Mortgage Debt, Hand-to-Mouth Households, and Monetary Policy Transmission[*]

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This version: December 2018

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Abstract

Using a representative sample of credit card holders from a Chinese commercial bank with a 10% credit card market share, we investigate how consumers respond to an unexpected interest rate decrease that automatically reduces interest expenses for all mortgagors in the country and thereby generates significant positive disposable-income shocks. Our difference-in-differences analysis shows that compared with homeowners without mortgage obligations, mortgagors increased their monthly credit card spending by 7.2% after the 230bps mortgage rate reduction announced in September 2008. We find a significant spending response both immediately after the announcement and during the post-reset period. The credit card delinquency rate also decreased after the mortgage rate reset. Subsequent to an interest-rate-increase episode, mortgagors symmetrically reduced their credit card spending. Hand-to-mouth consumers experienced a pronounced spending increase, even among those with a high credit limit, and their response was concentrated in the post-reset period. The debt-service channel plays an important role in transmitting monetary policy—our estimate implies a marginal propensity to consume (MPC) of 0.40-0.51 through credit card spending.

Keywords: Consumption, Monetary policy, Disposable income shocks, MPC, Mortgage, Housing, Policy, Constraints, Credit access, Wealthy hand-to-mouth, Debt, Deleverage, Credit cards, Household Finance, China

JEL codes: E5, E21, D12, D12, D14

I. Introduction

Monetary policy is one of the most important and commonly used policy tools to stimulate the economy, especially since the recent financial crisis (e.g., Bernanke and Gertler, 1995; Kashyap and Stein, 2000; Beraja, Fuster, Hurst, and Vavra, 2018). However, no consensus exists regarding the extent to which monetary policy can fulfil this goal. A comprehensive understanding of the monetary-policy-transmission channel is pivotal to answer this question. Our paper contributes to this debate by investigating how monetary policy affects household consumption and debt through its influence on household disposable income.

Traditional theories focus on the intertemporal substitution channel for the pass-through of monetary policy shocks. Under nominal rigidity, monetary policy changes the real rate of interest and thereby affects the relative price of current versus future consumption. However, Kapan, Moll, and Violante (2018) argue the intertemporal substitution effect is unlikely to play an important role, and the effectiveness of monetary policy in stimulating aggregate consumption hinges on its implications for household disposable income. This argument is consistent with the large literature on consumption response to income shocks (Jappelli and Pistaferri, 2010).

A direct channel for monetary policy to influence household disposable income centers on its effect on the cost of serving household debt. The largest component of household debt is mortgage. By the end of 2007, the outstanding mortgage debt in the US was as high as 99.5% of GDP, accounting for 74% of the total household debt.[1] An interest rate reduction can generate sizable disposable income to mortgagors by reducing the cost of servicing the mortgage (Di Maggio et al., 2017). Traditional theories predict a weak consumption response, as mortgagors are wealthier individuals with low sensitivity to income shocks. However, a rising literature highlights the high marginal propensity to consume for the wealthy consumers who nevertheless have low liquid assets and behave like constrained consumers (Kaplan and Violante, 2014; Kaplan, Violante, and Weidner, 2014; Jappelli and Pistaferri, 2018). Despite holding sizable housing assets, mortgagors may have low liquid assets due to the high debt burden and hence live hand-to-mouth. Consequently, changes in the mortgage-service cost can serve as an important role in the monetary policy transmission through affecting aggregate consumption.

Identifying the effect of the debt-service channel is empirically challenging. One hurdle is to isolate the effect of the debt-service channel from the effect of other confounding factors. For example, a household's choice of the interest rate structure of mortgage contracts is not random at the time of home purchase or during subsequent refinancing. Due to the dominance of fixed-rate mortgage (FRM) loans in the US market, evidence based on adjustable-rate mortgage (ARM) borrowers lacks representativeness, and the endogenous refinancing choice of FRM mortgages introduces confounding interpretations (Andersen, Campbell, Nielsen, and Ramadorai, 2018). Second, monetary policy pass-through faces multiple frictions. Central banks typically adjust

[1] Data source: Federal Reserve Bank of St Louis, Federal Reserve Bank of New York

short-term policy rates that indirectly influence mortgage rates, subjecting the transmission to other yield-curve factors and banks' discretionary decisions. Third, monetary policy also works through the asset-valuation channel or carries a general equilibrium effect on labor income, thereby independently affecting household consumption and debt (e.g., Kaplan, Moll, and Violante, 2018). Moreover, existing studies on monetary policy shocks do not have a well-defined announcement period, which may lead to an underestimation of the consumption response. Finally, data restrictions on the measurement of household balance sheets (e.g., mortgage status) and expenditure—typically low-frequency, survey-based consumption or expenditures of a specific type (e.g., car purchase) in existing studies—limit the scope of empirical identification.

Our study uses China's 2008 monetary policy shock to investigate the consumption and debt response to monetary policy through the debt-service channel. China is the second-largest economy in the world, and the monetary authority of China (i.e., People's Bank of China, PBC) has become an active user of monetary policy tools in the past two decades. In addition, household consumption on average accounted for over 40% of China's GDP during the first decade of the 2000s, which highlights the importance of the debt-service channel in evaluating monetary policy transmission to the aggregate economy. We focus on the unexpected announcement of an interest rate change in 2008, when the PBC decreased the benchmark mortgage interest rate by 230 bps, equivalent to a 36% mortgage rate cut.

Our policy experiment has several advantages. First, the large interest rate reduction during the 2008 monetary policy implies a sizable decrease in mortgagors' debt service cost, which offers a powerful test of the debt-service channel. Servicing the mortgage loan can consume as much as 47% of the annual income of a typical mortgagor in China (Fang et al., 2015). We estimate that, on average, the additional monthly disposable income a mortgagor in our sample receives, induced by the 2008 monetary policy change, constitutes 8% to 10% of monthly income. Second, all mortgages in China are ARMs. As a result, the interest rate decrease exogenously increases households' disposable income for the population of mortgagors in China. Third, the unique characteristics of China's monetary policy instruments guarantee 100% pass-through from the policy rate to the mortgage rate. In adjusting the policy rate, the PBC directly stipulates the level of the entire yield curve, with the mortgage rate mechanically determined based on the long end of the curve under a fixed formula. This characteristic helps us circumvent the frictions in the pass-through from the short-term policy rate to mortgage interest rates. Moreover, the monetary policy had a clear and unanticipated announcement date, allowing us to capture the announcement effect in the four-month period before the rate reset and obtain a comprehensive and accurate evaluation of the policy response.

We use a unique proprietary credit card dataset obtained from a leading Chinese commercial bank to study how consumers respond to the monetary policy shock. Our dataset captures a large proportion of the consumption response for two reasons. First, credit cards have become the most prevalent and important payment instrument in China. By the end of 2008, 140 million credit cards had been issued in China, meaning that, on average, every 10 Chinese citizens owned one credit

card. The total credit card spending in 2008-2009 was RMB 1.9 trillion, accounting for 15.4% of total household consumption in China.[2] Second, our dataset comes from a leading commercial bank of China, which enjoys about 10% of the credit card market share. The dataset contains the monthly credit-card-statement information—including credit card balance, spending, payments, and delinquent status—from April 2004 to December 2012, covering consumers from all 31 provinces and municipalities of mainland China. The comprehensiveness of our data provides us with a strong power to test the consumption and debt response to the monetary policy at the granular level. Detailed information on cardholders also enables us to classify consumers with varying levels of marginal propensity to consume (MPC) and study the heterogeneity of the consumption response. Notably, credit card holders in our sample have significantly higher levels of income and wealth than the national average, allowing us to investigate the role of wealthy consumers in the monetary policy transmission through affecting aggregate consumption.[3]

Our setting and data permit an empirically feasible methodology, as mortgagors benefit from a reduction in their mortgages' interest payment, whereas other households, especially owners without mortgage obligations, do not. At the same time, both mortgagors and owners without mortgage obligations are exposed to similar labor and asset market effects of the monetary policy. Our dataset not only allows us to observe ownership status, but also to distinguish owners with outstanding mortgages from owners with no mortgage obligations. Therefore, our identification relies on a difference-in-differences estimation, using homeowners with mortgage obligations as the treatment group, and homeowners who have already paid off their mortgage as the control group. The city-specific year-month fixed effects can control for the time-varying local labor market conditions as well as the local asset-valuation effects that are common to mortgagors and homeowners without mortgage obligations in the same city. The rich fixed effects help further isolate the disposable-income effect arising from a reduction in the mortgage payment.

We find that the 2008 monetary policy change significantly increased mortgagors' credit card spending both during the announcement period and in the post-mortgage-rate-reset period. During the announcement period, mortgagors increased their monthly credit card spending by 6.7% more than homeowners without mortgage obligations did, and mortgagors' monthly credit card spending in the post-mortgage-rate-reset period experienced a similar increase (by 7.2%). Given the average pre-event card spending of RMB 2,981 per month for mortgagors, the 2008 monetary policy change increased the credit card spending of an average mortgagor in our sample by RMB 200 (215) per month during the announcement period (post-reset period), which is equivalent to 2.3% (2.4%) of monthly income. We find an immediate card-spending increase among mortgagors following the policy announcement, and a persistently strong response throughout the 12 months after the mortgage rate reset. We further show the spending rose primarily in the discretionary category and non-durable goods.

[2] Source: *2011 Credit Card Report*, by NetEase Finance.

[3] According to our bank data, the average income of the consumers in our sample is RMB 75,252 per year, much higher than the per-capita disposable income of urban residents in 2008, which is RMB 15,780 per year.

We find no significant credit-card-debt response. On the other hand, the delinquency response was highly significant after the disbursement of the disposable liquidity. During the post-reset period, the credit card delinquency rate of mortgagors decreased by 0.3% more than that of homeowners without mortgage obligations. This decrease is economically large given the average delinquency rate of 1.8% during the pre-event period. The delinquency response suggests our results cannot be explained by a value increase of illiquid assets—such as through housing wealth increase or via revaluation of nominal mortgage liabilities—after the monetary policy shock, since illiquid wealth is hard to be liquidated to meet the credit-card payment obligations. The delinquency response thus corroborates the argument that the disposable income received by mortgagors improved their financial conditions and helped them avoid costly default.

We verify our identifying assumption—the control group serves as a good counterfactual for the treatment group—by explicitly testing the parallel-trends assumption and performing a matched-sample analysis. The response in the month immediately before the policy announcement was economically negligible and statistically insignificant, which confirms the underlying identifying assumption of a parallel trend. In addition, we match the treatment and the control groups using observable characteristics including credit limit, age, marital status, number of dependents, and city. The control group after matching is observationally similar to the treatment group, facilitating a more precise estimate of the counterfactuals. Using another independent dataset, we further verify that mortgagors and outright homeowners have similar levels of financial assets, such as bank deposits, bonds, stocks, and mutual funds, after controlling for observable characteristics. The results based on the matched sample resemble those from the main analysis: Consumers in the matched treatment group increased their monthly credit card spending by 9.5% (10.1%) more than consumers in the matched control group during the announcement period (post-reset period).

Yet, the treatment and the control consumers may differ in their housing assets. To the extent that residential properties account for 68% of households' wealth, the monetary policy may have a differential impact through its independent effect on housing asset valuation.[4] Nevertheless, no observable house-price increase occurred around the event window, based on the house-price index constructed by Fang et al. (2015), suggesting the housing-asset-valuation effect is less of a concern in our setting. By separating the cities in our sample by their past house-price movements, we also show the spending response was not stronger among cities with larger house-price increases. In addition, the wealth accumulation through housing assets can hardly be liquidated to meet the credit-card payment obligations, and therefore cannot explain the delinquency rate reduction.

The interest rate decrease may also affect the interest income of savings or payment of other debt obligations. However, the contemporaneous rate change in the variable-rate deposit is too small (32 bps) relative to the mortgage rate reduction (230 bps) to confound our results through

[4] Source: China Household Finance Survey 2011

the "lender" cash-flow channel (La Cava, Hughson, and Kaplan, 2016). On the liability side of the household balance sheet, the credit card interest rate in China is constant, regardless of monetary policy changes; the amount of outstanding variable-rate car loans is less than 1.9% of the amount of outstanding mortgage loans, which is also too small to drive our results. Overall, our results are unlikely to be confounded by the transmission of monetary policy through other components of the household balance sheet.

In 2008, China also announced an RMB 4 trillion fiscal package to stimulate the post-crisis economy. Nevertheless, the fiscal policy was not announced until November 2008, whereas the spending response started immediately after the September announcement. Although existing studies document a disproportionate effect of the fiscal stimulus on state-owned enterprises (SOEs), we find a similar response magnitude among mortgagors working at SOEs compared with other non-SOE mortgagors (Huang, Pagano, and Panizza, 2017).

Next, we investigate the effect of an interest increase by extending the sample period to incorporate the following round of contractionary monetary policy shocks from October 2010 to July 2011. The reversal of monetary policy allows us to further alleviate the confounding effect of fiscal stimulus as well as to examine whether the effect of the monetary-policy-induced disposable-income changes is symmetric for an interest rate increase. We find a negative spending response following a mortgage-payment increase, and the effect magnitude is comparable to the positive spending response during the 2008 interest rate cut. Also, mortgagors accumulated greater credit card debt following the interest rate increase. These results corroborate that our main findings are attributable to the monetary policy shock, given that no fiscal policy reversals occurred throughout the 2010-2011 contractionary monetary policy regime.[5] In addition, we note this round of contractionary policy shocks increased the commercial mortgage rate by 183 bps, while it increased the benchmark interest rate by only 111 bps. The fact that the mortgage rate increased disproportionally more than the benchmark interest rate also helps alleviate the monetary policy's potential confounding effect through other asset classes.

To further corroborate our results are driven by the debt-service channel of monetary policy transmission, we investigate the heterogeneous response among mortgages with different level of mortgage debt burden. We find a stronger spending response among high-mortgage-debt-burden mortgagors, especially during the post-reset period. They also accumulated more credit card debt during the announcement period, suggesting they were using credit cards as an instrument to intertemporally smooth their spending. However, they show a stronger deleveraging response after the mortgage rate reset, accompanied by a larger decrease in the delinquency rate. These results are consistent with the argument that the debt-service channel had a larger impact on high-mortgage-debt burden mortgagors.

[5] Although the central government concluded the fiscal stimulus program by the end of 2010, fiscal expansion continued until 2014, mainly financed by the off-balance-sheet Local Government Financing Vehicles (Chen, He, and Liu, 2017; Bai, Hsieh, and Song, 2016).

We then explore the heterogeneity in the spending and debt responses among constrained versus unconstrained consumers. We first find a stronger effect among the low-credit-limit consumers, consistent with previous findings on consumption responses. Furthermore, we examine the variation in the degree of hand-to-mouth, as measured by a consumer's pre-event credit-card-debt-to-income ratio (i.e., cash-on-hand constraints). The spending response among cash-on-hand constrained mortgagors is significantly stronger than that among less constrained mortgagors. However, unlike the spending response of an average mortgagor, which is equally strong during the announcement period and the post-reset period, the spending response among cash-on-hand-constrained consumers is concentrated during the post-reset period. This finding suggests consumers with cash-on-hand constraints may have difficulty fully exploiting the anticipated positive income shock during the announcement period. Importantly, the spending response among the cash-on-hand-constrained consumers is significant regardless of their credit access.

Our back-of-the-envelope calculation shows the monthly mortgage-payment reduction for mortgagors in our bank's dataset accounts for 7.7%–9.7% of his or her monthly income. This finding implies a significant MPC out of the disposable income shock, ranging from 0.40 to 0.51, in the 10-month post-announcement period (including four months during the announcement period and six months during the post-reset period). Because our data do not capture consumers' spending by cash and debit card, the estimated MPC is likely a lower bound of the overall consumption response.

We conduct a series of additional analyses to investigate the results' robustness as well as alternative mechanisms. Our result cannot be explained by the intertemporal substitution channel, or by more favorable credit expansion to the treatment group, or by the treatment group's increased inclination to use credit cards during the post-shock period.

Our paper directly adds to the broad literature on the transmission channel of monetary policy (e.g., Bernanke and Gertler, 1995; Kashyap and Stein, 2000; Beraja, Fuster, Hurst, and Vavra, 2018). A growing line of work focuses on the pass-through of monetary policy through household consumption and debt, including Agarwal et al. (2017b,c), Kaplan, Moll, and Violante (2018), Di Maggio et al. (2017), Sterk and Tenreyo (2016), and Wong (2014). Recent theoretical work suggests that when the mortgage debt duration is sufficiently short (e.g., ARM), accommodative monetary policies may effectively stimulate aggregate consumption through the reduction of mortgage payment (e.g., Garriga, Kydland, and Šustek, 2017; Auclert, 2017).

Although several empirical studies examine the above theory with aggregate data (Calza, Monacelli, and Stracca, 2013; Cloyne, Ferreira, and Surico, 2017), we are among the first to provide empirical evidence using disaggregate data. Di Maggio et al. (2017) focus on households with ARMs originated between 2005 and 2007 in the US; they find that when mortgage payments declined five years after their origination, due to the prolonged low interest rates, consumers on average increased their car purchases by 40%. Agarwal et al. (2017a) and Kaplan, Mitman, and

Violante (2017) show debt-relief programs may help prevent foreclosures and stimulate consumption. These papers highlight the role of non-conventional monetary policies in stimulating the economy. On the other hand, Jappelli and Scognamiglio (2018) find no significant consumption response among ARM mortgagors relative to FRM mortgagors following an interest rate cut in Italy. Our paper provides new evidence on the significant impact of interest rate changes on consumption through the debt-service channel. The aggregate MPC of 0.40-0.51 is economically significant. More importantly, our findings highlight the role of wealthy hand-to-mouth consumers as the key economic mechanism in understanding the large MPC. The big announcement effect also points to the potential underestimation of the aggregate effect derived from settings without well-defined policy-announcement dates.

Our paper is also related to the literature on the household-consumption response to income shocks. Our contribution is twofold. At the granular level, most of the existing literature has focused on the effects of fiscal policy on household consumption and debt decisions (e.g., Shapiro and Slemrod, 2003; Johnson, Parker and Souleles, 2006; Parker, Souleles, and Johnson, 2013; Agarwal, Liu, and Souleles, 2007; Agarwal and Qian, 2014). We use disaggregated data to document a significant consumption response to a monetary policy shock. Second, the existing literature studies the role of financial constraints in the consumption response to income shocks. (e.g., Zeldes, 1989; Johnson, Parker, and Souleles, 2006; Agarwal, Liu, and Souleles, 2007; Agarwal and Qian, 2014; Di Maggio et al., 2017). Kaplan and Violante (2014) highlight the importance of cash-on-hand constraints: Consumers with high levels of net worth may have most of their wealth locked up in illiquid assets and behave more like constrained consumers. Using linked financial account data, Baker (2018) shows that both credit constraints and liquidity constraints are important in explaining the heterogeneity in the consumption elasticity. Our study adds to the understanding of the marginal propensity to consume, by providing more nuanced analysis of different types of constraints. Consumers who are cash-on-hand constrained have a strong consumption response even if they have ample credit access, suggesting that ignoring cash-on-hand constraints may significantly understate MPC to income shocks.

Lastly, our findings provide new insight to the literature on the aggregate implications of the housing market, for example from the perspective of the role of housing net worth (Mian, Rao, and Sufi, 2013; Mian and Sufi, 2014), the mortgage credit channel (Greenwald, 2018), the collateral channel (Lustig and Nieuwerburgh, 2005; Bhutta and Keys, 2016), and the labor market channel (Sodini, et al., 2017; Gu, He, and Qian, 2018). We show that the housing and mortgage market serves as an important transmission channel for monetary policies by affecting aggregate consumption.

The remainder of the paper is organized as follows. Section II provides the institutional background of China's 2008 monetary policy. Section III describes the details of our proprietary dataset. Section IV explains the identification and empirical strategy, along with summary statistics. Section V shows the main results, and section VI provides more discussion on the heterogeneity and robustness of our findings. Finally, section VII concludes.

II. Institutional background

2.1 China's monetary policy tools

Until 2013, the two most influential and frequently used monetary policy tools were the change in the required reserve ratio (RRR) and the change in benchmark interest rates.[6] Whereas the RRR influences the overall liquidity of the financial market, the benchmark interest rates have a deterministic impact on mortgage interest rates. The PBC directly stipulates the entire yield curve: not only the short-term rate (maturity shorter than six months), but also the long-term rates, that is, one-year, three- to five-year, and five-year-or-above interest rates. The mortgage interest rate is directly determined by the five-year-or-above policy interest rate, leaving commercial banks with little discretionary power over mortgage rates. By contrast, the US policy rate, set by the Federal Reserve, does not directly apply to mortgage rates, leaving the monetary policy's effect on mortgage rates susceptible to potential confounding factors.

In addition to the RRR and the benchmark interest rates, the PBC also employs monetary policies that target specific aspects of the economy. One example is the multiplier of the mortgage interest rate. Generally, the mortgage rates provided by commercial banks are the product of the long-term benchmark interest rate and the multiplier. By changing the mortgage-interest-rate multiplier, the PBC can directly influence the cost of mortgage credit.

2.2 China's mortgage market

Residential mortgage loans are the primary form of household credit in China. As of the end of 2007, China's outstanding residential mortgage reached RMB 2.7 trillion, accounting for 82.5% of total household debt. All the mortgage contracts in China are ARMs (Fang et al., 2015). Commercial banks are the major mortgage loan providers: As of the end of 2007, 82.5% of the outstanding residential mortgage loans (or, equivalently, RMB 2.2 trillion) were provided by commercial banks, with the rest provided by the Housing Provident Fund (HPF).[7]

[6] Until 2013, open market operations were majorly employed to passively offset the funds outstanding for foreign exchange.

[7] Like many other developing countries, China employs the Housing Provident Fund (HPF) to provide long-term financing to contributing employees for purchasing a house. The funding of HPF comes from the mandatory contribution of employees and employers. The total contribution rate generally ranges from 10% to 20%. According to the estimate of Fang et al. (2015), the monthly mortgage payment typically consumes 45% of the monthly household income at the early stage of a mortgage; the down payment is generally 3.2 times the average household's annual income, which immediately consumes most, if not all, of the HPF savings of a mortgagor. Therefore, for most mortgagors, the HPF contribution is not enough to cover the monthly mortgage payment.

The mortgage interest rate in China is determined by a fixed formula as the product of the benchmark interest rate and the mortgage rate multiplier, both of which are directly stipulated by the PBC. For most mortgage contracts, interest rates are reset at the beginning of each year. The benchmark interest rate is the five-year-or-above long-term benchmark rate for commercial mortgage loans, and the HPF benchmark rate for HPF mortgage loans. The mortgage rate multiplier for commercial loans has ranged from 0.7 to 1.2 during the past two decades, whereas the multiplier is always 1 for HPF loans.

2.3 The 2008 monetary policy change of China

On September 15, 2008, the PBC announced an interest rate cut, which reduced the long-term benchmark interest rate by 9 bps, from 7.83% to 7.74%. It was an unanticipated interest rate shock, because policymaking in China typically does not involve lengthy discussions; moreover, the decision process is not disclosed to the public (*The Economist*, 2014). In the following three months, the PBC announced additional four rounds of interest rate reductions on the October 8, October 29, November 27, and December 22, respectively. By the end of 2008, the long-term interest rate was decreased by 189 bps, to 5.94%. At the same time, the HPF benchmark rate also decreased by 135 bps, from 5.22% to 3.87%. After the last round of interest rate cuts on December 23, the PBC made no further interest rate changes until October 2010. Meanwhile, the PBC announced a decrease in the mortgage rate multiplier on October 22, 2008, reducing it from 0.85x (effective since 2006) to 0.7x. This favorable multiplier was applicable not only to newly issued commercial mortgages, but also to the existing ones, and lasted until the end of 2011.

The prevailing rate for commercial mortgages before the monetary policy change was 6.66% (=7.83%×0.85), and after the change, the rate became 4.16% (=5.94%×0.7). The prevailing rate for HPF mortgages before the monetary policy was 5.22%, and after the change, the rate became 3.87%. Given the market share of commercial mortgages (82.5%) and HPF mortgages (17.5%), the 2008 monetary policy significantly decreased the average mortgage interest rate by 2.3%, from 6.41% to 4.11%. Even though the rate change was announced in 2008, the new rates were not applied until January 1, 2009. The time lag in the policy implementation provides an opportunity to study households' response during the announcement period and the reset period, respectively.

We conduct a back-of-the-envelope estimation of the disposable-income increase for an average mortgagor due to the monetary policy shock. According to a mortgage survey of 20 large Chinese cities conducted by the PBC in 2007, the average size of outstanding mortgage loans was RMB 274,000, and the average remaining maturity was 15.6 years (Shen and Yan, 2009). The dominant types of mortgage repayment schedules in China are fixed principal payments and fixed total payments. Given the average mortgage balance of RMB 274,000 at the end of 2007 and the average mortgage rate of 6.41% for year 2008, and assuming no mortgage prepayment before 2009, we can estimate the average mortgage balance immediately before the interest rate reset (i.e., end

of 2008). It was RMB 263,410 (RMB 256,417) under the fixed-principal-payment schedule (fixed-total-payment schedule). Under the assumption that the average remaining maturity at the beginning of 2009 was 14.6 years, we then calculate the monthly interest payment after the interest rate reset from January 2009, which implies an average monthly increase in disposable income of RMB 484 (RMB 317) for the fixed-principal-payment mortgage (fixed-total-payment mortgage) during the first six months after the interest rate reset. Since the disposable income of an average urban household in 2008 was RMB 3,814 per month, the decrease in monthly mortgage payment due to the monetary policy shock can account for 8% to 13% of monthly disposable household income (Source: National Bureau of Statistics). Therefore, the monetary policy shock had a large impact on households' disposable income.

III. Data

We use a unique proprietary dataset obtained from a leading commercial bank in China that enjoys 10% of China's credit card market share. The dataset contains the monthly credit card statement information, including balance, spending, payments, and fees, in detailed subcategories, of the whole population of the bank's credit cards from April 2004 to December 2012. We observe the delinquency status of each account from September 2004 to February 2012. The dataset also contains the transaction information of each credit card from January 2008 to October 2009, including transaction time, amount, and merchant category code of each credit card transaction. In addition, the dataset covers credit limit and a rich set of demographic and socioeconomic characteristics, including birth date, gender, ownership status, educational level, marital status, number of dependents, employment status, name and industry of employer, employer type (government, SOE, or private sector), occupation, and income, of a random sample of the entire credit card population.

Our dataset has the following advantages. First, credit card holders in China, on average, have higher income and wealth than the national average. According to our bank data, the average income of the consumers in our sample is RMB 75,252 per year, much higher than the per-capita disposable income of urban residents in 2008, which is RMB 15,780 per year. By looking at the consumers at the upper end of the wealth distribution, we can understand the role of wealthy consumers in the monetary policy transmission through affecting aggregate consumption.

Second, our credit card data can capture a large proportion of the consumption response, to the extent that credit cards have become the primary method of household consumption in China. According to the "Blue Book on the Development of China's Credit Card Industry," issued by the China Banking Association, total credit card transaction volume amounted to RMB 10 trillion by the end of 2012, equivalent to 18% of China's GDP in 2012. By the end of 2008, 140 million credit cards had been issued in China, meaning that, on average, every 10 Chinese citizens owned one

credit card. The total credit card spending in 2008–2009 accounted for about 15.4% of the total household consumption in China.

In addition, compared with the traditional household-finance datasets based on surveys (e.g., the Survey of Consumer Finance), our administrative dataset has little measurement error on consumption. In addition, compared with other household-finance datasets based on surveys (e.g., Consumer Expenditure Survey (CEX), which only traces a consumer four times on a quarterly basis, or the Living Costs and Food Survey (LCFS), which is a pooled cross-sectional dataset), our dataset can trace the consumption and debt behavior of a consumer for a longer period (as long as eight years) and at a higher frequency (on a monthly basis). In addition, thanks to the predominant market share of the bank from which we obtain the data, our sample is large and representative, covering consumers from all 31 provinces and municipalities in mainland China.

Last, the richness of the individual financial and demographic information facilitates a comprehensive understanding of the heterogeneity in consumers' response to the monetary policy shock. Our dataset provides us with more details about consumers' financial information, enabling us to identify consumers with different types of constraints. More importantly, we can observe consumers' housing tenure type—whether they were homeowners, and whether they owed mortgage debts.

Following Agarwal and Qian (2014, 2017), we aggregate the data at the individual-month level. Credit card spending is computed by adding monthly spending over all credit card accounts for each individual. Debt is computed by adding credit card debt (defined as the previous month's account balance minus the current month's credit card payment) over all credit card accounts for each individual, with negative values replaced by zero. Delinquency is a dummy variable equal to 1 if the consumer is 60 days past due on any of his/her credit card account.

Our bank's data contain 4 million credit card accounts that were issued before the monetary policy shock. We observe the demographics and financial characteristics for a random sample of these accounts (N= 198,800, corresponding to 163,585 consumers).[8] We further exclude inactive credit card users—individuals with no monthly spending for at least half of the pre-announcement sample period, leaving us with 95,415 active credit card users. To focus on consumers who were shocked by the policy, we also exclude consumers older than 65 or younger than 25 (as of August 2008), because they were less likely to own a home or owe mortgage debt.[9] We also focus on the top 250 cities in our sample, to ensure a sufficient number of observations that allow a reliable estimate of the city fixed effects. The final sample covers the credit card information of 81,380 individuals, from March 2008 to June 2012. In the main analysis, we focus on the sample period from March 2008 (six months before the monetary policy) to June 2009 (six months after mortgage

[8] We verify with the bank that this random sample of credit card holders are observationally similar to the rest of the credit-card-holder sample. Put differently, it is a representative sample of the credit-card-holder population for the bank.

[9] In China, borrowing a mortgage from banks is nearly impossible for those older than 65.

interest rate reset). In our final sample, 46,898 credit card holders are homeowners, either with or without mortgage obligations.

IV. Identification and Empirical Strategy

To evaluate the consumption and debt response to the 2008 monetary policy, we employ a difference-in-differences approach, using homeowners with mortgage obligations as the treatment group, and homeowners who have paid off their mortgages as the control group.

Table 1 shows the summary statistics of demographics and credit limits of the treatment and control groups in our sample. On average, consumers in the treatment group are younger, less likely to be married, have fewer dependents, and have higher credit limits. Mortgagors spend RMB 280 more per month than homeowners without mortgages. Mortgagors also have a higher level of credit card debt and delinquency rate than homeowners without mortgages. To the extent that the identifying assumption of the difference-in-differences analysis lies in the parallel-trends assumption, the difference in the levels of spending, debt, and delinquency rate between the treatment and control groups is less of a concern, and we test explicitly for the parallel trends between the two groups before the policy shock.

[Insert Table 1 here]

Before we proceed to a regression analysis, we plot the unconditional means of the logarithm of credit card spending, of the logarithm of debt, and of the 60-day delinquency rate of the treatment and control groups around the time of the monetary policy shock (March 2008–December 2009), as shown in Figure 1. Although, on average, the treatment and the control group have different levels of spending and debt, the gaps between the groups in both panels remain constant before the announcement of the policy, which supports the parallel-trends assumption. In addition, the differences in spending are discernibly larger after the policy shock, which provides suggestive evidence of the impact of monetary policy on mortgagors' spending.

[Insert Figure 1 here]

We then conduct our difference-in-differences regression using the following specification:

(1) $Y_{ict} = \beta_a \times 1_{treatment} \times 1_{announce} + \beta_r \times 1_{treatment} \times 1_{reset} + \alpha_i + \delta_{ct} + \epsilon_{ict}$.

Specifically, the dependent variable, Y_{ict}, is the logarithm of credit card spending, the logarithm of debt, or the delinquency status for individual i in month t from city c. $1_{treatment}$ is a dummy variable equal to 1 for mortgagors, and 0 for homeowners who have paid off their mortgages. $1_{announce}$ is a dummy that equals 1 for the months after the announcement of monetary policy and before the mortgage rate adjustment (i.e., September 2008-December 2008). 1_{reset} is a dummy that equals 1 for the months after the mortgage rate was reset (i.e., January 2009–June 2009). March

2008 to August 2008 are absorbed as the benchmark period in our estimation. α_i is the individual fixed effects, used to absorb individuals' unobservable characteristics that influence their credit-card-usage patterns; δ_{ct} is the city×year-month fixed effects, aimed to capture the time-varying city-level common shocks to consumers (e.g., house-price shock and local-labor-market shock). β_a and β_r respectively capture the average change in log credit card spending (or in log debt or in delinquency rate) in the treatment group (relative to the average change in the control group) during the monetary-policy-announcement period and post-reset period (compared with the benchmark period, i.e., March 2008–August 2008).

Because the lowered mortgage interest rate due to the monetary policy shock did not expire until the end of 2009, mortgagors were repeatedly treated by the interest rate reduction throughout the 12 months after the mortgage rate adjustment. Next, we explore the dynamics of consumers' responses. Specifically, we estimate the following distributed lag model:

$$Y_{ict} = \sum_{s=-1}^{15} \beta_s \times 1_{treatment} \times 1_{month\ s} + \alpha_i + \delta_{ct} + \epsilon_{ict}. \quad (2)$$

Following Agarwal and Qian (2014), the results can be interpreted as an event study. The coefficient β_s measures the average change in credit card spending, debt (both in percentage terms), and delinquency rate in the treatment group (relative to the average change in the control group) in the s^{th} month after the policy announcement (compared with the benchmark period, i.e., March 2008-July 2008), with s ranging from -1 (i.e., August 2008) to 15 (i.e., December 2009). By starting from the month immediately before the policy announcement, we can visualize the validity of the parallel-trends assumption. For spending, we calculate the cumulative coefficient $b_s \equiv \sum_{t=-1}^{s} \beta_t$, which gives us the cumulative change in spending s months after the policy announcement. For the debt and delinquency rate, we calculate the average coefficient $\bar{\beta}_s \equiv \frac{1}{s+2} \sum_{t=-1}^{s} \beta_s$, which gives us the average change in debt or delinquency rate s months after the policy announcement.

Unless stated otherwise, equations (1) and (2) are estimated using OLS, with standard errors clustered at the city level.

V. Main Results

5.1 Main results

We first show the results of the univariate difference-in-differences analysis in Table 2. We calculate the difference between an individual's pre-shock and post-shock average credit card spending, debt (both in logarithmic form), and delinquency rate, and compare the differences between the treatment group and the control group. The DID estimators show that, on average, mortgagors increased their credit card spending by 10.5% (i.e., exp(0.100)-1) more than

homeowners without mortgage obligations after the monetary policy shock. The treatment effect is economically large and statistically significant. We find no discernible debt response. The 60-day delinquency rate in the treatment group significantly decreased by 0.6% more than in the control group after the monetary policy shock.

[Insert Table 2 here]

Table 3 shows the results of the average response by applying equation (1) to log spending, log debt, and the 60-day delinquency dummy. The coefficients on $Mortgage \times 1_{announce}$ and $Mortgage \times 1_{reset}$ respectively capture the average difference in policy response between the treatment group and the control group, during the post-announcement period (September 2008–December 2008) and the post-mortgage interest-rate-reset period (January 2009–June 2009), relative to the benchmark period (March 2008–August 2008).

Column 1 shows the average spending response for the treatment group relative to the control group. We find a positive spending response both during the announcement period and after the mortgage rate was reset. Specifically, during the announcement period, consumers in the treatment group increased their monthly credit card spending by 6.7% relative to the control group. The estimate is statistically significant at the 10% level. The spending response during the mortgage reset period is 7.2%, and statistically significant at the 5% level. Given the average pre-shock monthly credit card spending of RMB 2,981 per month for the treatment group (Table 1 panel B), the 2008 monetary policy change on average increased the credit card spending of a mortgagor by RMB 200 and RMB 215 per month during the announcement and post-reset period, respectively. Given the average monthly income of RMB 8,862 for the treatment group (as observed from the bank's data), our estimate suggests the average spending response during the announcement (post-reset) period is equivalent to 2.26% (2.43%) of a mortgagor's monthly income.

In column 2, we find no significant debt response. On the other hand, the delinquency response is highly significant, but only after the disbursement of additional disposable income, as shown in column 3. During the post-reset period, the delinquency rate of consumers in the treatment group decreased by 0.3% more than consumers in the control group did. The delinquency response is economically large given the average delinquency rate of 1.8% for mortgagors during the pre-event period. The delinquency response suggests our results cannot be explained by a value increase of illiquid assets—such as through housing wealth increase or via revaluation of nominal mortgage liabilities—after the monetary policy shock, since illiquid wealth is hard to be liquidated to meet the credit-card payment obligations. The delinquency response thus corroborates the argument that the disposable income received by mortgagors improved their financial conditions and helped them avoid costly default.

[Insert Table 3 here]

5.2 Dynamics of the response

Because the lowered mortgage interest rate due to the monetary policy shock would not expire until the end of 2009, consumers with mortgages were repeatedly affected by the interest rate reduction throughout the 12 months after the mortgage rate adjustment. Therefore, we expect the change in consumers' spending patterns to be persistent without reversal during the entire 12-month post-reset period. In this section, we explicitly test the persistence of our results.

In Table 4, we repeat the main analysis in Table 3 but extend the sample period by incorporating six more months (July 2009–December 2009) into our sample. In column 1, we still find a significant spending response in the extended post-reset window: Consumers in the treatment group increased their monthly credit card spending by 6.7% relative to the control group during the post-reset period. We also find an equally strong announcement effect of spending response. Results in column 2 show no significant debt response. The delinquency response, as shown in column 3, was also persistently strong during the longer post-reset period, suggesting the mortgage payment reduction had a long-term positive effect on households' financial conditions.

[Insert Table 4 here]

Figure 2 shows the dynamic of spending, debt, and delinquency responses. For spending, we plot the cumulative coefficients b_s, which captures the cumulative spending response from the one month immediately before the policy announcement to s months after the announcement, as specified in equation (2), along with their corresponding 95% confidence intervals. We first note an immediate spending response following the policy announcement: The solid red line starts to surge in the month when the policy was announced and becomes highly significant in the following month. We also observe a persistently upward-sloping red solid line throughout the announcement and post-reset window. The cumulative spending response by the end of 2009, or b_{15}, is 1.13. Given the average pre-event monthly credit card spending of RMB 2,981 per month for the treatment group, mortgagors in total increased their credit card spending by RMB 3,369 in response to the reduction of mortgage payment during the four-month announcement period and twelve-month post-reset period. The spending response immediately before the policy announcement, b_{-1}, is economically small and statistically insignificant, which corroborates the parallel-trends assumption.

For credit card debt and delinquency rate, we depict the dynamic of their responses by showing the average response $\overline{\beta_s}$. Consistent with the regression results, the difference in credit card debt between the treatment group and the control group does not change significantly following the interest rate cut. The average delinquency response is economically small and statistically insignificant during the announcement window but becomes stronger and highly significant after the disbursement of the disposable liquidity.

[Insert Figure 2 here]

In summary, our results add two new findings to the literature on monetary policy response through the debt-service channel. First, the strong spending response among mortgagors after the interest rate cut suggests payment reduction of ARM loans is an important channel of expansionary monetary policy pass-through. In addition, the announcement effect we document, which is as significant as the spending response during the post-reset period, also emphasizes the potential underestimation of spending response estimated from settings without a well-defined policy-change-announcement window.

5.3 Testing the parallel-trends assumption

To explicitly examine the parallel-trends assumption, in Panel A of Table 5, we additionally control for $Mortgage \times 1_{pre}$, with 1_{pre} equal to 1 for the one month immediately before the announcement of the monetary policy (i.e., August 2008). The corresponding coefficient estimate captures the treatment effect in the month immediately before the policy announcement. For the parallel-trends assumption to hold, the coefficient on $Mortgage \times 1_{pre}$ should be statistically insignificant and economically small, which is what we find. This evidence confirms the validity of our empirical design.

[Insert Table 5 here]

5.4 Matched-sample evidence

One challenge with the current identification is that mortgagors and outright homeowners differ significantly along observable dimensions (Table 1). The pre-event parallel trends between the two groups have already mitigated the concern regarding our empirical strategy. We further conduct propensity-score matching to control for the differences in observables between the two groups. Specifically, we calculate propensity scores using a logistic regression that controls for the individual's latest updated pre-shock information of credit limit, age, marital status, number of dependents, and city dummy (see Panel A of Table A1 for the logistic regression result). We then conduct a one-to-one nearest-neighbor matching without replacement. Panel B in Table A1 shows that after matching, the difference between the two groups in credit card limit, age, and marital status becomes statistically and economically indistinguishable from zero. The number of dependents in the treatment group is slightly larger than that in the control group (significant at the 10% level), but the economic magnitude of the difference is negligible (0.02). In addition to the mean statistics, distributions of the pre-event credit limit and age of the treatment and control groups are also similar and comparable after matching (Figure A1). Therefore, we have a panel of reasonably balanced treatment and control individuals, which allows us to identify the policy response using the difference-in-differences approach.

In Panel B of Table 5, we repeat the analysis above using the matched sample. The results based on the matched sample are very similar to the ones based on the unmatched full sample. We observe a significant spending response in the matched sample: Consumers in the matched treatment group increased their monthly credit card spending by 9.5% (10.1%) more than consumers in the matched control group during the announcement period (post-reset period), as shown in column 1. As in the unmatched full sample, we find no significant debt response in the matched sample. The delinquency response is highly significant only after the disbursement of additional disposable income, as shown in column 3. During the post-reset period, the delinquency rate of consumers in the matched treatment group decreased by 0.5% more than that of consumers in the matched control group. These results corroborate the robustness of our main findings.

5.5 Other confounding transmission channels?

Admittedly, the matched-sample approach may not eliminate all the unobservable differences between the mortgagors and outright homeowners. One concern is that the treatment and control groups may have had different levels or compositions of asset holdings, making the monetary policy shock transmit through channels other than the cost of servicing the mortgage. We first examine the levels of financial assets, including bank deposits, bonds, stocks, and mutual funds, using the 2011 wave (the earliest wave) of the China Household Finance Survey (CHFS) data (Gan et al., 2013). Starting from 2011, the CHFS is a biannual survey that covers a representative set of households in China and provides a rich set of demographic and asset-holding information of each surveyed household. After controlling for observables similar to those in our matching procedure, we find that mortgagors and homeowners who had paid off their mortgage did not differ significantly in their levels of financial asset holding. [10]

Yet, the treatment and the control consumers may have differed in their housing-asset holdings, which may contaminate our results. To alleviate this concern, we first calculate the average house-price index around the event, based on the house-price indices estimated by Fang et al. (2015). Specifically, for each month, we calculate the average house-price index across all the cities, weighted by each city's number of consumers in our unmatched full sample. As Figure A2 shows, the average house-price growth rate was only -0.4% from March 2008 to June 2009, which is too small to drive the results even if the treatment and control group had different levels of housing-asset holdings. In addition, if the spending response we document was driven by the housing wealth effect, consumers from cities that experienced higher past house-price appreciation should have been more responsive. Based on the house-price index by Fang et al. (2015), we classify cities by the house-price appreciation between January 2003 (the beginning of the house-price index) and August 2008 (the month immediately before the policy change). A city is classified as

[10] Based on the 2011 wave of the CHFS, we confirm that mortgagors' liquid asset holdings, on average, are very small relative to their mortgage loan balance (with the mean ratio of 9% and median ratio of 3%). This evidence suggests that the bulk of mortgagors' wealth is held in illiquid assets, especially housing.

a "high house price appreciation" city if its house-price appreciation was in the top decile during this period. As shown in Panel A of Table A2, we do not find the spending response is significantly stronger in cities that experienced higher house-price appreciation, further suggesting the spending responses we documented above are unlikely to be explained by the housing wealth effect of monetary shocks. In addition, the wealth accumulation through housing assets can hardly be liquidated to meet the credit-card payment obligations, and therefore cannot explain the delinquency rate reduction.

The interest rate decrease may also affect the interest income of savings or payment of other debt obligations. However, some characteristics of our setting suggest our results are unlikely to be contaminated. The contemporaneous change in the variable-rate deposit rate was only 32 bps, much smaller than the mortgage rate reduction (230 bps). Given that variable-rate bank deposits on average consist of less than 7% of the total household wealth in China, our results are unlikely to be confounded by the "lender" cash-flow channel (La Cava, Hughson, and Kaplan, 2016). On the liability side of household balance sheets, we first note the credit card interest rate in China is fixed at 0.05% per day, regardless of monetary policy. In addition, consumers in China typically do not rely on car loans for car purchases: By the end of 2007, the amount of outstanding car loans was RMB 110.7 billion, equivalent to 3.7% of the amount of outstanding mortgage loans (Shen and Yan, 2009). Moreover, more than 50% of car loans are fixed-rate loans,[11] which further makes the potential transmission of monetary policy shock through car loans negligible relative to the transmission through mortgages. Overall, our results are unlikely to be driven by the transmission of monetary policy through other components of the household balance sheet.

Another concern about our identification is that the contemporaneous expansionary fiscal shock may confound our results. Nevertheless, the fiscal policy was not announced until November 2008, whereas the spending response started immediately after the September announcement, as shown in Figure 2. In addition, because both mortgagors and owners without mortgage obligations were exposed to the same fiscal shock, our difference-in-differences specification also helps mitigate the confounding effect of the fiscal stimulus. We further exploit the heterogeneity in the spending response across different economic sectors to evaluate the potential influence of the fiscal stimulus on our findings. As shown by Huang, Pagano, and Panizza (2017), state-owned-enterprises benefited disproportionately more from the fiscal stimulus package. If our results are driven by the contemporaneous fiscal policy, mortgagors working in state-owned-enterprises, who benefited more from the fiscal policy, should have had a stronger spending response. As shown in Panel B of Table A2, we do not find the spending response to be significantly stronger among mortgagors employed by state-owned-enterprises, again suggesting the spending responses we documented above are unlikely to be driven by the contemporaneous fiscal policy.

[11] Source: China Auto Finance Report 2012, by China Minsheng Bank & Deloitte China

5.6 The 2010 interest rate increase

We now extend our sample period to incorporate the contractionary monetary policies from October 2010 to July 2011. An interest rate increase will raise the monthly mortgage payment, constituting a corresponding decrease in disposable income. We take advantage of the reversal of monetary policy to investigate whether the spending and debt response we document above is symmetric for an interest rate increase.

The next benchmark interest rate adjustment following the 2008 interest rate cut was announced in October 2010, which increased the long-term interest rate by 20 bps. The PBC further launched another four rounds of interest rate increases in 2010 and 2011. By July 2011, which is the end of this tightening cycle, the long-term benchmark rate was 7.05%, 111 bps higher than the prevailing mortgage rate in 2009. In addition, from January 2012, the mortgage rate multiplier for commercial mortgage loans issued before 2009 reverted to 0.85, which further increased the monthly mortgage payment in 2012. In total, the prevailing interest rate for commercial mortgage loans increased by 183 bps (7.05%×0.85-5.94%×0.7) after this round of contractionary monetary policy change. [12] The fact that the mortgage rate increased disproportionately more than the benchmark interest rate also helps alleviate the potential confounding channels of the monetary policy pass-through.

Extending the sample period to June 2012, six months after the mortgage rate reset date in 2012, we examine the spending and debt response of the 2008 interest rate cut and the 2010-2011 interest rate increase by running the following regression:[13]

$$(3) \quad Y_{ict} = \beta_{a\_d} \times 1_{treatment} \times 1_{announce\_decrease} + \beta_{r\_d} \times 1_{treatment} \times 1_{reset\_decrease} + \beta_{a\_i} \times 1_{treatment} \times 1_{announce\_increase} + \beta_{2011} \times 1_{treatment} \times 1_{2011} + \beta_{2012} \times 1_{treatment} \times 1_{2012} + \alpha_i + \delta_{ct} + \epsilon_{ict}$$

Specifically, $1_{announce\_decrease}$ is a dummy that equals 1 for the months after the announcement of the interest rate cut and before the mortgage rate adjustment (i.e., September 2008–December 2008). $1_{reset\_decrease}$ is a dummy that equals 1 for the months after the implementation of the mortgage rate cut but before the announcement of the 2010 interest rate increase (i.e., January 2009–September 2010). $1_{announce\_increase}$ is a dummy that equals 1 for the months after the announcement of the 2010 interest rate increase and before the mortgage rate adjustment (i.e., October 2010–December 2010). During the 2010-2011 tightening cycle, more than half of the cumulative long-term benchmark rate increase was announced in 2011 (and implemented in January 2012). In addition, the reversal of the mortgage rate multiplier at the beginning of 2012

[12] Note the housing-tenure-type information in our sample is measured before 2009. Therefore, the increase in the mortgage rate multiplier in 2012 is applicable for all the mortgagors in our sample (except those who paid off their mortgage loans before 2012).

[13] Because the sample period of our delinquency data is too short to evaluate the delinquency response to the interest rate increase, in this subsection, we only focus on spending and debt response.

further increased the mortgage rate in 2012. We therefore divide the post-treatment period into two periods: 1_{2011} is a dummy that equals 1 during 2011 (i.e., January 2011–December 2011); 1_{2012} is a dummy that equals 1 for the months in 2012 until the end of our sample period (i.e., January 2012–June 2012). March 2008 to August 2008 are absorbed as the benchmark period. Columns 1 and 2 of Table 6 show the results of equation (3).

As in the main result, mortgagors significantly increased their credit card spending following the interest rate reduction, but this positive spending response started to revert after the interest rate increase, especially after the mortgage rate reset at the beginning of 2012. The difference in credit card spending between mortgagors and owners without mortgage obligations constitutes an inverted-U curve, implying a symmetric spending response to both interest rate cuts and increases. The debt response has a different pattern: Although the deleveraging response to interest rate cuts is weak, mortgagors attenuated the negative income shock due to the interest rate increase by accumulating more credit card debt.

In columns 3 and 4 of Table 6, we focus on the 2010-2011 tightening cycle by dropping the observations before April 2010, which is the sixth month before the beginning of the tightening cycle. Specifically, we run the following regression:

(4) $Y_{ict} = \beta_{a\_i} \times 1_{treatment} \times 1_{announce\_increase} + \beta_{2011} \times 1_{treatment} \times 1_{2011} + \beta_{2012} \times 1_{treatment} \times 1_{2012} + \alpha_i + \delta_{ct} + \epsilon_{ict}$.

The benchmark period runs from April 2010 to September 2010. Again, we find a significant decrease in credit card spending among mortgagors after the interest rate increase, accompanied by an increase in credit card debt. Although the magnitude of the spending response is comparable to what we observe during the expansionary monetary policy change, the debt response is discernibly stronger when the interest rate bounced back.

[Insert Table 6 here]

5.7 Marginal propensity to consume

We now conduct a back-of-the-envelope calculation for the marginal propensity to consume (MPC) out of the disposable income shock, induced by the mortgage payment reduction. In section 2.3, we estimate the monthly interest payment decrease, for an average mortgagor in the country, to be RMB 317 or 484. This amount is likely an underestimation of the disposable-income shock for the treated consumers in our sample, because consumers with credit cards, on average, have higher income and wealth than the national average. Therefore, we use an alternative strategy to infer the disposable-income increase for the mortgagors in our sample.

According to Fang et al. (2015), the average age at the time of home purchase is around 30. The typical mortgage maturity in China is 30 years. The average age of the mortgagors in our main

analysis is 34.4 at the end of 2008, which indicates the average remaining mortgage maturity is 25.6 years (or 307 months) at the time of the mortgage rate reset. Assuming an average down payment of 37.4% (Shen and Yan, 2009) and a price-to-income ratio of 8 (Fang et al., 2015), we compute the initial mortgage principal for our treatment group to be RMB 532,571, on average. Using the prevailing interest rate during the first 4.4 years of mortgage payment (6.41%), we find the remaining balance of the mortgage loans, at the end of 2008, was RMB 502,648 for fixed-total-payment mortgages, or RMB 454,165 for fixed-principal-payment mortgages. Given the mortgage rate reduction by 230 bps from January 2009, we calculate the increase in monthly disposable income for the treated consumers in our sample to be RMB 686 (863) for fixed-total-payment mortgages (fixed-principal-payment mortgages) for the first six months after the rate reset, or, equivalently, 7.7% (9.7%) of their monthly income.

Therefore, based on the first 10 months after the policy announcement (i.e., 4-month announcement window and 6-month post-reset window) and the estimates from the main specification (i.e., equation (1)), as shown in column 1 of Table 3, the estimated MPC based on credit card spending is between 0.40 (=(200×4+215×6)/(863×6)) and 0.51 (=(200×4+215×6)/(686×6)). Because our data do not capture consumers' spending by cash and debit card, the estimated MPC is likely to be a lower bound of the true spending response.

VI. Heterogeneity and Additional Analysis

6.1 Heterogeneous response across consumers: The role of mortgage debt burden

So far, we have identified the average spending, debt, and delinquency response to the mortgage payment reduction due to the interest rate cut. We then investigate the spending and debt response among consumers with different levels of mortgage debt burdens. Consumers with a higher level of mortgage debt burden should receive a larger amount of disposable income due to the mortgage rate reduction. The significant cost of servicing mortgage debt also suggests they were more hand-to-mouth, implying a greater consumption sensitivity. Therefore, we expect mortgagors with higher debt burdens should be more responsive to the monetary policy shock. According to Fang et al. (2015), first-tier cities (i.e., Beijing, Shanghai, Shenzhen and Guangzhou) witnessed higher house prices, faster house price growth, and larger divergence between house price growth and household disposable income growth from 2003 to 2008. This fact suggests mortgagors from first-tier cities, especially those at the early stage of the life cycle, were more likely to face a higher level of mortgage debt burden. We therefore classify a consumer as bearing high mortgage debt burden if he/she was from a first-tier city and was in the bottom quartile of the age distribution among mortgagors (i.e., under 30).

Results are reported in Table 7, based on the unmatched full sample from March 2008 to June 2009. The coefficient estimates on "*Mortgage*×$1_{announce}$×*high mortgage debt burden*" and "*Mortgage*×1_{reset}×*high mortgage debt burden*" capture the treatment effect of the high-mortgage-debt-burden mortgagors during the announcement and the post-reset period, respectively. "*Mortgage*×$1_{announce}$×*low mortgage debt burden*" and "*Mortgage*×1_{reset}×*low mortgage debt burden*" capture the treatment effect of the low-mortgage-debt-burden mortgagors during the announcement and the post-reset period, respectively. As shown in column 1, the spending response among high-mortgage-debt-burden mortgagors was discernibly stronger than that among low-mortgage-debt-burden mortgagors during the post-reset period. A formal F test shows that the difference in the spending response during the post-reset period between the high- and low-mortgage-debt-burden mortgagors was statistically significant (p<0.01). This finding corroborates that the spending response we document is attributable to the reduction of mortgage-service cost. In addition, unlike the spending response among low-mortgage-debt-burden mortgagors, which was equally strong during the announcement period and post-reset period, the spending response among high-mortgage-debt-burden mortgagors was concentrated during the post-reset period. This evidence suggests high-mortgage-debt-burden mortgagors were more likely to be hand-to-mouth consumers, and had difficulty fully exploiting the anticipated positive income shock during the announcement period.

Column 2 shows the result of debt response. We first note high-mortgage-debt-burden mortgagors significantly increased their credit card debt by 10.8% during the announcement period, relative to the consumers in the control group, suggesting they were using credit cards as an instrument to intertemporally smooth their spending. We also observe a significant deleveraging response among high-mortgage-debt-burden mortgagors after the mortgage rate reset: the credit card debt of high-mortgage-debt-burden mortgagors on average decreased by 17.1% during the post-reset period, relative to that of the consumers in the control group. The significant deleveraging response again suggests our results are unlikely to be driven by a value increase of illiquid assets, which cannot generate disposable liquidity to pay off credit card debt. In addition, the deleveraging response among high-mortgage-debt-burden mortgagors was significantly larger than that among low-mortgage-debt-burden mortgagors (p<0.01), consistent with the argument that the debt-service channel had a larger impact on high-mortgage-debt burden mortgagors.

In column 3, we find a significant delinquency-rate response among both high- and low-mortgage-debt-burden mortgagors, but only after the mortgage rate reset. In addition, the delinquency response was significantly larger among high-mortgage-debt-burden mortgagors (p<0.01), again suggesting high-mortgage-debt burden mortgagors benefited more from the debt-service channel of monetary policy transmission.

[Insert Table 7 here]

6.2 Heterogeneous response across consumers: The role of credit constraints

Previous literature has shown that more constrained consumers have a stronger consumption response to positive income shocks (e.g., Agarwal, Liu, and Souleles, 2007; Agarwal and Qian, 2014; Di Maggio et al., 2017). Our data provide us with more details about the financial information of consumers, enabling us to identify consumers with different types of financial constraints. In this subsection, we evaluate the role of credit constraints, proxied by the level of approved credit limit. A consumer is classified as having a low credit limit if his or her credit limit before the event was below the bottom quartile of the credit-card-limit distribution within the city, and is classified as having a high credit limit if otherwise.

The results are reported in Table 8, based on the unmatched full sample from March 2008 to June 2009. The coefficient estimates on "*Mortgage* $\times 1_{announce} \times$ *low credit limit*" and "*Mortgage* $\times 1_{reset} \times$ *low credit limit*" capture the response of the low-credit-limit mortgagors relative to the low-credit-limit owners without mortgage obligations, respectively, during the announcement and the post-reset period. "*Mortgage* $\times 1_{announce} \times$ *high credit limit*" and "*Mortgage* $\times 1_{reset} \times$ *high credit limit*" capture the response of the high-credit-card-limit mortgagors relative to the high-credit-card-limit owners without mortgage obligations, respectively, during the announcement and the post-reset period. As shown in column 1, low-credit-card-limit mortgagors responded strongly during both the announcement and the reset period. Specifically, they increased their credit card spending by 9.1% and 10.3% per month during the announcement and reset period, relative to the low-credit-card-limit owners without mortgage obligations. On the other hand, the spending response of high-credit-card-limit mortgagors was economically smaller and statistically insignificant. Although statistically insignificant, the difference in the spending response between high-credit-card-limit and low-credit-card-limit consumers is economically large (4.1% during the announcement period and 6.0% during the post-reset period), suggesting low-credit-limit consumers may have a higher marginal propensity to consume than high-credit-limit consumers.

Column 2 shows no debt response in either group of consumers. In column 3, we find a significant delinquency-rate response among low-credit-limit mortgagors, but only during the post-reset period. The delinquency-rate response among the high-credit-limit mortgagors, on the other hand, is economically small and statistically insignificant. The difference in the delinquency response between the low- and high-credit-card-limit mortgagors was statistically significant in the post-reset period ($p<0.05$), suggesting the disposable income generated due to the monetary shock significantly enhanced the financial condition of the credit-constrained consumers.

[Insert Table 8 here]

6.3 Heterogeneous response across consumers: The role of cash-on-hand constraints

We then investigate the spending and debt response among consumers with another type of financial constraint: the cash-on-hand constraint. The extant theoretical literature has shown cash-on-hand-constrained consumers may have a higher marginal propensity to consume (e.g., Kaplan and Violante (2014)). In addition, the lack of cash on hand makes these constrained consumers less able to exploit the anticipated positive income shock during the announcement period. Therefore, their spending response should be concentrated during the post-reset period. Although we cannot observe a consumer's entire balance sheet, we can infer his/her cash-on-hand-constraint level based on the credit-card-usage information in our dataset. Consumers who accumulated a significant amount of credit card debt presumably faced binding cash-on-hand constraints given the high costs of this credit-access instrument. Therefore, we classify a consumer as cash-on-hand constrained if his/her average debt-to-income ratio during the six-month pre-event period was in the top decile of the sample distribution.[14]

The results are reported in Table 9, based on the unmatched sample from March 2008 to June 2009. The coefficient estimates on "$Mortgage \times 1_{announce} \times CoH\ constrained$" and "$Mortgage \times 1_{reset} \times CoH\ constrained$" capture the response of the cash-on-hand-constrained mortgagors relative to the cash-on-hand-constrained owners without mortgage obligations, respectively, during the announcement and the post-reset period. "$Mortgage \times 1_{announce} \times CoH\ unconstrained$" and "$Mortgage \times 1_{reset} \times CoH\ unconstrained$" captures the response of the less cash-on-hand-constrained mortgagors relative to the less cash-on-hand-constrained owners without mortgage obligations, respectively, during the announcement and the post-reset period.

We first note the magnitude of the spending response among cash-on-hand-constrained mortgagors is significantly larger than that of the less constrained mortgagors, especially during the post-reset period. Specifically, cash-on-hand-constrained mortgagors increased their credit card spending by 31.9% per month during the post-reset period, relative to cash-on-hand-constrained owners without mortgage obligations. The spending response among less constrained mortgagors during the post-reset period is only 4.7% and statistically insignificant. A formal F-test shows the difference between the two coefficient estimates is statistically significant at the 1% level. This finding suggests cash-on-hand-constrained consumers may have a higher marginal propensity to consume than less cash-on-hand-constrained consumers.

Second, the timing of the spending response differs between cash-on-hand-constrained and less constrained mortgagors. For less constrained mortgagors, the spending response during the announcement period is statistically significant, with a magnitude comparable to that during the post-reset period, indicating their ability to increase their spending even before the disbursement of the disposable income. For constrained mortgagors, the spending response is statistically significant only after the disbursement of the liquidity. The coefficient on "$Mortgage \times 1_{reset} \times CoH$

[14] Unlike in section 6.1 or 6.2, where we use the bottom quartile as the cutoff point, here we do not use the top quartile as the cutoff point because the corresponding debt-to-(monthly) income ratio is too low (8%) to capture cash-on-hand-constrained consumers. That said, our results remain qualitatively the same if we use the top 15th percentile or the top 20th percentile as the cutoff point.

constrained" is also 3.2 times larger than that on "*Mortgage*×$1_{announce}$×*CoH constrained*." A formal F-test shows the two estimates are significantly different at the 1% level. The lack of an announcement effect among cash-on-hand-constrained mortgagors suggests these consumers have difficulty fully exploiting the anticipated positive income shock before they receive the liquidity.

In column 2, we find some weak evidence of credit-card-debt response among cash-on-hand constrained consumers, but the estimates are statistically insignificant. Specifically, they slightly increased their debt levels during the announcement period, but seemed to pay off their debt after they receive the disposable liquidity. Column 3 shows that both groups of consumers decreased their probability of credit card delinquency after the disbursement of disposable income.

[Insert Table 9 here]

6.4 Credit constraints versus cash-on-hand constraints: Which is more important?

So far, we have shown that spending response is stronger among credit-constrained or cash-on-hand constrained consumers. We now turn to assess the relative importance of the two financial constraints in understanding the spending response.

We divide all the consumers based on their credit-limit and cash-on-hand-constraint levels into four groups. As Table 10 shows, consumers are first classified into a low-credit-limit group (column 1) and a high-credit-limit group (column 2). Within each credit limit group, we examine the spending responses for the cash-on-hand-constrained and cash-on-hand-unconstrained consumers, respectively.

We find consumers constrained by both credit access and cash-on-hand liquidity have the strongest spending response. In addition, mortgagors constrained only by cash-on-hand liquidity (i.e., high-credit-limit consumers with cash-on-hand constraints) and mortgagors constrained only by credit access (i.e., low-credit-limit consumers without cash-on-hand constraints) are both strongly responsive to the positive income shock. Specifically, mortgagors constrained only by cash-on-hand liquidity increased their credit card spending by 23.1% per month during the post-reset period, relative to owners without mortgage obligations who were constrained only by cash-on-hand liquidity. The fact that consumers who were cash-on-hand constrained had a strong spending response even if they had ample credit access suggests ignoring cash-on-hand constraints may significantly understate the MPC to income shocks. Mortgagors constrained only by credit access increased their credit card spending by 10.5% per month during the announcement period, but experienced no significant spending response after the mortgage rate reset.

We then compare the role of credit constraints and cash-on-hand constraints in driving the spending response. Specifically, we compare the cumulative spending response throughout the 10 months after the policy announcement among mortgagors constrained only by cash-on-hand

liquidity (i.e., high-credit-limit consumers with cash-on-hand constraints) and mortgagors constrained only by credit access (i.e., low-credit-limit consumers without cash-on-hand constraints). We find the cumulative spending response throughout the announcement and reset periods among mortgagors constrained only by cash on hand is 167.4% ($4\times Mortgage\times 1_{announce}\times constrained + 6\times Mortgage\times 1_{announce}\times constrained$ in column 2). The cumulative spending response among mortgagors constrained only by credit access, on the other hand, is 84.6% ($4\times Mortgage\times 1_{announce}\times unconstrained + 6\times Mortgage\times 1_{announce}\times unconstrained$ in column 1). The difference in the cumulative spending response between these two groups of mortgagors is 82.8%, or equivalently, 8.3% per month. Although statistically insignificant (p=0.344), the magnitude of the difference is large, suggesting cash-on-hand constraints play a more important role in driving the spending response.

[Insert Table 10 here]

6.5 Heterogeneous response: By spending categories

The extant literature documents a heterogeneous consumption response among different consumption categories (e.g., Agarwal and Qian, 2014). Taking advantage of the credit-card-transaction information in our dataset, which provides the Merchant Category Code of each transaction, we classify spending into discretionary versus non-discretionary spending and durable versus non-durable spending.[15] Results are shown in Table 11. Consistent with Agarwal and Qian (2014), we find the spending response is mainly driven by discretionary spending (column 1): The discretionary spending of mortgagors increased by 4.1% and 7.9%, respectively, during the announcement and post-reset period, relative to that of owners without mortgage obligations. The estimates on non-discretionary spending, on the other hand, are economically smaller and statistically insignificant (column 2). Columns 3 and 4 show the results for durable versus non-durable goods. We find the spending response is mainly driven by spending on non-durables (column 4): The non-durable spending of mortgagors increased by 5.1% and 6.4%, respectively, during the announcement and post-reset period, relative to that of owners without mortgage obligations. The estimates on durable spending, on the other hand, are economically smaller and statistically insignificant (column 3).

[Insert Table 11 here]

[15] Similar to Agarwal, Qian, and Zou (2017), non-discretionary spending includes spending on "local conveyance & taxi," "supermarkets," "food & beverage stores," "utilities," "fuel," and "government," and the rest is defined as discretionary spending. The average proportion of non-discretionary spending is 18.5%, suggesting a discretionary spending proportion of 81.5%.

6.6 More robustness checks

To cleanly identify the treatment effect of the monetary policy, we conducted propensity-score matching based on a series of demographic characteristics as a robustness check. However, the treatment and control may be different in other unobservable dimensions, for instance, the intertemporal rate of substitution. If mortgagors have a higher intertemporal rate of substitution, their spending response would also be stronger in the absence of the cash-flow channel. However, the decrease in the delinquency rate in the treatment group is at odds with the prediction of the intertemporal substitution effect: If consumers increase current spending due to the intertemporal substitution channel, the delinquency rate should increase or at least remain constant. The decrease in the delinquency rate corroborates that the disposable income due to the monetary policy shock significantly improved the financial condition of mortgagors and helped them avoid costly default.

Following an interest rate cut, banks likely expand the supply of credit, thereby stimulating consumption (Bernanke and Gertler, 1995). As shown by Agarwal et al. (2017b), banks pass through credit expansions differently for consumers with different characteristics. The credit-supply channel of monetary policy transmission might contaminate our result if mortgagors were granted higher credit card limits after the monetary shock. In Table A3, we evaluate the change in the credit card limit of mortgagors around the monetary policy shock relative to owners without mortgage obligations and find no evidence of a disproportionate increase in credit limits among mortgagors after the shock.

One may also worry that compared with owners without mortgage obligations, mortgagors are more inclined to use credit cards after the shock, which may confound the interpretation of our result. However, the change in credit-card-spending frequency after the shock is statistically insignificant (see Table A4). The estimated coefficient (0.025) is economically negligible, given the average monthly frequency of credit card usage during the pre-shock period of 3.68. Therefore, our results are unlikely to be explained by the differential inclination of credit card usage after the shock.

VII. Conclusion

Using a unique, new panel dataset of credit card information of over 22 million credit card accounts from a leading commercial bank in China, this paper investigates how monetary policy affects household consumption through the debt-service channel. From September to December 2008, the People's Bank of China decreased the benchmark mortgage interest rates by 230 bps, which reduces the monthly mortgage payments of the population of mortgagors in China after the beginning of 2009—the mortgage rate reset day.

Using a difference-in-differences analysis, we find that compared with owners without mortgage obligations, mortgagors increased their monthly credit card spending by 7.2% after the mortgage interest rate was reset. Importantly, we observe an equally strong spending response after the policy announcement but before the disbursement of the disposable income. The announcement effect we document emphasizes the potential underestimation of policy response estimated from settings without a well-defined announcement date. We also find the spending response is stronger among consumers with lower credit limits or cash-on-hand constraints. Interestingly, consumers who are cash-on-hand constrained have a strong consumption response even if they have ample credit access, suggesting that ignoring cash-on-hands constraints may significantly understate MPC to income shocks. Spending rose primarily in the discretionary or non-durable spending. In addition, the credit card delinquency rate also decreased among mortgagors but only after the disbursement of the liquidity. The delinquency response suggests our results cannot be explained by a value increase of illiquid assets—such as through housing wealth increase or via revaluation of nominal mortgage liabilities—after the monetary policy shock, since illiquid wealth is hard to be liquidated to meet the credit-card payment obligations.

The spending response was not driven by consumers from cities that witnessed higher house-price appreciation, suggesting our findings are unlikely to be explained by the confounding wealth effect. We also find our results cannot be explained by the contemporaneous fiscal policy shock, by the intertemporal substitution effect of monetary shock, by more favorable credit expansion to the treatment group, or by the treatment group's increased inclination to use credit cards during the post-shock period. Subsequent to an interest-rate-increase episode, we find a symmetric effect: Consumers reduced their credit card spending while accumulating a greater amount of credit card debt. Taken together, our results highlight the important role of the debt-service channel of monetary policy transmission. Our estimate indicates a significant MPC of 0.40-0.51 through credit card spending, which is likely a lower bound of the overall consumption response.

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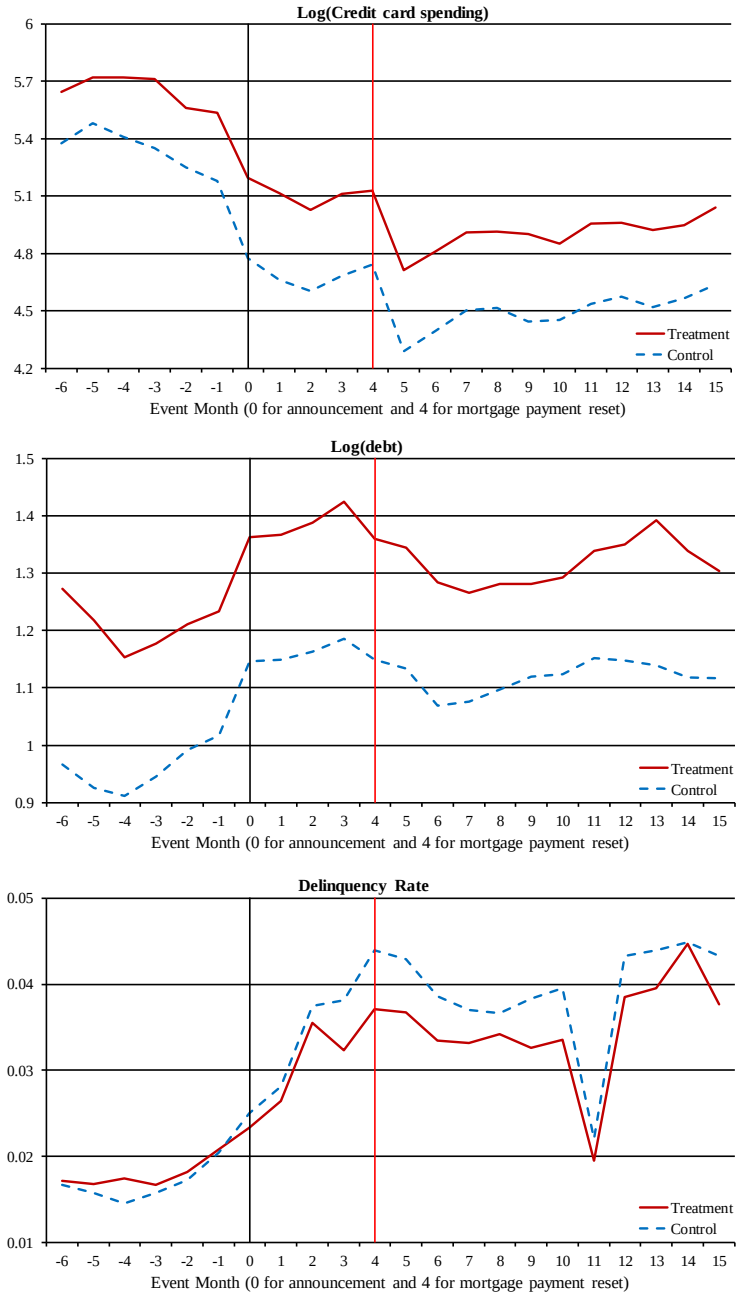
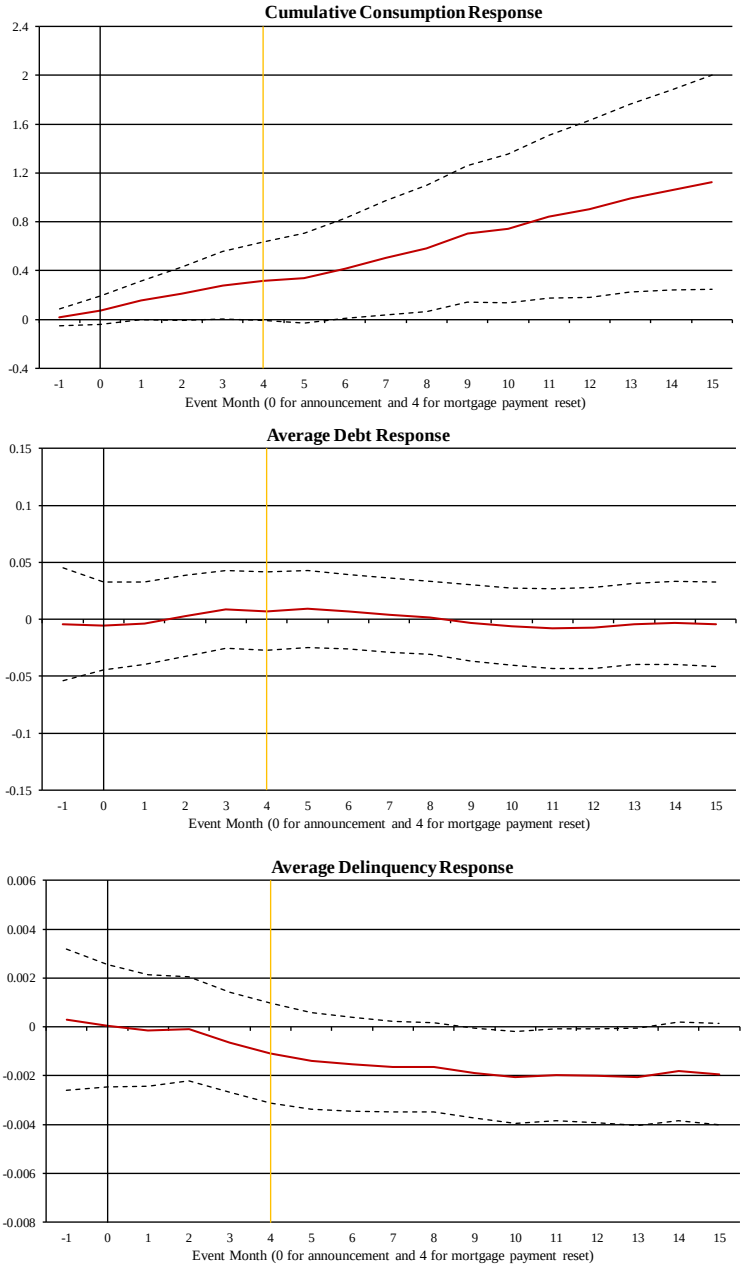
FIGURE 1. UNCONDITIONAL MEAN OF CREDIT CARD SPENDING, DEBT, AND DELINQUENCY RATE SURROUNDING THE MONETARY POLICY SHOCK



This figure shows the unconditional means of the logarithm of credit card spending, of the logarithm of credit card debt, and of the delinquency rate of the treatment and control group during the period of March 2008–December 2009, based on the unmatched full sample. The *x*-axis denotes the s^{th} month after the announcement of September 2008 monetary policy shock.

FIGURE 2. ESTIMATED CREDIT CARD SPENDING, DEBT, AND DELINQUENCY RATE RESPONSE DYNAMICS



This figure shows the dynamics of the cumulative response in credit card spending, credit card debt, and delinquency rate based on the unmatched full sample. The x-axis denotes the s^{th} month after the announcement of the September 2008 monetary policy shock. For spending, each point on the red line shows the cumulative coefficient of treatment effect b_s as estimated from equation (2). For debt and delinquency, each point on the red line shows the average coefficient of treatment effect $\bar{\beta}_s$ as estimated from equation (2). The dashed lines show the corresponding 95% confidence intervals.

TABLE 1. —SUMMARY STATISTICS

	Mortgagor (Treatment)		Outright homeowner (Control)	
Variable	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)
Age	34.1	6.5	37.0	7.7
# of dependents	0.43	0.8	0.64	0.8
Married (%)	83.8	36.9	90.3	30.0
Credit limit	18,173	33,524	15,009	27,234
Credit card spending	2,981	5,423	2,701	5,437
Debt	545	1,876	382	1553
Delinquency	0.018	0.133	0.017	0.129
# of consumers	7,514		39,384	

This table reports the summary statistics of our treatment and control sample during the six-month pre-event window (2008:03 – 2008:08). The treatment sample consists of homeowners with mortgage obligations, and the control sample consists of homeowners who have paid off their mortgages. We restrict our sample to the consumers from the top 250 cities in our sample. We exclude inactive credit card users—individuals with no monthly spending for at least half of the sample period as of the month before the event time—August 2008 (e.g., for two months if the individual entered our sample in May 2008), and individuals who entered our sample later than the event time or quit our sample before the event time. We also exclude individuals older than 65 or younger than 25 as of August 2008. *Credit limit* is defined as the maximum credit limit among all the credit limits of each individual's credit cards, as of August 2008. *Credit card spending* is computed by adding monthly credit card spending over all credit card accounts for each individual. *Debt* is computed by adding credit card debt (defined as the previous month's account balance minus the current month's credit card payment) over all credit card accounts of each individual, with negative values replaced by zero. *Delinquency* is a dummy variable equal to 1 if the consumer is 60 days past due on any of his/her credit card account. *Credit limit, credit card spending, and debt* are winsorized at the 1% and 99% levels. Significant at *** 1%, **5%, and *10%.

TABLE 2. —DIFFERENCE IN DIFFERENCES TEST RESULTS: UNIVARIATE

	(1) Pre-shock	(2) Post-shock	(3) Diff.	(4) DID estimator
Log(credit card spending)				
Treatment	5.764	4.924	-0.841***	0.100***
Control	5.446	4.505	-0.941***	(3.50)
Log(debt)				
Treatment	1.060	1.321	0.261***	-0.015
Control	0.841	1.117	0.276***	(-0.75)
Delinquency				
Treatment	0.015	0.033	0.018***	-0.006***
Control	0.014	0.037	0.024***	(-3.69)

This table reports the DID test results, based on the unmatched full sample. The pre-shock period consists of the six months before the monetary policy announcement (i.e., March 2008–August 2008). The post-shock period consists of 10 months after the announcement of the monetary policy (i.e., September 2008–June 2009). For each individual, we respectively calculate the pre-shock-period and post-shock-period means of credit card spending, debt (both in logarithmic form), and delinquency status, and calculate each individual's difference using his/her post-shock-period mean minus pre-shock-period mean. We then take the average among individuals in the treatment group and control group, respectively. Refer to Table 1 for definitions of the variables. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 3. —THE AVERAGE CREDIT CARD SPENDING, DEBT, AND DELINQUENCY RESPONSE

	(1) Log(credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{announce}$	0.067*	0.011	-0.001
	(1.85)	(0.48)	(-0.91)
Mortgage $\times 1_{reset}$	0.072**	-0.014	-0.003**
	(2.35)	(-0.57)	(-2.41)
Fixed effects	Individual, city×year-month		
# of individual	46,892	46,892	46,892
Observations	677,052	677,052	677,052
R^2	0.321	0.500	0.297

This table shows the average credit-card-spending, debt, and delinquency response to the monetary policy announced on September 15, 2008, based on the unmatched full sample from March 2008 to June 2009. "*Mortgage*" is a dummy that equals to 1 for homeowners with mortgage obligations, and 0 for homeowners who have paid off their mortgage. "$1_{announce}$" is a dummy that equals 1 for the months after the announcement of the benchmark rate reduction and before the mortgage rate adjustment (i.e., September 2008–December 2008). "1_{reset}" is a dummy that equals 1 for the months after mortgage rates were reset (i.e., ≥January 2009). March 2008 to August 2008 are absorbed as the benchmark. Individual and city×year-month fixed effects are included. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 4. — THE AVERAGE RESPONSE: A LONGER POST-EVENT WINDOW

	(1) Log(credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{announce}$	0.062*	0.013	-0.001
	(1.72)	(0.58)	(-0.65)
Mortgage $\times 1_{reset}$	0.067**	-0.009	-0.003*
	(2.09)	(-0.36)	(-1.70)
Fixed effects	Individual, city×year-month		
# of individual	46,892	46,892	46,892
Observations	939,092	939,092	939,092
R^2	0.326	0.491	0.313

This table shows the average credit-card-spending, debt, and delinquency response to the monetary policy announced on September 15, 2008, based the unmatched full sample from March 2008 to December 2009. 1_{reset} is a dummy that equals 1 for the months after mortgage rates were reset (i.e., January 2009–December 2009). Refer to Tables 1 and 3 for definitions of other variables. March 2008 to August 2008 are absorbed as the benchmark. Individual and city×year-month fixed effects are included. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 5. —TESTING THE PARALLEL-TRENDS ASSUMPTION AND THE MATCHED-SAMPLE EVIDENCE

	(1) Log(credit card spending)	(2) Log(debt)	(3) Delinquency
Panel A: Unmatched full sample			
Mortgage $\times 1_{pre}$	0.022	-0.006	-0.000
	(0.52)	(-0.21)	(-0.10)
Mortgage $\times 1_{announce}$	0.071*	0.009	-0.001
	(1.91)	(0.40)	(-0.93)
Mortgage $\times 1_{reset}$	0.077**	-0.015	-0.003**
	(2.26)	(-0.60)	(-2.30)
Fixed effects	Individual, city×year-month		
# of individual	46,892	46,892	46,892
Observations	677,052	677,052	677,052
R^2	0.326	0.491	0.313
Panel B: Matched sample			
Mortgage $\times 1_{pre}$	0.014	-0.026	-0.002
	(0.29)	(-0.67)	(-1.02)
Mortgage $\times 1_{announce}$	0.095**	0.005	-0.002
	(2.01)	(0.18)	(-0.97)
Mortgage $\times 1_{reset}$	0.101***	-0.018	-0.005**
	(2.62)	(-0.63)	(-2.48)
Fixed effects	Individual, city×year-month		
# of individual	15,015	15,015	15,015
Observations	218,313	218,313	218,313
R^2	0.328	0.533	0.301

This table shows the average credit card spending, debt, and delinquency response to the monetary policy announced on September 15, 2008. The results in Panels A and B are based on the unmatched full sample and matched sample, respectively, from March 2008 to June 2009. "*Mortgage*" is a dummy that equals to 1 for homeowners with a mortgage, and 0 for homeowners who have paid off their mortgage. "1_{pre}" is a dummy that equals 1 for the one month immediately before the announcement of the monetary policy (i.e., August 2008). "$1_{announce}$" is a dummy that equals 1 for the months after the announcement of benchmark rate reduction and before the mortgage rate adjustment (i.e., September 2008–December 2008). "1_{reset}" is a dummy that equals 1 for the months after mortgage rates are reset (i.e., ≥January 2009). March 2008 to July 2008 are absorbed as the benchmark. Individual and city×year-month fixed effects are included. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 6. — RESPONSE TO AN INTEREST RATE INCREASE

	(1) Log(credit card spending)	(2) Log(debt)	(3) Log(credit card spending)	(4) Log(debt)
Mortgage $\times 1_{announce\_decrease}$	0.061*	0.015		
	(1.71)	(0.69)		
Mortgage $\times 1_{reset\ decrease}$	0.083***	-0.015		
	(2.84)	(-0.52)		
Mortgage $\times 1_{announce\_increase}$	0.004	-0.039	-0.037	-0.021
	(0.09)	(-1.36)	(-1.18)	(-0.93)
Mortgage $\times 1_{2011}$	-0.023	0.047	-0.062**	0.063
	(-0.57)	(0.97)	(-2.16)	(1.61)
Mortgage $\times 1_{2012}$	-0.079*	0.219***	-0.121***	0.224***
	(-1.83)	(3.13)	(-3.40)	(3.83)
Fixed effects		Individual, city×year-month		
# of individuals	46,892	46,892	42,455	42,455
Observations	2,066,143	2,066,143	999,119	999,119
R^2	0.323	0.323	0.435	0.528

This table shows the average credit card spending and debt response to the monetary policy announced on October 20, 2010, based on the unmatched full sample. The sample period of columns 1-2 is from March 2008 to June 2012; the sample period of columns 3-4 is from April 2010 to June 2012. $1_{announce\text{-}decrease}$ is a dummy that equals 1 for the months after the announcement of the interest rate decrease and before the mortgage rate adjustment (i.e., September 2008–December 2008). $1_{reset\text{-}decrease}$ is a dummy that equals 1 for the months after mortgage rates were reset but before the announcement of the next round of monetary policy change (i.e., January 2009–September 2010). $1_{announce\text{-}increase}$ is a dummy that equals 1 for the months after the announcement of the interest increase and before the mortgage rate adjustment (i.e., October 2010–December 2010). 1_{2011} is a dummy that equals 1 for the 12 months throughout 2011, and 1_{2012} equals 1 for months after January 2012. In columns 1-2, March 2008 to August 2008 are absorbed as the benchmark; in columns 3-4, April 2010 to September 2010 are absorbed as the benchmark. Individual and city×year-month fixed effects are included. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 7. — HETEROGENEITY ANALYSIS: HIGH- VERSUS LOW-MORTGAGE-DEBT-BURDEN CONSUMERS

	(1) Log (credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{announce} \times$ high mortgage debt burden	0.060	0.108**	-0.007
	(1.25)	(2.09)	(-0.84)
Mortgage $\times 1_{reset} \times$ high mortgage debt burden	0.189***	-0.171***	-0.016***
	(7.22)	(-8.09)	(-3.47)
Mortgage $\times 1_{announce} \times$ low mortgage debt burden	0.068*	0.005	-0.001
	(1.84)	(0.21)	(-0.63)
Mortgage $\times 1_{reset} \times$ low mortgage debt burden	0.065*	-0.005	-0.003*
	(1.95)	(-0.21)	(-1.79)
Observations	677,052	677,052	677,052
R^2	0.321	0.500	0.297

This table shows the credit-card-spending, debt, and delinquency-response heterogeneity among individuals with different levels of mortgage debt burden. The results are based on the unmatched full sample from March 2008 to June 2009. We respectively interact the main effect with the "high mortgage debt burden" dummy equal to 1 if a consumer was from a first-tier city and was in the bottom quartile of the age distribution among mortgagors (i.e., under 30), and the "*low mortgage debt burden*" dummy equal to 1 minus the "*high mortgage debt burden*" dummy. Refer to Table 3 for definitions of variables. In all regressions, we include the individual fixed effects and the city×year-month fixed effects interacting with the "*high mortgage debt burden*" dummy. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 8. — HETEROGENEITY ANALYSIS: HIGH- VERSUS LOW-CREDIT-LIMIT CONSUMERS

	(1) Log (credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{announce} \times$ low credit limit	0.091**	-0.014	-0.002
	(2.15)	(-0.36)	(-0.71)
Mortgage $\times 1_{reset} \times$ low credit limit	0.103**	-0.019	-0.009***
	(2.28)	(-0.41)	(-2.73)
Mortgage $\times 1_{announce} \times$ high credit limit	0.050	0.023	-0.001
	(0.94)	(0.83)	(-0.72)
Mortgage $\times 1_{reset} \times$ high credit limit	0.044	-0.006	-0.000
	(1.08)	(-0.23)	(-0.09)
Observations	676,890	676,890	676,890
R^2	0.321	0.500	0.298

This table shows the credit-card-spending, debt, and delinquency-response heterogeneity among individuals with different credit-card-limit levels. The results are based on the unmatched full sample from March 2008 to June 2009. We respectively interact the main effect with the "*low credit limit*" dummy equal to 1 if a consumer's credit limit was below the bottom quartile of the credit-card-limit distribution within the city, and the "*high credit limit*" dummy equal to 1 minus the "*low credit limit*" dummy. Refer to Table 3 for definitions of variables. In all regressions, we include the individual fixed effects and the city×year-month fixed effects interacting with the "*low credit limit*" dummy. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 9. — HETEROGENEITY ANALYSIS: THE ROLE OF CASH-ON-HAND CONSTRAINTS

	(1) Log (credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{announce} \times$ CoH constrained	0.076	0.038	-0.011
	(0.75)	(0.38)	(-1.17)
Mortgage $\times 1_{reset} \times$ CoH constrained	0.319***	-0.079	-0.014*
	(3.36)	(-0.75)	(-1.73)
Mortgage $\times 1_{announce} \times$ CoH unconstrained	0.070*	0.016	-0.001
	(1.83)	(0.67)	(-1.15)
Mortgage $\times 1_{reset} \times$ CoH unconstrained	0.047	0.013	-0.003**
	(1.47)	(0.52)	(-2.14)
Observations	676,456	676,456	676,456
R^2	0.322	0.507	0.312

This table shows the average credit card spending, debt and delinquency response grouped by cash-on-hand constraints. The results are based on the unmatched full sample from March 2008 to June 2009. We respectively interact the main effect with a dummy "*CoH constrained*" equal to 1 if a consumer is cash-on-hand constrained, and a dummy "*CoH Unconstrained*" equal to 1 minus the "*CoH constrained*" dummy. The "*CoH constrained*" dummy is equal to 1 if the consumer's average debt-to-income ratio during the six-month pre-event period was in the top decile of the sample distribution. Refer to Table 3 for definitions of variables. In all regressions, we include the individual fixed effects and the city×year-month fixed effects interacting with the "*CoH constrained*" dummy. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 10. — CREDIT ACCESS VERSUS CASH-ON-HAND CONSTRAINTS: WHICH IS MORE IMPORTANT?

	Log(credit card spending)	
	Low credit limit	High credit limit
	(1)	(2)
Mortgage $\times 1_{announce} \times$ CoH constrained	0.060	0.072
	(0.43)	(0.50)
Mortgage $\times 1_{reset} \times$ CoH constrained	0.438***	0.231*
	(2.96)	(1.65)
Mortgage $\times 1_{announce} \times$ CoH unconstrained	0.105**	0.046
	(2.21)	(0.85)
Mortgage $\times 1_{reset} \times$ CoH unconstrained	0.071	0.023
	(1.55)	(0.53)
Observations	259,556	415,791
R^2	0.312	0.321

This table shows the average credit card spending and debt response grouped by cash-on-hand constraints and credit limit. The results are based on the unmatched full sample from March 2008 to June 2009. In column 1, we restrict the sample to low-credit-card-limit consumers (i.e., consumers with credit card limits lower than the bottom quartile of the credit-card-limit distribution within the city); in column 2, we restrict the sample to high-credit-card-limit consumers (i.e., consumers with credit card limits equal to or higher than the bottom quartile of the credit-card-limit distribution within the city). We respectively interact the main effect with a dummy "*CoH constrained*" equal to 1 if a consumer is cash-on-hand constrained, and a dummy "*CoH unconstrained*" equal to 1 minus the "*CoH constrained*" dummy. A consumer is classified as cash-on-hand constrained if the consumer's average debt-to-income ratio during the six-month pre-event period was in the top decile of the sample distribution. Refer to Table 3 for definitions of variables. In both regressions, we include the individual fixed effects and the city×year-month fixed effects interacting with the "*CoH constrained*" dummy. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE 11. —HETEROGENEITY IN SPENDING RESPONSE: BY SPENDING CATEGORIES

	(1) Discretionary	(2) Non-discretionary	(3) Durable	(4) Nondurable
Mortgage $\times 1_{announce}$	0.041	0.033	0.009	0.051
	(0.96)	(1.36)	(0.36)	(1.34)
Mortgage $\times 1_{reset}$	0.079**	0.018	0.013	0.064*
	(2.58)	(0.59)	(0.61)	(1.89)
Fixed effects	Individual, city×year-month			
# of individuals	46,298	46,298	46,298	46,298
Observations	641,569	641,569	641,569	641,569
R^2	0.333	0.347	0.213	0.327

This table shows the average discretionary, non-discretionary, durable, and non-durable credit-card-spending response of the monetary policy announced on September 15, 2008, based on the unmatched full sample from March 2008 to June 2009. Non-discretionary spending includes spending on "local conveyance & taxi," "supermarkets," "food & beverage stores," "utilities," "fuel," and "government," and the rest are defined as discretionary spending. Individual and city×year-month fixed effects are included. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

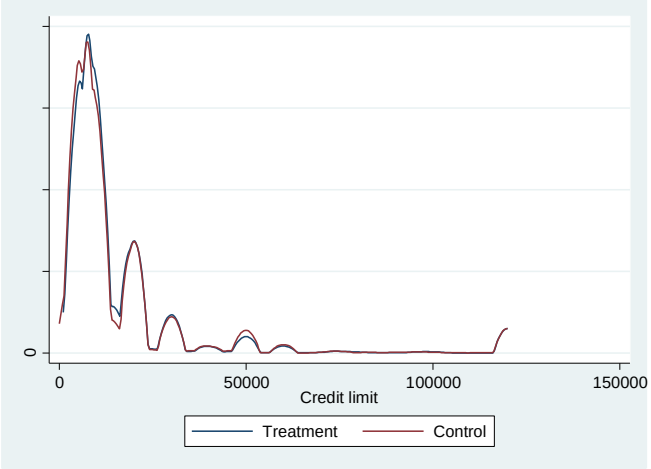
INTERNET APPENDIX

FOR

NOT INTENDED FOR PUBLICATION

FIGURE A1. —KERNEL DENSITY PLOTS FOR THE MATCHED SAMPLE

Panel A, Credit limit as of August 2008



Panel B, Age as of August 2008

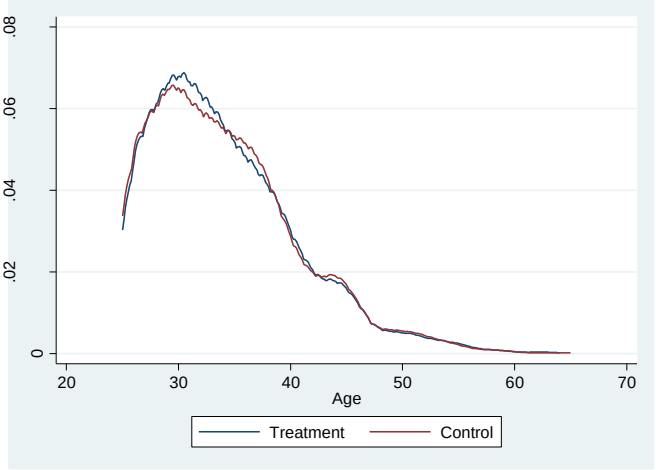


Figure A1 compares the distribution of the continuous matching variables in the treatment group and the control group, after the propensity score matching. Panel A and B respectively compare the distribution of credit card limit and age, based on the latest updated information before the announcement of the 2008 interest rate reduction.

FIGURE A2. —AVERAGE HOUSING PRICE INDEX AROUND THE EVENT

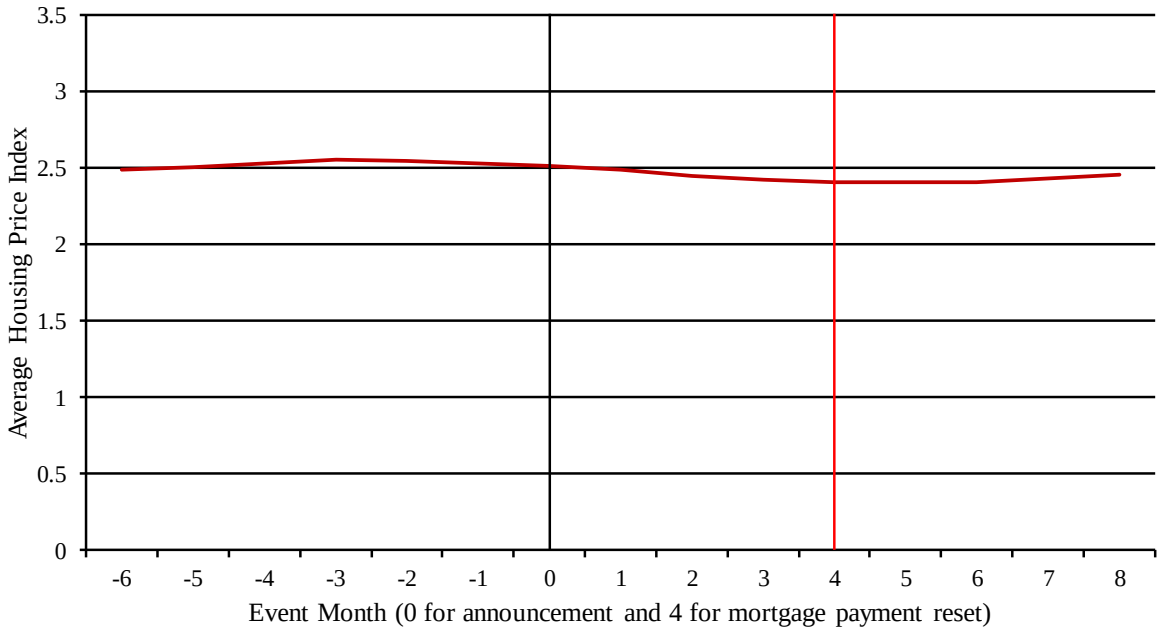


Figure A2 shows the trend of the average house-price index around the event, based on the house-price indices estimated by Fang et al. (2015). Specifically, for each month, we calculate the average house-price indices across all the cities, weighted by the number of consumers in each city from our unmatched full sample. The x-axis denotes the s^{th} month after the announcement of the September 2008 monetary policy shock.

TABLE A1. —PROPENSITY SCORE MATCHING LOGISTIC REGRESSION

Panel A: Matching logistic regression

	Mortgagor
Credit limit	0.000***
	(2.58)
Credit limit, quadratic	-0.000**
	(-2.01)
Age	0.023
	(1.36)
Age, quadratic	-0.001***
	(-4.91)
# of dependents	-0.259***
	(-6.56)
# of dependents, quadratic	0.064***
	(4.84)
Married	-0.039
	(-0.97)
Fixed Effects	City
Observations	46,082
Pseudo R-squared	0.107

Panel B: Post-matching characteristics

	Matched Treatment		Matched Control		Diff.
Age	34.1	6.5	34.0	6.4	-0.1
# of dependents	0.43	0.8	0.41	0.7	-0.02*
Married (%)	83.8	36.9	84.4	36.0	0.7
Credit limit	18,173	33,524	18,401	34,049	-228
# of consumers	7,514		7,514		

Panel A of this table shows the result of the propensity score matching logistic regression. The dependent variable is equal to one for individuals in the treatment group (i.e., homeowners with mortgage obligations), and equal to zero for individuals in the control group (i.e., homeowners who have paid off their mortgage). In addition to the explanatory variables above, we also control for the city fixed effects. T-statistics are reported in parentheses under the coefficient estimates. Panel B reports the summary statistics of our matched treatment and control sample. We restrict our sample to the consumers from the top 250 cities in our sample. We exclude dormant individuals who are inactive—individuals with no monthly spending for at least half of the sample period as of the month before the event time—August 2008 (e.g., for two months if the individual entered our sample in May 2008), and individuals who are not treated—individuals who enter our sample later than the event time or quit our sample before the event time. We also exclude individuals older than 65 or younger than 25 as of 2008. Significant at *** 1%, **5%, and *10%.

TABLE A2. — ADDITIONAL ROBUSTNESS ANALYSIS

	(1) Log(credit card spending)
Panel A: Heterogeneity across cities	
Mortgage $\times 1_{announce} \times$ High appreciation	-0.038
	(-0.79)
Mortgage $\times 1_{reset} \times$ High appreciation	0.078
	(1.16)
Mortgage $\times 1_{announce} \times$ Low appreciation	0.098***
	(2.63)
Mortgage $\times 1_{reset} \times$ Low appreciation	0.071**
	(2.03)
Observations	677,052
R^2	0.321
Panel B: Heterogeneity across economic sectors	
Mortgage $\times 1_{announce} \times$ SOE	-0.053
	(-0.39)
Mortgage $\times 1_{reset} \times$ SOE	0.074
	(0.55)
Mortgage $\times 1_{announce} \times$ Non- SOE	0.073**
	(2.04)
Mortgage $\times 1_{reset} \times$ Non- SOE	0.072**
	(2.38)
Observations	676,204
R^2	0.321

This table shows the average credit-card-spending, debt and delinquency-response heterogeneity among individuals from different cities (shown in panel A) or different economic sectors (shown in panel B). The results are based on the unmatched sample from March 2008 to June 2009. In panel A, we respectively interact the main effect with a dummy "*high appreciation*", and a dummy "*low appreciation*" equal to 1-"*high appreciation*". "*high appreciation*" equals 1 for cities whose house-price appreciation between January 2003 and August 2008 is in the top decile according to the house-price index by Fang et al. (2015). In panel B, we respectively interact the main effect with a dummy "*SOE*" equal to 1 if the consumer is an employee of a state-owned-enterprise, and a dummy "*Non- SOE*" equal to 1-"*SOE*". In both regressions, we include the individual fixed effects and the city×year-month fixed effects interacting with the "*high appreciation*" (in panel A) or "*SOE*" dummy (in panel B). Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE A3. — SUPPLY OF CREDIT TO CONSUMERS AROUND THE SHOCK

	Log (credit limit)
Mortgage $\times 1_{announce}$	-0.002
	(-1.13)
Mortgage $\times 1_{reset}$	-0.005
	(-1.31)
Fixed effects	Individual, city×year-month
# of Individuals	46,892
Observations	677,052
R^2	0.968

This table shows the change in the credit card limit of mortgagors relative to owners without mortgage obligations around the monetary policy announced on September 15, 2008, estimated according to equation (1) based on the unmatched full sample from March 2008 to June 2009. The dependent variable is log (1+credit card limit). "*Mortgage*" is a dummy that equals 1 for homeowners with mortgage obligations, and 0 for homeowners who have paid off their mortgage. "$1_{announce}$" is a dummy that equals 1 for the months after the announcement of the benchmark rate reduction and before the mortgage rate adjustment (i.e., September 2008–December 2008). "1_{reset}" is a dummy that equals 1 for the months after mortgage rates were reset (i.e., ≥January 2009). March 2008 to August 2008 are absorbed as the benchmark. Individual and city×year-month fixed effects are included. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.

TABLE A4. —THE FREQUENCY OF CREDIT CARD USAGE AROUND THE SHOCK

	Frequency of credit card spending
Mortgage $\times 1_{announce}$	-0.015
	(-0.44)
Mortgage $\times 1_{reset}$	0.025
	(0.51)
Fixed effects	Individual, city×year-month
# of Individuals	46,892
Observations	677,052
R^2	0.425

This table shows the change in credit-card-spending frequency of mortgagors relative to owners without mortgage obligations around the monetary policy announced on September 15, 2008, estimated according to equation (1) based on the unmatched full sample from March 2008 to June 2009. The dependent variable is the monthly frequency of credit card spending of a consumer. Refer to Table A3 for definitions of other variables. March 2008 to August 2008 are absorbed as the benchmark. Individual and city×year-month fixed effects are included. Standard errors are clustered at the city level. T-statistics are reported in parentheses under the coefficient estimates. Significant at *** 1%, **5%, and *10%.