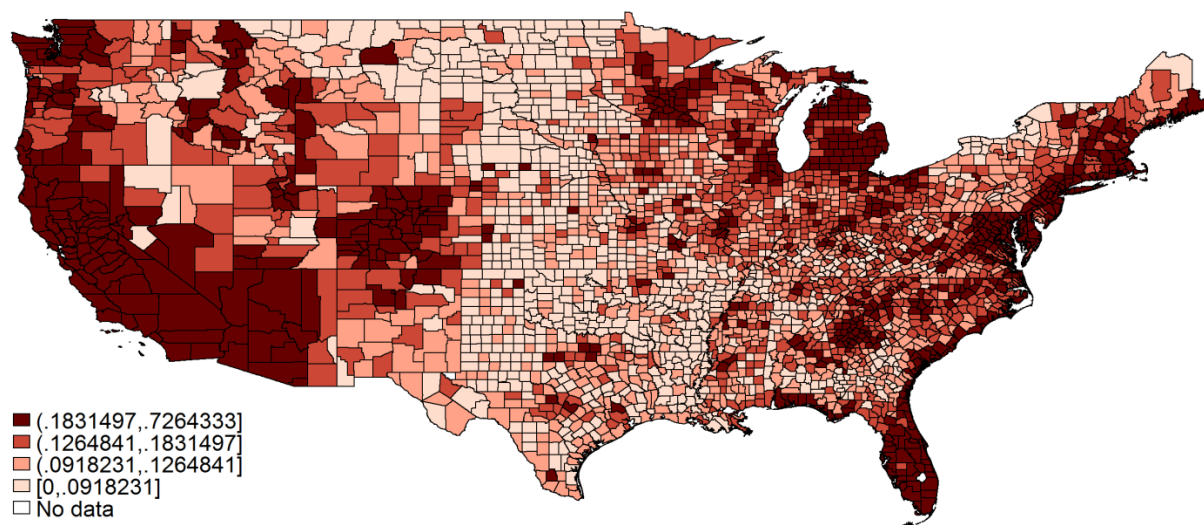


Figure 11 – Fraction of Adjustable-Rate Mortgages in 2006

This figure plots the fraction of ARMs originated in each county in 2006 using data from LPS.

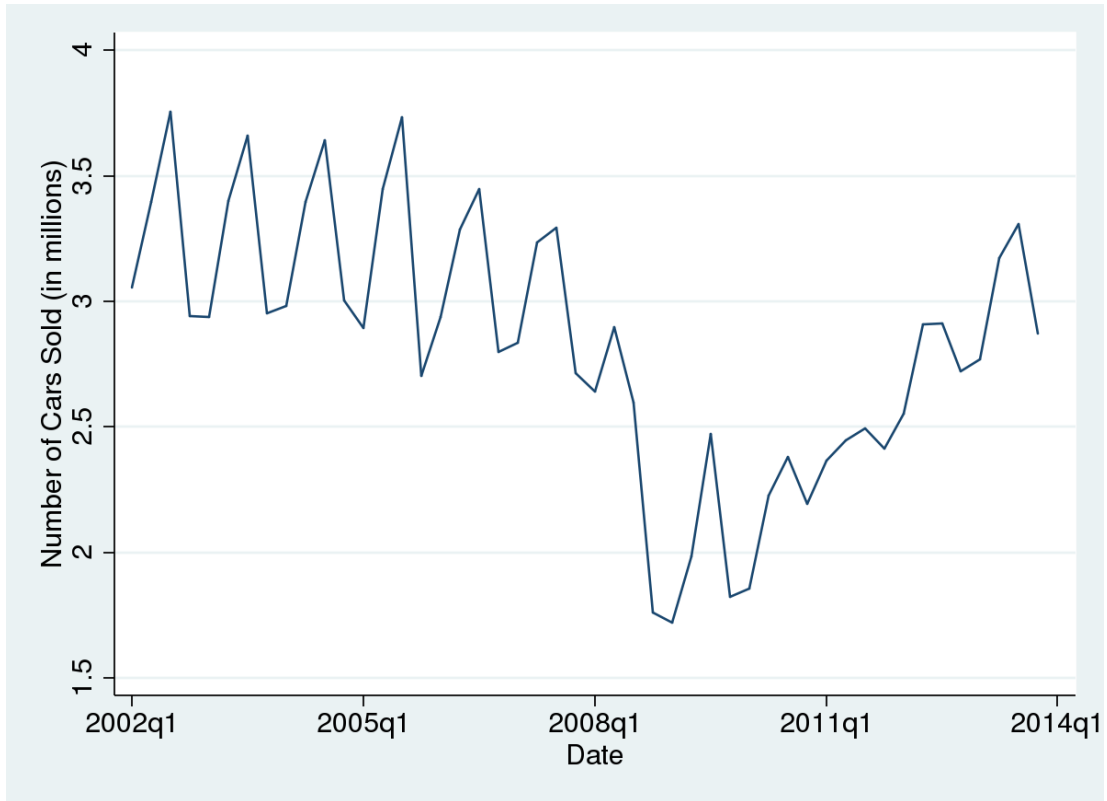


Figure 12 – Car Sales

The figure plots the number (in millions) of cars sold in the U.S. every quarter for the period 2002-2014.



Figure 13 -- LIBOR

The figure plots the 6-month LIBOR rate, which serves as index for the majority of ARMs in our sample.

Table 1.A
Summary Statistics

The table reports descriptive statistics for the main variables employed in our analysis. In the top panel, we present the main mortgage characteristics at origination, as provided by BlackBox, for ARMs originated between 2005 and 2007 with an interest rate adjustment after five and after ten years of origination. The bottom panel presents county-level characteristics, computed aggregating loan-level data from LPS and the Census, for the period 2007-2010.

Panel A: Individual Level Characteristics

<i>5-ARM Characteristics at Origination:</i>								
	N	Mean	St. Dev.	p1	p10	p50	p90	p99
FICO at Origination	46,578	736.2	348.5	661	673	719	781	809
Original Balance	46,578	357,949	271,600	79,200	132,000	288,000	630,000	1.393e+06
Mortgage Interest Rate	(Instrumented by Fra	46,397	77.11	10.01	40.98	65	80	100
Original Interest Rate		46,497	6.449	0.765	5	5.500	6.375	8.375
Average Monthly Payment	(Instrumented by	45,424	1,921	1,471	427.5	697.8	1,547	3,392
Interest Rate After Adjustment		45,156	3.096	0.480	2.375	2.625	3	3.625
Monthly Payment After Adjustment		44,941	915.8	721.9	129.8	314.8	725.3	1,669
<i>Data on Borrowers holding 5-ARM</i>								
	N	Mean	St. Dev.	p1	p10	p50	p90	p99
Monthly Expenditure on New Car	2,894,000	305.1	3,161	0	0	0	0	13,507
Fraction of Households Who Purchased a Car Each Month	2,894,000	0.0137	0.116	0	0	0	0	1
Partial Prepayment	2,627,000	52.21	400.1	0	0	59.61	210.8	1,004
Retail Sale	1,158,000	56.70	442.2	0	0	0	0	1,588
<i>10-ARM Characteristics at Origination:</i>								
	N	Mean	St. Dev.	p1	p10	p50	p90	p99
FICO at Origination	26,543	793.7	736.3	661	681	737	790	815
Original Balance	26,538	536,342	347,622	89,600	186,000	486,280	928,000	1.866e+06
Original LTV	26,518	72.82	12.05	30.61	55.90	79.40	80	95
Original Interest Rate	24,348	6.149	0.525	5	5.500	6.125	6.800	7.625
Original Monthly Payment	23,765	2,700	1,819	488.0	936.5	2,430	4,623	9,465
<i>Data on Borrowers holding 10-ARM</i>								
	N	Mean	St. Dev.	p50	p75	p90	p95	p99
Monthly Expenditure on New Car	1,702,000	364.4	3,711	0	0	0	0	16,000
Fraction of Households Who Purchased a Car Each Month	1,703,000	0.0148	0.121	0	0	0	0	1
Partial Prepayment	1,668,000	88.49	619.6	0	0	128.2	390.1	1,535
Retail Sale	616,705	68.84	522.1	0	0	0	0	1,816

Panel B: County Level Characteristics:

	N	Mean	St. Dev.	Min	Max
Log(Median income)	2,208.00	10.70	0.25	9.88	11.65
Poverty rate	2,208.00	15.04	5.93	2.00	46.90
Log(Population)	2,208.00	10.68	1.13	9.17	15.82
Median household leverage in 2006	2,208.00	1.57	0.58	0.58	4.93
Fraction of Fixed Rate Mortgage debt in 2006	2,208.00	0.83	0.09	0.27	0.97

Table 1.B
External Validity

The table reports descriptive statistics for the main variables employed in our analysis, but for different types of mortgages as provided by Lender Processing Services, which covers about 64% of the origination count reported under the Home Mortgage Disclosure Act (HMDA) over the period 2005–07. We first report the statistics for the whole sample, and then we focus on different subsamples comprising fixed-rate mortgages, adjustable rate mortgages (ARMs) and 5-year ARMs. We only consider home-owners.

	N	Mean	St. Dev.
<i>Mortgages Originated between 2005 and 2008</i>			
FICO	15,520,963	703.76	68.55
Interest Rate at Origination	19,104,660	6.27	1.23
Mortgage Interest Rate (Instrumer	18,452,315	74.53	17.51
Mortgage Size	19,106,272	239043.24	202721.63
Average Monthly Payment (Instru:	17,300,637	1654.32	1514.99
<i>Fixed-Rate Mortgages Originated between 2005 and 2007</i>			
FICO	10,754,081	705.16	68.68
Interest Rate at Origination	13,263,190	6.30	0.89
Loan-to-Value Ratio	12,729,960	74.23	19.05
Mortgage Size	13,264,696	196125.18	139312.44
Initial Monthly Payment	11,812,181	1485.49	1258.87
<i>Adjustable-Rate Mortgages Originated between 2005 and 2007</i>			
FICO	2,039,025	687.97	73.22
Interest Rate at Origination	2,521,322	6.06	2.35
Loan-to-Value Ratio	2,441,813	76.06	13.77
Mortgage Size	2,521,297	312466.01	271243.03
Initial Monthly Payment	2,426,317	1765.34	1770.98
<i>5-ARMs Originated between 2005 and 2007</i>			
FICO	308,927	720.97	51.96
Interest Rate at Origination	341,728	5.92	0.71
Loan-to-Value Ratio	340,398	73.99	13.61
Mortgage Size	341,728	349099.78	287061.08
Initial Monthly Payment	334,572	2077.86	1831.93

Table 2
Monthly Payment and Interest Rate Reset

The table reports coefficient estimates of least square regressions relating the monthly payment of 5-year adjustable rate mortgages with a 10-year interest only period to the reset of interest rate 5 years after the origination. The dependent variable is the mortgage monthly payment for mortgages originated between 2004 and 2007 and is based upon data from BlackBox Logic. The main independent variables are dummies identifying different time periods before and after the reset date. Column (6) normalizes the monthly payment by the size of the monthly payment of the mortgage at the origination. "FICO" is provided monthly by Equifax. "Income" is the income predicted by BlackBox employing the household's balance sheet information. "Log(House Prices)" is the logarithm of zip-level house prices. Origination cohort is the quarter of origination of the mortgage. Robust standard errors, clustered at the household level, are below the coefficients in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

	1	2	3	4	5	6
	Monthly Interest Payment					Normalized by Payment Size at Origination
Four Quarters Before	-11.27** (5.363)	-5.429 (4.184)	-10.58** (4.692)	-11.77*** (3.000)	-10.81** (4.903)	-0.00265*** (0.000683)
Three Quarters Before	-0.392 (7.425)	4.967 (6.222)	-4.113 (6.745)	-21.11*** (4.614)	-7.803 (7.659)	-0.00474*** (0.000923)
Mortgage Interest Rate						
Two Quarters Before	18.54* (11.11)	20.48** (10.18)	7.885 (10.84)	-25.73*** (5.267)	-0.651 (12.93)	-0.00690*** (0.00103)
Average Monthly Payment						
One Quarter Before	45.49*** (15.90)	28.59* (14.77)	9.389 (15.86)	-23.22*** (6.940)	-12.30 (18.06)	-0.00897*** (0.00161)
One Quarter After	-940.4*** (34.33)	-889.5*** (34.42)	-927.4*** (34.43)	-926.2*** (43.03)	-963.2*** (36.47)	-0.534*** (0.00607)
Two Quarters After	-885.4*** (30.23)	-821.7*** (25.92)	-873.7*** (26.21)	-854.9*** (33.57)	-932.0*** (31.28)	-0.531*** (0.00574)
Three Quarters After	-815.3*** (23.57)	-771.0*** (18.62)	-832.1*** (19.15)	-801.8*** (32.67)	-918.8*** (26.46)	-0.529*** (0.00724)
Four Quarters After	-754.5*** (19.11)	-730.8*** (14.86)	-799.4*** (16.88)	-761.3*** (33.58)	-912.8*** (23.77)	-0.525*** (0.00681)
Two Years After	-612.5*** (30.83)	-659.3*** (17.14)	-746.5*** (17.85)	-726.3*** (33.99)	-927.1*** (18.54)	-0.528*** (0.00744)
FICO Score		-0.0182*** (0.00641)	-0.0274*** (0.00502)	-0.0200*** (0.00588)	-0.0541*** (0.00493)	-3.41e-05*** (2.49e-06)
Log(House Prices)		-0.135*** (0.0401)	-0.416*** (0.0648)	-0.145*** (0.0407)	-0.0476*** (0.0112)	-5.82e-05*** (3.91e-06)
Time Fixed Effects	Yes	Yes				
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
County X Time Fixed Effect			Yes			
Origination Cohort X Time Fixed Effect				Yes		Yes
Origination X Time Fixed Effect					Yes	
Observations	2,853,421	2,256,015	2,154,533	2,256,015	2,223,212	2,223,212
R-squared	0.962	0.975	0.633	0.976	0.981	0.781

Table 3
Car Purchases and Interest Rate Reset

The table reports coefficient estimates of least square regressions relating the monthly car purchases to the reset of interest rate 5 years after the origination. The dependent variable in columns (1)-(5) is the monthly amount spent on car purchase and is computed based on the balance of the household's auto loan. In Column (6) the dependent variable is the probability to purchase a car and we report the coefficients in percentage points, while in Column (7) we have normalized the car expenditures by the size of the monthly payment of the mortgage at the origination.. The main independent variables are dummies identifying different time periods before and after the reset date. "FICO" is provided monthly by Equifax. "Log(House Prices)" is the logarithm of zip-level house prices. Origination cohort is the quarter of origination of the mortgage. Monthly Payment at Origination identifies the quartiles of the monthly payment. In Column (3)-(5) we allow in turn for different trends for each county, for each origination cohort, and for different monthly payments at origination. The sample includes mortgages originated between 2005 and 2007 provided by BlackBox Logic. Robust standard errors, clustered at the month level, are below the coefficients in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

	1	2	3	4	5	6	7
	Car Purchase					Likelihood to Purchase a Car in %	Normalized by Payment Size at Origination
Four Quarters Before	43.30*** (11.26)	29.80** (11.22)	20.19* (11.51)	19.66* (11.66)	23.20* (12.64)	0.116** (0.000440)	0.00918 (0.00808)
Three Quarters Before	68.31*** (11.71)	41.88*** (12.00)	29.44** (13.54)	33.13** (13.08)	31.68** (12.60)	0.174*** (0.000530)	0.00862 (0.00912)
Mortgage Interest Rate							
Two Quarters Before	43.24*** (9.841)	21.28* (10.78)	9.460 (10.66)	17.62 (14.55)	14.21 (11.52)	0.120** (0.000591)	0.00798 (0.00983)
Average Monthly Payment							
One Quarter Before	77.64*** (12.29)	47.45*** (13.69)	43.25*** (14.97)	52.44*** (18.92)	38.25** (14.48)	0.222*** (0.000822)	0.0231 (0.0150)
One Quarter After	101.0*** (12.27)	76.59*** (13.51)	66.67*** (13.40)	92.82*** (20.16)	66.91*** (13.77)	0.348*** (0.000721)	0.0531*** (0.0145)
Two Quarters After	119.1*** (14.38)	92.91*** (16.71)	87.44*** (17.35)	117.2*** (25.05)	80.84*** (16.92)	0.450*** (0.000900)	0.0579*** (0.0190)
Three Quarters After	146.3*** (18.67)	111.0*** (21.23)	90.68*** (22.21)	144.6*** (29.10)	101.5*** (22.14)	0.454*** (0.000895)	0.0733*** (0.0201)
Four Quarters After	166.6*** (17.51)	113.6*** (18.06)	91.57*** (18.10)	152.5*** (31.53)	96.28*** (19.75)	0.526*** (0.00117)	0.0954*** (0.0253)
Two Years After	203.0*** (18.09)	137.1*** (17.82)	107.9*** (20.16)	166.1*** (34.75)	117.5*** (19.63)	0.572*** (0.00144)	0.116*** (0.0277)
FICO Score		1.797*** (0.0641)	1.793*** (0.0692)	1.789*** (0.0644)	1.784*** (0.0634)	6.99e-05*** (2.00e-06)	0.00112*** (3.58e-05)
Log House Prices		0.192 (0.143)	0.380 (0.227)	0.161 (0.143)	0.167 (0.136)	1.16e-06 (5.52e-06)	-1.99e-05 (0.000108)
Time Fixed Effects	Yes	Yes					
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
County X Time Fixed Effect			Yes				
Origination Cohort X Time Fixed Effect				Yes		Yes	Yes
Monthly Payment at Origination X Time Fixed Effect					Yes		
Observations	2,893,823	2,291,225	2,188,424	2,291,225	2,223,758	2,252,352	2,223,758
R-squared	0.027	0.031	0.019	0.031	0.031	0.001	0.026

Table 4
Voluntary Deleveraging and Interest Rate Reset

The table reports coefficient estimates of least square regressions relating the monthly mortgage prepayment to the reset of interest rate 5 years after the origination. The dependent variable in columns (1)-(5) is the monthly reduction in the mortgage balance and is computed based on data from BlackBox. In Column (6) we have normalized the partial prepayment of the mortgage by the size of the monthly payment of the mortgage at the origination. The main independent variables are dummies identifying different time periods before and after the reset date. "FICO" is provided monthly by Equifax. "Log(House Prices)" is the logarithm of zip-level house prices. Origination cohort is the year of origination of the mortgage. Monthly Payment at Origination identifies the quartiles of the monthly payment. In Column (3)-(5) we allow in turn for different trends for each county, for each origination cohort, and for different monthly payments at origination. The sample includes mortgages originated between 2005 and 2007 provided by BlackBox Logic. Robust standard errors, clustered at the month level, are below the coefficients in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

	1	2	3	4	5	6
	Partial Prepayment					Normalized by Payment Size at Origination
Four Quarters Before	1.033 (1.195)	1.457 (1.306)	1.736 (1.299)	2.658 (1.615)	1.441 (1.266)	0.00104 (0.000900)
Three Quarters Before	1.935 (1.340)	2.030 (1.404)	2.981* (1.574)	5.006*** (1.799)	3.042** (1.432)	0.00268* (0.00154)
Mortgage Interest Rate						
Two Quarters Before	1.961 (1.487)	1.400 (1.664)	2.103 (1.742)	6.234** (2.410)	3.493* (1.829)	0.00303** (0.00151)
Average Monthly Payment						
One Quarter Before	2.094 (1.396)	3.021** (1.363)	4.907*** (1.524)	9.403*** (2.502)	6.668*** (1.410)	0.00496** (0.00211)
One Quarter After	61.33*** (2.849)	57.36*** (2.366)	60.83*** (2.514)	66.36*** (3.602)	64.10*** (2.152)	0.0430*** (0.00238)
Two Quarters After	65.35*** (2.733)	63.05*** (2.382)	67.92*** (2.311)	75.11*** (4.054)	72.80*** (2.366)	0.0493*** (0.00300)
Three Quarters After	61.40*** (2.717)	64.59*** (2.763)	70.10*** (2.728)	78.59*** (5.045)	76.93*** (2.833)	0.0533*** (0.00353)
Four Quarters After	57.89*** (2.437)	61.56*** (2.649)	68.93*** (2.643)	77.20*** (5.440)	77.28*** (2.775)	0.0525*** (0.00355)
Two Years After	56.20*** (2.744)	58.75*** (3.341)	68.80*** (3.151)	79.42*** (6.361)	79.75*** (2.886)	0.0553*** (0.00415)
FICO Score		0.131*** (0.00987)	0.135*** (0.0105)	0.132*** (0.00995)	0.132*** (0.0103)	7.87e-05*** (6.37e-06)
Log House Prices		0.0688*** (0.0161)	0.0186 (0.0252)	0.0722*** (0.0160)	0.0566*** (0.0149)	3.75e-05*** (1.10e-05)
Time Fixed Effects	Yes	Yes				
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
County X Time Fixed Effect			Yes			
Origination Cohort X Time Fixed Effect				Yes		Yes
Monthly Payment at Origination X Time Fixed Effect					Yes	
Observations	2,626,647	2,101,428	2,006,743	2,101,428	2,038,591	2,038,591
R-squared	0.229	0.238	0.022	0.238	0.241	0.154

Table 5
Difference-in-Differences Results

The table reports coefficient estimates of least square regressions relating the monthly mortgage payment, car purchases and mortgage principal prepayment to the reset of interest rate 5 years after the origination. The sample includes both 5-year and 10-year mortgages originated between 2005 and 2007 as provided by BlackBox Logic. The dependent variable in Column (1) is the mortgage monthly payment. The dependent variable in Column (2) is the monthly amount spent on car purchase and is computed based on the balance of the household's auto loan.. The dependent variable in Column (3) is the monthly reduction in the mortgage balance and is computed based on data from BlackBox. Columns (3)-(6) show the results when we normalized the dependent variables by the size of the monthly payment of the mortgage at the origination. The main independent variables are dummies identifying different time periods before and after the reset date, and effectively compare the mortgage payments, car purchases and principal prepayment for the 5-year mortgages that have their interest rate reset with the 10-year mortgages that do not. "FICO" is provided monthly by Equifax. "Log(House Prices)" is the logarithm of zip-level house prices. Mortgage age fixed effects are the quarters since origination. Origination cohort is the quarter of origination of the mortgage, and loan type identifies the 5-year and 10-year ARMs. We allow for different trends for each loan type originated in different years. Robust standard errors, clustered at the household level, are below the coefficients in parenthesis. Asterisks denote significance levels (**=1%, ***=5%, *=10%).

	1	2	3	4	5	6
				<i>Normalized by Payment Size at Origination</i>		
	Interest Payment	Car Purchase	Prepayment	Interest Payment	Car Purchase	Prepayment
Four Quarters Before	-10.75*** (3.135)	40.11* (21.58)	8.442** (3.206)	-0.00194** (0.000772)	0.0152 (0.0133)	0.00312 (0.00194)
Mortgage Interest Rate	-19.75*** (4.852)	26.13 (31.32)	6.935 (4.462)	-0.00355*** (0.00101)	0.00703 (0.0154)	0.00272 (0.00245)
Average Monthly Payment	-23.72*** (5.342)	48.57 (34.26)	12.12*** (4.511)	-0.00508*** (0.00114)	0.0207 (0.0154)	0.00641*** (0.00227)
One Quarter Before	-20.74*** (7.376)	99.45*** (33.88)	10.61** (4.931)	-0.00668*** (0.00180)	0.0356* (0.0197)	0.00436 (0.00288)
One Quarter After	-922.3*** (43.58)	146.7*** (46.24)	66.26*** (6.329)	-0.530*** (0.00626)	0.0601*** (0.0225)	0.0402*** (0.00406)
Two Quarters After	-848.7*** (33.86)	162.3*** (46.17)	75.30*** (6.956)	-0.527*** (0.00598)	0.0682** (0.0313)	0.0436*** (0.00413)
Three Quarters After	-793.6*** (33.06)	187.3*** (42.69)	71.74*** (7.501)	-0.523*** (0.00743)	0.0740** (0.0298)	0.0445*** (0.00478)
Four Quarters After	-750.6*** (33.88)	186.1*** (60.19)	67.25*** (8.844)	-0.517*** (0.00704)	0.104** (0.0401)	0.0429*** (0.00537)
Two Years After	-713.5*** (34.58)	137.7* (80.01)	62.21*** (9.658)	-0.518*** (0.00766)	0.0949** (0.0419)	0.0431*** (0.00647)
FICO Score	-0.0266*** (0.00495)	1.803*** (0.0564)	0.152*** (0.0101)	-2.91e-05*** (2.16e-06)	0.00104*** (3.22e-05)	7.71e-05*** (5.58e-06)
Log(House Prices)	-0.141*** (0.0262)	0.157 (0.139)	0.129*** (0.0165)	-5.51e-05*** (3.34e-06)	3.42e-05 (9.04e-05)	5.69e-05*** (9.69e-06)
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Origination Cohort X Loan Type X Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Mortgage Age Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,530,401	4,596,110	4,294,354	3,507,231	3,563,218	3,368,065
R-squared	0.977	0.030	0.243	0.987	0.033	0.253

Table 6
Heterogeneous Effects: Income

The table reports coefficient estimates of least square regressions relating the monthly mortgage payment, car purchases and mortgage principal prepayment to the reset of interest rate 5 years after the origination. The sample includes 5-year ARMs originated between 2005 and 2007 as provided by BlackBox Logic. The dependent variable in Columns (1) is the mortgage monthly payment, while in column (2) it is the monthly amount spent on car purchase and is computed based on the balance of the household's auto loan and in column (3) the dependent variable is the monthly partial prepayment and is computed based on data from BlackBox. The main independent variables are dummies identifying different time periods before and after the reset date. "One Year Before" identifies the twelve months before up to one month before the interest rate adjustment. "One Year After" includes the month of the adjustment up to twelve months after. "Two Years After " "High Income" is a dummy equal to one if the household income, averaged over 2 years to 1 year before the adjustment, is greater than the median income. "Log(House Prices)" is the logarithm of zip-level house prices. Origination cohort is the year of origination of the mortgage. Robust standard errors, clustered at the household level, are below the coefficients in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

	(1)	(2)	(3)
	Interest Payment	Car Purchase	Prepayment
One Year Before	-0.00554*** (0.000523)	0.0273** (0.0112)	6.86e-05 (0.00135)
One Year After	-0.543*** (0.000787)	0.0706*** (0.0169)	0.0369*** (0.00201)
Mortgage Interest Rate (Inst	-0.545*** (0.00121)	0.137*** (0.0260)	0.0435*** (0.00305)
Two Years After	0.00358*** (0.000581)	-0.0405*** (0.0125)	0.00165 (0.00151)
Average Monthly Payment (I	0.0303*** (0.000835)	-0.0529*** (0.0179)	0.00967*** (0.00216)
One Year Before X High Income	0.0307*** (0.00124)	-0.124*** (0.0266)	0.00183 (0.00317)
One Year After X High Income	-2.87e-05*** (1.53e-06)	0.00111*** (3.28e-05)	8.21e-05*** (3.99e-06)
Two Years After X High Income	-5.25e-05*** (4.29e-06)	-5.68e-05 (9.22e-05)	2.73e-05** (1.10e-05)
FICO			
Log(House Prices)			
Households Fixed Effects	Yes	Yes	Yes
Origination Cohort X Time Fixed Effect	Yes	Yes	Yes
High Income X Time Fixed Effects	Yes	Yes	Yes
Low Income X Time Fixed Effects	Yes	Yes	Yes
Observations	2,213,765	2,214,311	2,030,646
R-squared	0.781	0.026	0.154

Table 7
Heterogeneous Effects: Loan to Value Ratio

The table reports coefficient estimates of least square regressions relating the monthly mortgage payment, car purchases and mortgage principal prepayment to the reset of interest rate 5 years after the origination. The sample includes 5-year ARMs originated between 2005 and 2007 as provided by BlackBox Logic. The dependent variable in Columns (1) is the mortgage monthly payment, while in column (2) it is the monthly amount spent on car purchase and is computed based on the balance of the household's auto loan and in column (3) the dependent variable is the monthly partial prepayment and is computed based on data from BlackBox. The main independent variables are dummies identifying different time periods before and after the reset date. "One Year Before" identifies the twelve months before up to one month before the interest rate adjustment. "One Year After" includes the month of the adjustment up to twelve months after. "Two Years After" "High LTV" is a dummy equal to one if the LTV one year before the adjustment is greater than the median LTV. "Log(House Prices)" is the logarithm of zip-level house prices. Origination cohort is the year of origination of the mortgage. Robust standard errors, clustered at the household level, are below the coefficients in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

	(1)	(2)	(3)
	Interest Payment	Car Purchase	Prepayment
One Year Before	0.00132** (0.000609)	-0.00850 (0.0115)	0.000969 (0.00140)
One Year After	-0.520*** (0.000929)	0.0303* (0.0176)	0.0417*** (0.00211)
Mortgage Interest Rate			
Two Years After	-0.525*** (0.00155)	0.00982 (0.0293)	0.0438*** (0.00346)
Average Monthly Payment			
One Year Before X High LTV	-0.00958*** (0.000745)	0.0339** (0.0141)	0.000368 (0.00176)
One Year After X High LTV	-0.0377*** (0.00110)	0.0485** (0.0209)	-0.00814*** (0.00259)
Two Years After X High LTV	-0.0398*** (0.00179)	0.111*** (0.0338)	-0.000578 (0.00410)
FICO	-3.41e-05*** (1.78e-06)	0.00108*** (3.37e-05)	7.20e-05*** (4.19e-06)
Log(House Prices)	1.18e-05** (5.90e-06)	4.01e-05 (0.000112)	2.83e-05** (1.36e-05)
Households Fixed Effects	Yes	Yes	Yes
Origination Cohort X Time Fixed Effect	Yes	Yes	Yes
High LTV X Time Fixed Effects	Yes	Yes	Yes
Low LTV X Time Fixed Effects	Yes	Yes	Yes
Observations	1,838,722	1,838,983	1,666,847
R-squared	0.732	0.025	0.147

Table 8
Heterogeneous Effects: Fico Score

The table reports coefficient estimates of least square regressions relating the monthly mortgage payment, car purchases and mortgage principal prepayment to the reset of interest rate 5 years after the origination. The sample includes 5-year ARMs originated between 2005 and 2007 as provided by BlackBox Logic. The dependent variable in Columns (1) is the mortgage monthly payment, while in column (2) it is the monthly amount spent on car purchase and is computed based on the balance of the household's auto loan and in column (3) the dependent variable is the monthly partial prepayment and is computed based on data from BlackBox. The main independent variables are dummies identifying different time periods before and after the reset date. "One Year Before" identifies the twelve months before up to one month before the interest rate adjustment. "One Year After" includes the month of the adjustment up to twelve months after. "Two Years After " "High FICO" is a dummy equal to one if the FICO one year before the adjustment is greater than 666. "Log(House Prices)" is the logarithm of zip-level house prices. Origination cohort is the year of origination of the mortgage. Robust standard errors, clustered at the household level, are below the coefficients in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

	(1)	(2)	(3)
	Interest Payment	Car Purchase	Prepayment
One Year Before	-0.00547***	-0.00532	0.000264
Mortgage Interest Rate (In	(0.000575)	(0.0124)	(0.00150)
One Year After	-0.548***	0.00312	0.0247***
Average Monthly Payment	(0.000867)	(0.0186)	(0.00223)
Two Years After	-0.547***	0.0255	0.0326***
	(0.00138)	(0.0297)	(0.00350)
One Year Before X High FICO	0.00324***	0.0178	0.00125
	(0.000611)	(0.0131)	(0.00159)
One Year After X High FICO	0.0317***	0.0592***	0.0263***
	(0.000888)	(0.0191)	(0.00230)
Two Years After X High FICO	0.0290***	0.0648**	0.0176***
	(0.00135)	(0.0290)	(0.00346)
FICO	-1.99e-05***	0.00105***	7.72e-05***
	(1.60e-06)	(3.45e-05)	(4.18e-06)
Log(House Prices)	-5.26e-05***	-7.81e-05	2.86e-05***
	(4.26e-06)	(9.14e-05)	(1.09e-05)
Households Fixed Effects	Yes	Yes	Yes
Origination Cohort X Time Fixed Effect	Yes	Yes	Yes
High FICO X Time Fixed Effects	Yes	Yes	Yes
Low FICO X Time Fixed Effects	Yes	Yes	Yes
Observations	2,212,779	2,213,325	2,029,757
R-squared	0.781	0.026	0.155

Table 9
Credit Card Consumption and Interest Rate Reset

The table reports coefficient estimates of least square regressions relating the monthly purchases on credit cards, equity loans and home equity line of credit to the reset of interest rate 5 years after the origination. Panel A focus on consumption, while Panel B analyzes households' deleveraging decisions. The dependent variables are computed based on the households' balance of each type of loan as provided by Equifax. Columns (1)-(3) analyze the effect of the interest rate reset on store credit cards, while Columns (4)-(6) focus on credit cards issued by banks. For bank credit cards, we focus on households that use them for monthly payment, identified as those for whom there is enough volatility in their monthly balance. The dependent variables in Panel B are equity loans and home equity line of credit provided by Equifax. The main independent variables are dummies identifying different time periods before and after the reset date. "FICO" is provided monthly by Equifax. "Log(House Prices)" is the logarithm of zip-level house prices. Origination cohort is the quarter of origination of the mortgage. Monthly payment at origination identifies the quartiles of different monthly payment size at origination. The sample includes mortgages originated between 2004 and 2007 provided by BlackBox Logic. Robust standard errors, clustered at the household level, are below the coefficients in parenthesis. Asterisks denote significance levels (**=1%, ***=5%, *=10%).

<i>Panel A: Interest Rate Adjustment and Consumption</i>						
	1	2	3	4	5	6
	Store Credit Cards	Store Credit Cards (Normalized)	Store Credit Cards	Bank Credit Cards	Bank Credit Cards (Normalized)	Bank Credit Cards
Four Quarters Before	1.170 (2.649)	0.000343 (0.00194)	1.025 (2.245)	19.34 (26.00)	-0.0268 (0.0175)	-11.22 (23.40)
Three Quarters Before	3.174 (3.194)	1.05e-05 (0.00234)	3.175 (2.391)	19.09 (31.94)	-0.0534** (0.0202)	-19.56 (25.22)
Mortgage Interest Rate	(In: 0.451 (3.760)	-0.000841 (0.00276)	-0.484 (2.558)	46.02 (44.86)	-0.0595* (0.0312)	2.855 (32.74)
Two Quarters Before	10.01** (4.324)	0.00358 (0.00317)	7.395*** (2.774)	87.69 (54.99)	-0.0566 (0.0423)	23.17 (32.45)
One Quarter Before	14.25*** (4.926)	0.00733** (0.00362)	9.842*** (3.048)	129.0** (61.27)	-0.0446 (0.0457)	46.08 (36.25)
One Quarter After	15.32*** (5.564)	0.00795* (0.00409)	8.915*** (3.397)	125.3* (71.48)	-0.0239 (0.0541)	37.30 (46.77)
Two Quarters After	15.22** (6.191)	0.00516 (0.00455)	7.858** (3.764)	140.4 (89.33)	-0.0209 (0.0665)	40.64 (52.28)
Three Quarters After	20.87*** (6.919)	0.0113** (0.00508)	11.37*** (4.184)	275.6*** (98.48)	0.0806 (0.0829)	153.0*** (53.59)
Four Quarters After	27.85*** (7.877)	0.0147** (0.00579)	16.24*** (4.089)	330.0** (123.4)	0.163* (0.0915)	176.3*** (60.84)
Two Years After	0.215*** (0.00856)	0.000143*** (6.27e-06)	0.216*** (0.00872)	-8.559*** (0.494)	-0.00563*** (0.000353)	-8.402*** (0.495)
FICO Score	0.0432* (0.0245)	3.71e-05** (1.80e-05)	0.0465* (0.0254)	2.173*** (0.412)	0.00152*** (0.000295)	1.714*** (0.399)
Log House Prices						
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Origination Cohort X Time Fixed Effect	Yes	Yes		Yes	Yes	
Monthly Payment at Origination X Time Fixed Effect			Yes			Yes
Observations	1,158,492	1,124,408	1,124,408	289,562	279,911	279,911
R-squared	0.060	0.049	0.060	0.365	0.423	0.366

Panel B: Interest Rate Adjustment and Deleveraging

	1	2	3	4	5	6
	Equity Loan	HELOC	Equity Loan (Normalized)	HELOC (Normalized)	Equity Loan	HELOC
Four Quarters Before	-1.063 (1.349)	-4.839* (2.801)	-0.000396 (0.00105)	-0.00426** (0.00205)	-0.852 (1.151)	-5.499** (2.388)
Three Quarters Before	-0.120 (1.642)	-7.802** (3.399)	0.000646 (0.00128)	-0.00828*** (0.00249)	1.349 (1.244)	-7.984*** (2.564)
Mortgage Interest Rate (In)	-0.880 (1.946)	-8.139** (4.037)	0.00142 (0.00151)	-0.00947*** (0.00296)	2.832** (1.351)	-7.974*** (2.762)
Average Monthly Payment	-1.732 (2.254)	-8.626* (4.688)	0.00178 (0.00175)	-0.00981*** (0.00344)	3.158** (1.478)	-8.458*** (3.010)
One Quarter After	7.465*** (2.574)	16.63*** (5.354)	0.0102*** (0.00200)	0.00377 (0.00393)	12.85*** (1.632)	17.68*** (3.294)
Two Quarters After	7.767*** (2.912)	15.65*** (6.062)	0.0111*** (0.00226)	0.00327 (0.00445)	14.50*** (1.823)	16.75*** (3.650)
Three Quarters After	7.442** (3.252)	19.58*** (6.751)	0.0126*** (0.00253)	0.00669 (0.00496)	16.31*** (2.028)	20.02*** (4.025)
Four Quarters After	3.157 (3.648)	19.58*** (7.484)	0.0109*** (0.00284)	0.00786 (0.00550)	12.50*** (2.274)	18.28*** (4.424)
Two Years After	2.278 (4.195)	16.71** (8.487)	0.0131*** (0.00327)	0.00525 (0.00624)	15.38*** (2.330)	8.588* (4.518)
FICO Score	0.136*** (0.00525)	0.201*** (0.0114)	9.69e-05*** (4.07e-06)	0.000112*** (8.38e-06)	0.135*** (0.00532)	0.198*** (0.0116)
Log House Prices	0.188*** (0.0199)	0.221*** (0.0445)	0.000170*** (1.55e-05)	0.000169*** (3.26e-05)	0.198*** (0.0205)	0.253*** (0.0454)
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Household Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Origination Cohort X Time Fixed Effect	Yes	Yes	Yes	Yes		
Monthly Payment at Origination X Time Fixed Effect					Yes	Yes
Observations	532,163	396,952	513,391	384,551	513,391	384,551
R-squared	0.357	0.394	0.342	0.388	0.358	0.394

Table 10
Aggregate Evidence: ARMs and Mortgage Interest Rate

Panel A reports the correlations between the fraction of adjustable-rate mortgages computed in 2006 and the characteristics of the county. We consider the debt-to-income ratio as in 2006, reported by the New York Fed Consumer Credit Panel. "Securitization" is computed using data from BlackBox Logic and is the change in the fraction of loans in a county that are securitized in the period 2004-2006. Panel B reports coefficient estimates of least square relating the quarterly change in the average mortgage interest rate in a county, with the fraction of adjustable-rate mortgages in the same county interacted with the six-month LIBOR rate which is the most common index rate for the ARMs employed in the individual-level analysis. County controls include the interaction between the variables in Panel A and the six-month LIBOR rate. The sample covers the period from 2007 to 2013. Fraction of ARMs₂₀₀₆ is the fraction of adjustable-rate mortgages originated in each county in 2006. Both columns in Panel B include time and county fixed effects and Columns (2) and (4) also include State X Time fixed effects. Robust standard errors, clustered at the county level, are below the coefficients in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

Panel A: Fraction of ARMs and County Characteristics

	1
	Fraction of ARMs in 2006
Debt-to-Income ratio in 2006	0.115***
Mortgage Interest Rate	(Instrumented by Fraction of (0.00657)
Log(Median Income)	0.195***
Average Monthly Payment	(Instrumented by Fractio (0.0275)
Poverty Rate	0.00665***
	(0.00107)
Securitization 2004-2006	0.225***
	(0.0362)
Observations	804
R-squared	0.715

Panel B: Fraction of ARMs and Mortgage Interest Rates

	1	2	3	4
	Mortgage Interest Rate	Mortgage Interest Rate	Average Monthly Payment	Average Monthly Payment
Fraction of ARMs ₂₀₀₆ X Six-Month LIBOR	0.172***	0.197***	0.0587***	0.0332***
	(0.0113)	(0.0117)	(0.00813)	(0.00689)
County Controls	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes	Yes
State X Time Fixed Effects		Yes		Yes
Observations	24,204	24,176	24,204	24,176
R-squared	0.342	0.245	0.143	0.145
Number of Counties	865	864	865	864

Table 11
Aggregate Evidence: Aggregate Consumption and Deleveraging

The table reports coefficient estimates relating the consumption and deleveraging in a county with the average mortgage interest rate in that county, instrumented by the interaction of the Fraction of ARMs in 2006 and the six-month LIBOR rate. Fraction of ARMs₂₀₀₆ is the fraction of adjustable-rate mortgages originated in each county in 2006. The first four columns of Panel A report the results for the reduced form estimates, while the last four columns instrument the mortgage interest rate with the interaction of fraction of ARMs and the six-month LIBOR rate which is the mostly used index rate for these mortgages. "Car Sales" is derived from Polk data. Log(Credit Card Balance) is the average balance on credit cards in a county employing data from the New York Consumer Credit Panel. The dependent variable in Panel B is the log of the average mortgage balances in a county and is reported by the New York Consumer Credit Panel. We control for the log of the median income and population in a county. Moreover, we also control for the debt-to-income and securitization interacted with the six-month LIBOR rate. The debt-to-income ratio as in 2006 is reported by the New York Fed Consumer Credit Panel, while "Securitization" is computed using data from BlackBox Logic and is the change in the fraction of loans in a county that are securitized in the period 2004-2006. The sample covers the 2007-2013 period. All columns include time and county fixed effects. Columns (3)-(4) and (7)-(8) of Panel A as well as Columns (3) and (4) of Panel B include state-time fixed effects. Robust standard errors, clustered at the county level, are below the coefficients in parenthesis. Asterisks denote significance levels (**=1%, **=5%, *=10%).

	1	2	3	4	5	6	IV	7	8	9
	Car Sales	Log(Credit Card Balance)	Log(Mortgage Balance)	Car Sales	Log(Credit Card Balance)	Log(Mortgage Balance)		Car Sales	Log(Credit Card Balance)	Log(Mortgage Balance)
Fraction of ARMs ₂₀₀₆ X Six-Month LIBOR	-0.0592*** (0.0140)	-0.0729*** (0.0176)	0.0262*** (0.00995)							
Mortgage Interest Rate (Instrumented by Fraction of ARMs2006 X Six-Month LIBOR)				-0.340*** (0.0806)	-0.424*** (0.103)	0.152*** (0.0589)				
Average Monthly Payment (Instrumented by Fraction of ARMs2006 X Six-Month LIBOR)								-1.009*** (0.272)	-1.243*** (0.349)	0.447*** (0.146)
County Controls	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
County Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes
Observations	23,980	24,204	24,204	23,981	24,204	24,204		23,980	24,204	24,204
R-squared	0.072	0.088	0.461	0.059	0.075	0.439		0.000	0.020	0.567
Number of Counties	857	865	865	858	865	865		857	865	865