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

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Abstract

Using a representative sample of credit card holders from a leading Chinese commercial bank, we investigate how consumers respond to an unexpected interest rate decrease that automatically reduces interest expenses for all mortgage borrowers in the country and thereby generates significant positive disposable-income shocks. Our difference-in-differences analysis shows that compared with homeowners without mortgage obligations, mortgage borrowers increased their monthly credit card spending by 8.6% 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, mortgage borrowers symmetrically reduced their credit card spending. Hand-to-mouth mortgage borrowers experienced a more pronounced spending increase, even among those with ample credit access. The debt-service channel plays an important role in transmitting monetary policy—our estimate implies a marginal propensity to consume (MPC) of 0.41-0.54 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; Ozdagli and Weber, 2018). 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, Kaplan, 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 (e.g., Jappelli and Pistaferri, 2010; Johnson, Parker and Souleles, 2006; Parker, Souleles, Johnson, and McClelland, 2013).

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 73.1% of the total household debt (source: Federal Reserve Bank of St. Louis and New York). An interest rate reduction can generate sizable disposable income to mortgage borrowers by reducing the cost of servicing the mortgage (Di Maggio et al., 2017). Traditional theories predict a weak consumption response, as mortgage borrowers 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, 2020). Despite holding sizable housing assets, mortgage borrowers may have low liquid assets due to high debt burden and hence live hand-to-mouth. Consequently, these consumers are responsive to changes in disposable income induced by changes in the mortgage-service cost, making it an important channel transmitting monetary policy.

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 does not easily generalize, and the endogenous refinancing choice of FRM mortgages introduces confounding interpretations (Andersen, Campbell, Nielsen, and Ramadorai, 2020). Second, monetary policy pass-through faces multiple frictions. Central banks typically adjust 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. Collectively, these limitations make it very difficult to quantify the consumption response and thus assess the aggregate impact of the debt service change induced by monetary policy shocks.

We use 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 35.9% mortgage rate cut.

Our setting has several advantages. First, mortgage borrowers in China face substantial financial burdens. Servicing the mortgage debt can consume as much as 35% of borrowers' household disposable income (Fang, Gu, Xiong, and Zhou, 2015; Li, Qin, and Wu, 2020), which is significantly larger than the average debt-to-income ratio of 25% in the U.S (Quigley and Raphael, 2004). Moreover, a low loan-to-value ratio of 62.6% for the average mortgage borrower in China (Shen and Yan, 2009), combined with an average price-to-household income ratio of over 5 (Fang et al., 2015), suggests that down payment consumes two times their annual household income at the time of house purchase and therefore significantly drains their liquid savings. Therefore, our setting allows us to study the role of wealthy hand-to-mouth consumers in monetary policy transmission. Second, all mortgages in China are ARMs. As a result, the interest rate decrease exogenously increases households' disposable income for the population of mortgage borrowers in China. In addition, 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 allows us to measure the precise change in mortgage rate that is transparent and applicable to all, which helps identify and quantify the aggregate impact. Third, the large interest rate reduction during the 2008 monetary policy implies a sizable decrease in mortgage borrowers' debt service cost, which offers a powerful test of the debt-service channel. We estimate that, on average, the additional monthly disposable income a mortgage borrower receives constitutes 8.3% to 12.7% of monthly income.[1] Moreover, the monetary policy had a clear and unanticipated announcement date, allowing us to

[1] Other household debt unlikely play significant role in our context, given a much smaller car loan market (< 4% of the total mortgage loan) and the fixed credit card interest rate scheme in China.

capture the announcement effect during the four months 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. 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 offers great power to identify the consumption and debt response to the monetary policy at the granular level. Detailed information on cardholder demographics also enables us to 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 mortgage borrowers benefit from a reduction in their mortgages' interest payment, whereas other households, especially owners without mortgage obligations, do not. 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. Our DID estimate allows us to control for the contemporaneous events that affect both the treatment and the control groups (e.g., the 4-trillion-yuan stimulus package and the surge of money supply in early 2009), as well as other interest rate cut transmission channels that both the treatment and the control groups are exposed to (e.g., labor and asset market effects). The city-specific year-month fixed effects can also control for the time-varying local labor market conditions as well as the local asset-valuation effects that are common to mortgage borrowers 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 mortgage borrowers' credit card spending both during the announcement period and in the post-mortgage-rate-reset period. During the announcement period, mortgage borrowers increased their monthly credit card

[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 76,817 per year, much higher than the per-capita disposable income of urban residents in 2008, which is RMB 15,780 per year.

spending by 7.9% more than homeowners without mortgage obligations did, and mortgage borrowers' monthly credit card spending in the post-mortgage-rate-reset period experienced a similar increase (by 8.6%). Given the average pre-event card spending of RMB 3,085 per month for the treatment group, the 2008 monetary policy change increased the credit card spending of an average mortgage borrower in our sample by RMB 244 (265) per month during the announcement period (post-reset period), which is equivalent to 2.8% (3.0%) of monthly income. We find an immediate card spending increase among mortgage borrowers following the policy announcement, and a persistently strong response throughout the entire expansionary monetary policy regime from September 2008 to September 2010. We further show the spending rose primarily in the discretionary category and non-durable goods.

We find no significant credit-card-debt response. On the other hand, the delinquency response is highly significant after the disbursement of the disposable liquidity. During the post-reset period, the credit card delinquency rate of mortgage borrowers decreased by 0.4% more than that of homeowners without mortgage obligations. This decrease is economically large, given the average delinquency rate of 1.7% 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 mortgage borrowers 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—using multiple approaches. We first show that the response before the policy announcement is economically negligible and statistically insignificant, which confirms the underlying identifying assumption of a parallel trend. Next, we match the treatment and the control groups using observable characteristics including credit limit, age, marital status, number of dependents, and city. The results based on the matched sample resemble those from the main analysis. Using another independent dataset, we further verify that mortgage borrowers and outright homeowners also have similar levels of financial assets, such as bank deposits, bonds, stocks, and mutual funds, after controlling for observable characteristics. Moreover, China's house prices experienced little change around the event window—based on the house-price index constructed by Fang et al. (2015)—suggesting that the housing-asset-valuation effect unlikely explains the consumption and debt response difference between the treatment group and the control group.

To further alleviate the concern that homeowners without mortgage obligations may differ from mortgage borrowers in other unobservable dimensions, we restrict to mortgage borrowers only and estimate the spending response by exploiting heterogeneity in the disposable income shock within the treatment group. For credit card users who also originated mortgage loans from our bank, we observe their detailed mortgage loan information, based on which we can back out the precise amount of the disposable income increase due to the interest rate cut. We find that for

each dollar of disposable income received from the reduction of the mortgage payment, mortgage borrowers on average spent 28.6 cents per month after the mortgage rate reset. Consistent with the main result, we also find an equally significant spending response during the announcement period.

Next, we investigate the effect of an interest rate 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 investigate the confounding effects of concurrent macro policies or trends. It also provides a setting 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, mortgage borrowers accumulated greater credit card debt following the interest rate increase. These results corroborate that our main findings are attributable to the monetary policy shock, since the general macro trends or policies between 2008-2009 persist throughout the 2010-2011 period as well. 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.

We then explore 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 mortgage borrowers is significantly stronger than that among less constrained mortgage borrowers. Importantly, the spending response among the cash-on-hand-constrained consumers is significant even when they have ample credit access, highlighting the distinct and incremental role of cash-on-hand constraints. In the subsample of mortgage borrowers for whom we observe the precise mortgage balance, we also exploit variation in their mortgage payment-to-income ratio and find corroborative evidence. For every dollar of debt reduction, we observe a stronger consumption increase (i.e., a greater MPC) among mortgage borrowers dedicating a higher fraction of their income to serving mortgage debt.

Our back-of-the-envelope calculation indicates a significant MPC out of the disposable income shock, ranging from 0.41 to 0.54, during the entire expansionary monetary policy regime. 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 estimate the aggregate credit card spending increase through the debt service channel during the expansionary monetary policy regime to be between RMB 49.2 billion and RMB 64.8 billion, equivalent to 0.14%-0.19% of China's GDP in 2009.

We conduct a series of additional analyses to investigate the results' robustness as well as alternative mechanisms. Based on the unmatched full sample, we investigate the heterogeneous response among mortgage borrowers with different levels of mortgage debt burden and find a stronger spending response among high-mortgage-debt-burden mortgage borrowers. By separating the cities in our sample by their past house-price movements, we show that the spending response is not stronger among cities with larger house-price increases, which further corroborates that our main results are unlikely explained by the housing wealth effect. While existing studies document a disproportionate effect of the fiscal stimulus on state-owned enterprises (SOEs), we find a similar response magnitude among mortgage borrowers working at SOEs compared with other non-SOE mortgage borrowers (Huang, Pagano, and Panizza, 2017). We further show that our results cannot be explained by the contemporaneous shocks in money supply, the contemporaneous decrease in export or exchange rate policy change, by the intertemporal substitution channel, 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; Ozdagli and Weber, 2018; Ravn and Sterk, 2020). A growing line of work focuses on the pass-through of monetary policy through household consumption and debt, including Agarwal et al. (2017b, 2020), Kaplan, Moll, and Violante (2018), Di Maggio et al. (2017), Sterk and Tenreyro (2018), and Wong (2019). 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, 2019).

Although several empirical studies examine the above theory with aggregate or pseudo-panel data (Calza, Monacelli, and Stracca, 2013; Cloyne, Ferreira, and Surico, 2020), we are among the first to provide empirical evidence using individual-level panel 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 (2020) 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 mortgage borrowers relative to FRM mortgage borrowers 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 0.41-0.54 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, Johnson, and McClelland, 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 Van Nieuwerburgh, 2005; Bhutta and Keys, 2016, Bahaj et al. 2018), 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

Unlike the US monetary authority, which uses the federal fund rate as the intermediate target of monetary policy, China employs M2 growth as the intermediate policy target. The main policy instruments PBC employs to meet the M2 growth target are open market operations, reserve

requirement ratio (i.e., RRR) adjustments, and benchmark rate adjustments. While the open market operations and RRR influence the overall liquidity of the financial market, only 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 open market operations, RRR adjustments, and benchmark interest rate adjustments, 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).[4]

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. All mortgagors face the same mortgage rate formula. 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.

[4] Like many other developing countries, China employs the Housing Provident Fund (HPF) to provide long-term financing to contributing employees for purchasing a house. In addition, the Housing Provident Fund requires mandatory monthly contribution from employees and employers, and the total contribution rate generally ranges from 10% to 20%. The forced (and otherwise illiquid) savings can be used to pay towards the down payment as well as the monthly mortgage payment. However, the HPF contribution is generally far from enough given the heavy mortgage debt-to-income ratio (35%) and a large down payment commitment (i.e., 2 times the annual household income).

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 is 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 benchmark 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%. Figure A1 in the Internet Appendix demonstrates the dynamic of the mortgage rate, long-term benchmark rate, and mortgage rate multiplier for commercial mortgage loans during our sample period. Note that 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 mortgage borrower 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 monthly 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) for fixed-principal-payment mortgages (fixed-monthly-payment mortgages). 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 fixed-principal-payment mortgages (fixed-monthly-payment mortgages) 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 accounts for 8.3% to 12.7% of monthly disposable household income (Source: National Bureau of Statistics).

Through the mortgage-debt-service-channel, the 2008 monetary policy shock also generated a large disposable income shock at the aggregate level. The total mortgage balance in China at the end of 2008 is RMB 2.98 trillion. Given the interest rate cut of 2.30%, the aggregate increase in disposable income is RMB 5.71 billion per month. Throughout the entire expansionary monetary policy regime (September 2008-September 2010), the cumulative increase in disposable income through the mortgage-debt-service-channel is RMB 119.95 billion, or 0.3% of China's GDP in 2009.

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 the 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 18.6% of China's GDP in 2012. By the end of 2008, 140 million credit cards had been issued in China, and the total credit card spending in 2008–2009 accounted

for about 15.4% of the total household consumption in China. Moreover, most credit card users in China hold no more than 2 credit cards (source: *2012 Credit Card Report*, by NetEase Finance), suggesting that our credit card data capture a large proportion of the spending of the consumers in our sample.

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. Compared with other household-finance datasets based on surveys (e.g., Consumer Expenditure Survey (CEX) or the Living Costs and Food Survey (LCFS)), our dataset can trace the consumption and debt behavior of a consumer for a longer period (up to eight years) and at a higher frequency (on a monthly basis). Given the predominant market share of our bank, 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 are homeowners, and whether they owe 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. We code observations of flow variables as zero if the consumer did not have any corresponding transactions in the given month.

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).[5] 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 18 (as of August 2008), because they were less likely to own a home or owe mortgage debt.[6] 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

[5] 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.

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

individuals, from January 2008 to June 2012. In the main analysis, we focus on the sample period from January 2008 (eight months before the monetary policy) to June 2009 (six months after mortgage interest rate reset). We exclude months before 2008 to avoid the confounding effect of the previous round of monetary policy in 2007. In our final sample, 48,840 credit card holders are homeowners, and 16.0% of them are mortgage borrowers. This ratio is consistent with the national statistics – 12.3% of urban homeowners have mortgages according to the China Household Finance Survey (CHFS) in 2011.[7]

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. Mortgage borrowers spend RMB 244 more per month than homeowners without mortgages. Mortgage borrowers also have a higher level of credit card debt and a similar level of delinquency rate compared with 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 and debt 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 delinquency rate of the treatment and control groups around the time of the monetary policy shock (January 2008–June 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 mortgage borrowers' spending.

[Insert Figure 1 here]

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

[7] 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 (Gan et al., 2013).

(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 mortgage borrowers, 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). January 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., January 2008–August 2008).

Next, we explore the dynamics of consumers' responses. Specifically, we estimate the following distributed lag model:

(2) $Y_{ict} = \sum_{s=-1}^{9} \beta_s \times 1_{treatment} \times 1_{month\ s} + \alpha_i + \delta_{ct} + \epsilon_{ict}$.

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., January 2008-July 2008), with *s* ranging from -1 (i.e., August 2008) to 9 (i.e., June 2009). By starting from the month immediately before the policy announcement, we can visualize the validity of the parallel-trends assumption. For spending, which is a flow variable, we show 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 show the dynamic of β_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, mortgage borrowers increased their credit card spending by 9.9% (=exp(0.094)-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 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 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 (January 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 7.9% relative to the control group. The estimate is statistically significant at the 5% level. The spending response during the mortgage reset period is 8.6%, and statistically significant at the 1% level. Given the average pre-shock monthly credit card spending of RMB 3,085 per month for the treatment group (Table 1), the 2008 monetary policy change on average increased the credit card spending of a mortgage borrower by RMB 244 and RMB 265 per month during the announcement and post-reset period, respectively. Given the average monthly income of RMB 8,761 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 2.8% (3.0%) of a mortgage borrower'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 0.4% more than consumers in the control group did. The delinquency response is economically large, given the average delinquency rate of 1.7% for mortgage borrowers 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 mortgage borrowers improved their financial conditions and helped them avoid costly default.

[Insert Table 3 here]

Figure 2 shows the dynamic of spending, debt, and delinquency responses. For spending, which is a flow variable, 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). 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 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, which are stock variables, we depict the dynamic of their responses by showing the average response β_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]

5.2 Testing the identifying assumptions

5.2.1 Parallel trend

To explicitly examine the parallel-trends assumption, in Panel A of Table 4, 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). We use the one-month pre-event window to allow sufficient observations for a precise estimate of spending in the baseline period, since our sample starts from January 2008. The coefficient estimate of $Mortgage \times 1_{pre}$ 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. In Table A2, we further test the parallel-trends assumption by looking at the three months immediately before the announcement of the monetary policy (i.e., June 2008 to August 2008). We find the response during the three months prior to the policy announcement statistically insignificant and economically small. This evidence confirms the validity of the parallel-trends assumption.

[Insert Table 4 here]

5.2.2 Controlling for the observable differences between the treatment and control groups

One challenge with the current identification is that mortgage borrowers 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-event 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 of these observables between the two groups becomes statistically and economically indistinguishable from zero. In addition to the mean statistics, distributions of the pre-event credit limit, age and monthly income of the treatment and control groups are also similar and comparable after matching (Figure A2).

In Panel B of Table 4, 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 9.1% (8.8%) 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 0.7% more than that of consumers in the matched control group. These results corroborate the robustness of our main findings.

5.2.3 Investigating the unobservable differences between the treatment and control groups

Admittedly, the matched-sample approach may not eliminate all the unobservable differences between the mortgage borrowers 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). After controlling for observables similar to those in our matching procedure, we find that mortgage borrowers and homeowners who had paid off their mortgage did not differ significantly in their levels of financial asset holdings.[8] Moreover, the annualized house-price

[8] In any event, our results are unlikely to be confounded by the "lender" cash-flow channel (La Cava, Hughson, and Kaplan, 2016). This is because 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, the change in savings due to the interest rate cut is too small to drive our result.

growth rate, estimated by Fang et al. (2015), was only 1.1% from January 2008 to June 2009 (Figure A3). This growth rate is too small to drive the results even if the treatment and control groups had different levels of housing-asset holdings.

To further alleviate the concern that homeowners without mortgage obligations may differ from mortgage borrowers in unobservable ways, we restrict to mortgage borrowers only and estimate the spending, debt, and delinquency response by exploiting the heterogeneity in the disposable income shock within the treatment group. For a subsample of credit card users who originated mortgage loans from our bank, we can observe their mortgage loan information, including the date of origination, the loan maturity, and the loan principal. The key mortgage characteristics of this subsample are representative of the national population. First, the average loan-to-value ratio in this subsample is 61.8%, close to the national average (62.6% according to Shen and Yan (2009)). Using the interest rate applicable in 2008, we also calculate the average debt to (disposable) income ratio to range from 34.6% to 39.9%. In comparison, the national average is 35% (Li, Qin, and Wu, 2020). Lastly, we compute the actual decrease in mortgage payment in this subsample based on the mortgage contract information. The calculated mortgage payment decrease is equivalent to 11.1% of their monthly income, which is again consistent with the national average (8.3%-12.7%).

We estimate the following regression model:

$$(3)\ Y_{ict} = \beta_p \times X_{ict} \times 1_{pre} + \beta_a \times X_{ict} \times 1_{announce} + \beta_r \times X_{ict} \times 1_{reset} + \alpha_i + \delta_{ct} + \epsilon_{ict}.$$

In comparison with Equation (1), the main difference in the empirical specification lies in that we restrict to the subsample of mortgage borrowers as described above and exploit the variation in the amount of the mortgage payment decrease (X_{ict})—or equivalently the disposable income increase—that we directly compute in this subsample. During the announcement period and the month immediately before the policy announcement, X_{ict} is coded as consumer i's disposable income change in January 2009, the month of mortgage rate reset. To facilitate interpretation, we divide X_{ict} by 100. Therefore, $\beta_{p,}$ β_a and β_r respectively capture the average change in credit card spending (or debt, or delinquency rate in percentage term) during the 1-month pre-announcement period, announcement period and post-reset period, in response to one hundred RMB increase in disposable income (compared with the benchmark period, i.e., January 2008–July 2008).

The results are shown in Table 5. In Column 1, we find a significant consumption response during both the announcement period and the post-reset period. Specifically, for each one hundred RMB received from the reduction of the monthly mortgage payment, mortgage borrowers on average spent RMB 30.12 (28.59) per month during the announcement (post-reset) period. As before, we do not find any significant debt response (Column 2). The delinquency response is highly significant only after the disbursement of additional disposable income (Column 3). Specifically, for each one hundred RMB received, the delinquency rate on average decreased by 0.06%. In all columns, we find the response in the month immediately before the policy announcement is statistically insignificant and economically small, which confirms the validity of

the parallel-trends assumption. Overall, the results in Table 5 corroborate the robustness of our main findings.

[Insert Table 5 here]

5.3 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. This allows us to answer two questions. First, we can test whether the spending and debt response we document above is symmetric for an interest rate increase. Second, it allows us to further examine the exclusion restriction of our empirical design. For example, one may still be concerned that the treatment group may have a larger exposure to the housing wealth channel of the expansionary monetary policy, which could confound our main findings. In that case, we expect to find no spending decrease during the 2010-2011 contractionary monetary policy regime given a steady increase in house prices in China during this period. There were also other contemporaneous events during the 2008-2009 interest rate cut, including the 4-trillion-yuan stimulus package announced in November 2008 and the positive money supply shocks in early 2009 (Deng et al. 2014; Chen, Ren, and Zha, 2018). Our estimates based on the 2010-2011 interest rate increase should not be confounded by these events since there was no reversal of fiscal expansion or negative shocks in money supply until 2014 (Bai, Hsieh, and Song, 2016; Chen, He, and Liu, 2020).

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, when the last round of interest rate increase was announced, 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) during this contractionary monetary policy regime. [9] 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.

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

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:[10]

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

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 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). January 2008 to August 2008 are absorbed as the benchmark period. Columns 1 and 2 of Table 6 show the results of Equation (4).

As in the main result, mortgage borrowers 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 mortgage borrowers 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, mortgage borrowers 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:

$$(5) \quad Y_{ict} = \beta_{a\_i} \times 1_{treatment} \times 1_{announce\_increase} + \beta_{2011} \times 1_{treatment} \times 1_{2011} + \beta_{2012} \times 1_{treatment} \times 1_{2012} + \alpha_i + \delta_{ct} + \epsilon_{ict}.$$

The benchmark period runs from April 2010 to September 2010. Again, we find a significant decrease in credit card spending among mortgage borrowers after the interest rate increase,

[10] 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.

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]

5.4 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. We start with the estimate of total spending response based on the main result (Column 1 of Table 3). By the end of the sixth month after the mortgage rate reset, mortgagors, on average, increase their credit card spending by RMB 2,566 (976 (=244×4) during the 4-month announcement period, and 1,590 (=265×6) during the 6-month post-reset period.)

We then estimate the disposable-income increase for the mortgage borrowers 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 mortgage borrowers 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 526,483, 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, to be RMB 496,902 for fixed-monthly-payment mortgages, or RMB 448,973 for fixed-principal-payment mortgages.[11] Given the mortgage rate reduction by 230 bps from January 2009, we calculate the increase in monthly disposable income for treated consumers in our sample to be RMB 678 (854) for fixed-monthly-payment mortgages (fixed-principal-payment mortgages) during the six-month post-reset window. The increase amounts to 7.7% (9.7%) of their monthly income, which is consistent with the national average ratio (8.3%-12.7%). It follows that the total increase in disposable income by the end of the sixth month after the mortgage rate reset is 4,068=678×6 (5,124=854×6) for fixed-monthly-payment mortgagors (fixed-principal-payment mortgagors).

Therefore, by the end of the sixth month after the mortgage rate reset, the estimated MPC based on credit card spending is between 0.50 (=2,566 /5,124) and 0.63 (=2,566 /4,068). In addition, we show that our main estimate of the consumption (as well as debt and delinquency) remains persistent throughout the expansionary monetary policy regime (see detailed results in Table A3).

[11] In our dataset we are unable to observe the specific mortgage payment schedules.

Based on the spending response estimated from this extended sample period, the MPC is estimated to be 0.44-0.54 during the full expansionary period.

We also corroborate this result using the direct MPC estimate from the subsample of mortgage borrowers for whom we observe the mortgage information. The estimates in Table 5 imply an MPC by the end of the sixth month after the mortgage rate reset (i.e., during the first 10 months after the policy announcement) to be 0.49 (= (0.301×4+0.286×6)/6). Again, we revisit the spending response in Table 5 during the full expansionary monetary policy period. Based on the spending response estimated from this extended sample period, the MPC during the full expansionary monetary policy period is 0.41. This estimate is broadly consistent with MPC derived from the main analysis sample.

As discussed in section 2.3, the aggregate increase of disposable income is estimated to be RMB 120 billion from January 2009 to September 2010. Based on our estimates of MPC (i.e., 0.41-0.54), it follows that the aggregate credit card spending increase through the debt service channel during the expansionary monetary policy regime is between RMB 49.2 billion and RMB 64.8 billion, which is equivalent to 0.14%-0.19% of China's GDP in 2009.

VI. Heterogeneity and Additional Analysis

We start this section by investigating the economic mechanism explaining our main findings. Our hypothesis centers on a strong consumption response to the disposable income increase induced by the mortgage debt service reduction, especially for the cash-on-hand constrained consumers. We first note that the other liabilities of household balance sheets unlikely play a major role in transmitting the monetary policy in our context. The credit card interest rate in China is fixed at 0.05% per day, regardless of the monetary policy. In addition, the penetration rate of car loans remained very low in China during that period, rendering the amount of outstanding car loans negligible relative to the amount of mortgage loans.[12]

6.1 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

[12] According to the "China Auto Finance Report 2012" by China Minsheng Bank & Deloitte China, the penetration rate of car loan was less than 10% by the end of 2010. The amount of outstanding car loans was RMB 110.7 billion at the end of 2007, equivalent to 3.7% of the amount of outstanding mortgage loans (Shen and Yan, 2009).

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 is 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 7, based on the unmatched full sample from January 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 mortgage borrowers 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 mortgage borrowers 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 mortgage borrowers responded strongly during both the announcement and the reset period. Specifically, they increased their credit card spending by 8.5% and 9.7% 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 mortgage borrowers is economically smaller and statistically insignificant, 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 mortgage borrowers, but only during the post-reset period. The delinquency-rate response among the high-credit-limit mortgage borrowers, on the other hand, is economically small and statistically insignificant. The difference in the delinquency response between the low- and high-credit-card-limit mortgage borrowers is 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 7 here]

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

We then investigate the role of 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 the entire balance sheet for consumers in the full sample, we can infer his/her cash-on-hand-constraint level based on the

credit-card-usage information in our dataset. Consumers who accumulate a significant amount of credit card debt presumably face 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 credit-card-debt-to-income ratio during the six months before the event is in the top decile of the sample distribution.[13] Our measure of cash-on-hand constraint is distinct from the borrowing constraint. The mean (median) of credit card utilization rates among cash-on-hand constrained consumers is 0.45 (0.37), suggesting their borrowing constraints are unlikely binding.

The results are reported in Table 8, based on the unmatched sample from January 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 mortgage borrowers 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 mortgage borrowers 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 mortgage borrowers is significantly larger than that of the less constrained mortgage borrowers, especially during the post-reset period. Specifically, cash-on-hand-constrained mortgage borrowers increased their credit card spending by 37.7% per month during the post-reset period, relative to cash-on-hand-constrained owners without mortgage obligations. The spending response among less constrained mortgage borrowers during the post-reset period is only 5.5%. 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 mortgage borrowers. For less constrained mortgage borrowers, the spending response during the announcement period is statistically significant and is larger than the response during the post-reset period, indicating their ability to increase their spending even before the disbursement of the disposable income. For constrained mortgage borrowers, the spending response is statistically significant only after the disbursement of the liquidity. The coefficient on "$Mortgage \times 1_{reset} \times CoH\ constrained$" is also two times larger than that on "$Mortgage \times 1_{announce} \times CoH\ constrained$." A formal F-test shows the two estimates are significantly different at the 1% level. The back-loaded pattern of the consumption response among the cash-

[13] Unlike in section 6.1, 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 credit card debt-to-(monthly) income ratio is too low (8%) to capture cash-on-hand-constrained consumers. This sample split is due to the skewed distribution of credit card debt rather than lack of cash-on-hand constrained consumers in the population. As shown later using the subsample of mortgage borrowers for whom we observe their mortgage information, those with mortgage debt-to-income in the top quartile of the distribution experienced significantly higher credit card spending response.

on-hand-constrained mortgage borrowers 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 and paid off their debt after they received the disposable liquidity. Column 3 shows that both groups of consumers decreased their probability of credit card delinquency after the rate reset.

[Insert Table 8 here]

We also repeat the above analysis based on the subsample of credit card users who originated mortgage loans from our bank. We classify a mortgage borrower as cash-on-hand constrained if his/her mortgage-debt-to-income ratio in the month immediately before the mortgage rate reset was in the top quartile of the sample distribution. We find consistent evidence: for every dollar of debt reduction, we observe a stronger consumption increase among mortgage borrowers dedicating a higher fraction of their income to serving mortgage debt (see Table A4 in the Internet Appendix). Importantly, this empirical specification also allows us to mitigate the concern that our previous subsample results might reflect heterogeneous treatment intensity rather than heterogeneous MPC. Since we include the precise amount of the disposable income change in the regression, the estimated coefficient exactly captures MPC and therefore a greater coefficient corresponds to a larger MPC for the cash-on-hand constrained consumers.

Overall, our results suggest that the cash-on-hand constraint is an important mechanism of monetary policy transmission through the debt-service channel.

6.3 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 9 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, mortgage borrowers constrained only by cash-on-hand liquidity (i.e., high-credit-limit consumers with cash-on-hand constraints) and mortgage borrowers 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, mortgage borrowers constrained only by cash-on-hand liquidity increased their credit card spending by 27.6% per month during the post-reset period, relative to outright homeowners constrained only by cash-on-hand liquidity. The fact that cash-on-hand constrained consumers 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. Mortgage borrowers constrained only by credit access increased their credit card spending by 9.2% 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 mortgage borrowers constrained only by cash-on-hand liquidity (i.e., high-credit-limit consumers with cash-on-hand constraints) and mortgage borrowers 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 mortgage borrowers constrained only by cash on hand is 215.7% ($4\times Mortgage\times 1_{announce}\times constrained + 6\times Mortgage\times 1_{announce}\times constrained$ in Column 2). The cumulative spending response among mortgage borrowers constrained only by credit access, on the other hand, is 68.4% ($4\times Mortgage\times 1_{announce}\times unconstrained + 6\times Mortgage\times 1_{announce}\times unconstrained$ in Column 1). The difference in the cumulative spending response between these two groups of mortgage borrowers is 147.3%, or equivalently, 14.7% per month. Although statistically insignificant (p=0.364), the magnitude of the difference is large, suggesting cash-on-hand constraints play a more important role in driving the spending response.

[Insert Table 9 here]

6.4 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.[14] Results are shown in Table 10. Consistent with Agarwal and Qian (2014), we find the spending response is mainly driven by discretionary spending (Column 1): The discretionary spending of mortgage borrowers increased by 5.4% and 8.4%, respectively, during the announcement and post-reset period, relative to that of owners without mortgage obligations.

[14] 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%.

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 mortgage borrowers increased by 5.2% and 6.8%, 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 10 here]

6.5 More robustness checks

6.5.1 Additional control variables

One concern regarding our spending response is that outright homeowners and mortgage borrowers may have differential exposure to the changes in the economic environment other than mortgage payment cut, which may confound the estimate of debt-service channel. To mitigate this concern, we additionally control for some macroeconomic variables interacted with mortgage status, including the year-over-year growth rate of disposable personal income per capita at the quarterly frequency (source: Chang, Chen, Waggoner, and Zha, 2016), the short-term interbank rate (i.e., 3-month SHIBOR rate) (source: CEIC), and the shock to money supply identified by Chen, Ren, and Zha (2018). As shown in Column 1 to 3 in Table A5 of the Internet Appendix, in all cases, the spending responses are statistically significant and quantitatively similar to the estimates in the main results.

Recall that in Table 5, we restrict to a subsample of mortgage borrowers and exploit the heterogeneity in the disposable income shock, which is determined by a mortgagor's remaining loan balance. To mitigate the concern that mortgagors with differential levels of debts may have different time preferences or MPC, we additionally control for mortgagors' LTV ratio as of the mortgage contract time, interacted with $1_{announce}$ and 1_{reset}. As shown in Column 4 of Table A5, the spending responses remain unchanged.

6.5.2 Falsification test

We examine the spending response of mortgage borrowers during July 2009 to June 2010, a period that does not overlap with that in our main analysis and does not involve mortgage rate changes. We define $1_{announce\_falsified}$ ($1_{reset\_falsified}$) as a dummy equal to 1 for September 2009-December 2009 (January 2010–June 2010), one year after the true announcement (post-reset) period. As shown in Column 5 of Table A5 in the Internet Appendix, the spending response of mortgage borrowers during the falsified announcement and post-reset periods are economically small and statistically insignificant.

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

In Table 5, we exploit the heterogeneity in the disposable income shock within a subsample of the treated consumers who originated mortgage loans from our bank. As a robustness check, we also investigate the heterogeneous response across consumers with different levels of treatment intensity based on the full sample. 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 mortgage borrowers from first-tier cities, especially those at the early stage of the life cycle, are more likely to face a higher level of mortgage debt burden, and thereby a larger shock in disposable income. We therefore classify a consumer as bearing high mortgage debt burden if he/she is from a first-tier city and was in the bottom quartile of the age distribution among mortgage borrowers (i.e., under 30). The spending response among high-mortgage-debt-burden mortgage borrowers is discernibly stronger than that among low-mortgage-debt-burden mortgage borrowers during the post-reset period (refer to Panel A of Table A6 in the Internet Appendix). Moreover, the spending increase is concentrated in the post-reset period.

6.5.4 Additional discussion about the housing wealth channel

To further mitigate the concern regarding the housing wealth channel, we examine the heterogeneous response across cities that experienced different levels of past house-price appreciation. If the spending response we document was driven by the housing wealth effect, consumers from cities that experienced higher past house-price appreciation would be 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 a "high house price appreciation" city if its house-price appreciation is in the top decile during this period. We do not find the spending response significantly stronger in cities that experienced higher house-price appreciation (Panel B of Table A6 in the Internet Appendix). In addition, the wealth increase through housing price appreciation can hardly be liquidated to meet the credit-card payment obligations, and therefore this channel cannot explain the delinquency rate reduction result either.

6.5.5 Additional discussion about key concurrent events

We further discuss the implications for our results of key concurrent events including the fiscal stimulus policy and money supply increase. The fiscal policy was not announced until November 2008, and money supply did not surge until the first quarter of 2009. Nevertheless, the spending response started immediately after the September announcement (Figure 2). We also further evaluate the potential influence of the fiscal stimulus and the money supply shock by exploiting the response heterogeneity across different economic sectors. State-owned-enterprises benefited disproportionately more from the fiscal stimulus package and money supply shock (Deng et al.,

2014; Huang, Pagano, and Panizza, 2020). The fiscal-policy-driven and money-supply-driven interpretation predicts a stronger spending response for mortgage borrowers working in state-owned-enterprises. We do not find the spending response to be significantly stronger among mortgage borrowers employed by state-owned-enterprises (Panel C of Table A6 in the Internet Appendix).

6.5.6 Other robustness checks

Starting from November 2008, China's export experienced a significant drop. The contemporaneous export decline may potentially confound our results. The change in export cannot explain the spending decrease during the 2010-2011 interest rate increase given no corresponding export growth during the same period. In addition, starting from July 2008, PBC effectively pegged the RMB to the US dollar. This policy change can hardly explain our results either, since spending did not increase in the two-month period after the exchange rate regime change when the monetary policy was not announced. To further alleviate the above concerns, we examine the heterogeneous response among cities with different levels of export dependence. If the spending response we document was driven by the export shocks or the exchange rate policy change, consumers from export-dependent cities would be more responsive. A city is classified as a "export dependent" city if its export-to-GDP ratio in 2007 is in the top decile of our sample distribution (source: China Statistical Yearbook for Regional Economy). We find the spending response among consumers from export-dependent cities is comparable to the response among consumers from less export-dependent cities (p=0.890 for the F-test during the announcement period, p=0.769 during the post-reset period, as shown in Panel D of Table A6).

Another concern is whether our results can be explained by mortgage borrowers' higher intertemporal rate of substitution (relative to the control group). Conceptually, consumers with higher intertemporal rate of substitution would exhibit a larger increase in spending following an interest rate cut in the absence of the cash-flow channel. However, the intertemporal substitution channel does not predict a decrease in the delinquency rate among mortgage borrowers. The decrease in the delinquency rate lends further credence to our interpretation: the disposable income increase due to the monetary policy shock significantly improves the financial condition of mortgage borrowers and helps 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 mortgage borrowers were granted higher credit card limits after the monetary shock. We find no evidence of a disproportionate increase in credit limits among mortgage borrowers after the shock (Table A7 in the Internet Appendix). We also examine and find no significant change in credit-card-spending frequency for the treatment group (Table A8 in the Internet Appendix). Therefore, our results are also 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 mortgage borrowers 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, mortgage borrowers increased their monthly credit card spending by 8.6% 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. 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 mortgage borrowers 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.

Subsequent to an interest-rate-increase episode, we find a symmetric effect as reflected by a significant spending decline. Consumers reduced their credit card spending while accumulating a greater amount of credit card debt. Further analyses suggest our results are unlikely contaminated by other confounding factors. Collectively, the paper highlights the important role of the debt-service channel in transmitting monetary policy shocks—our estimate indicates a significant MPC of 0.41-0.54 through credit card spending.

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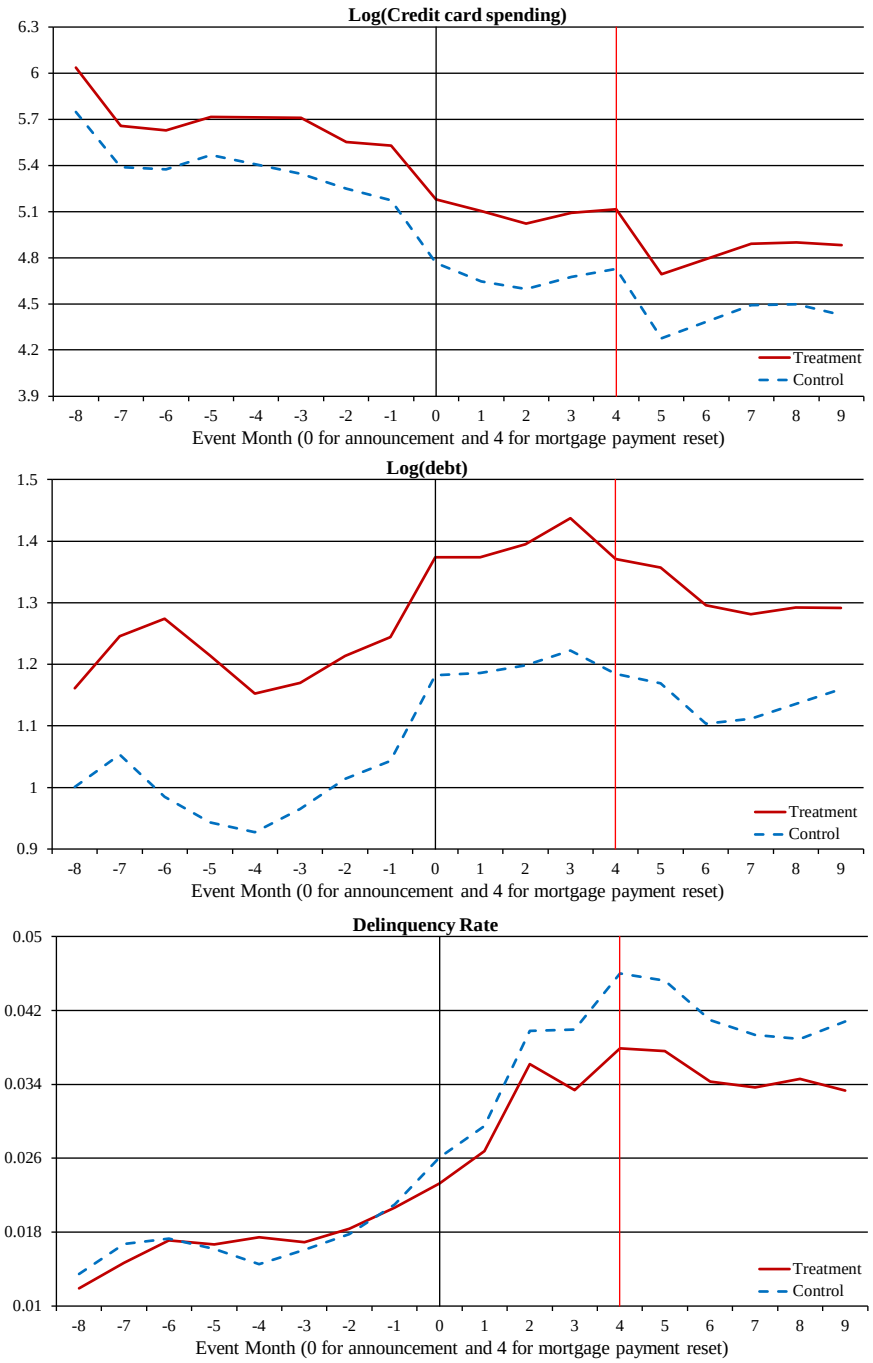
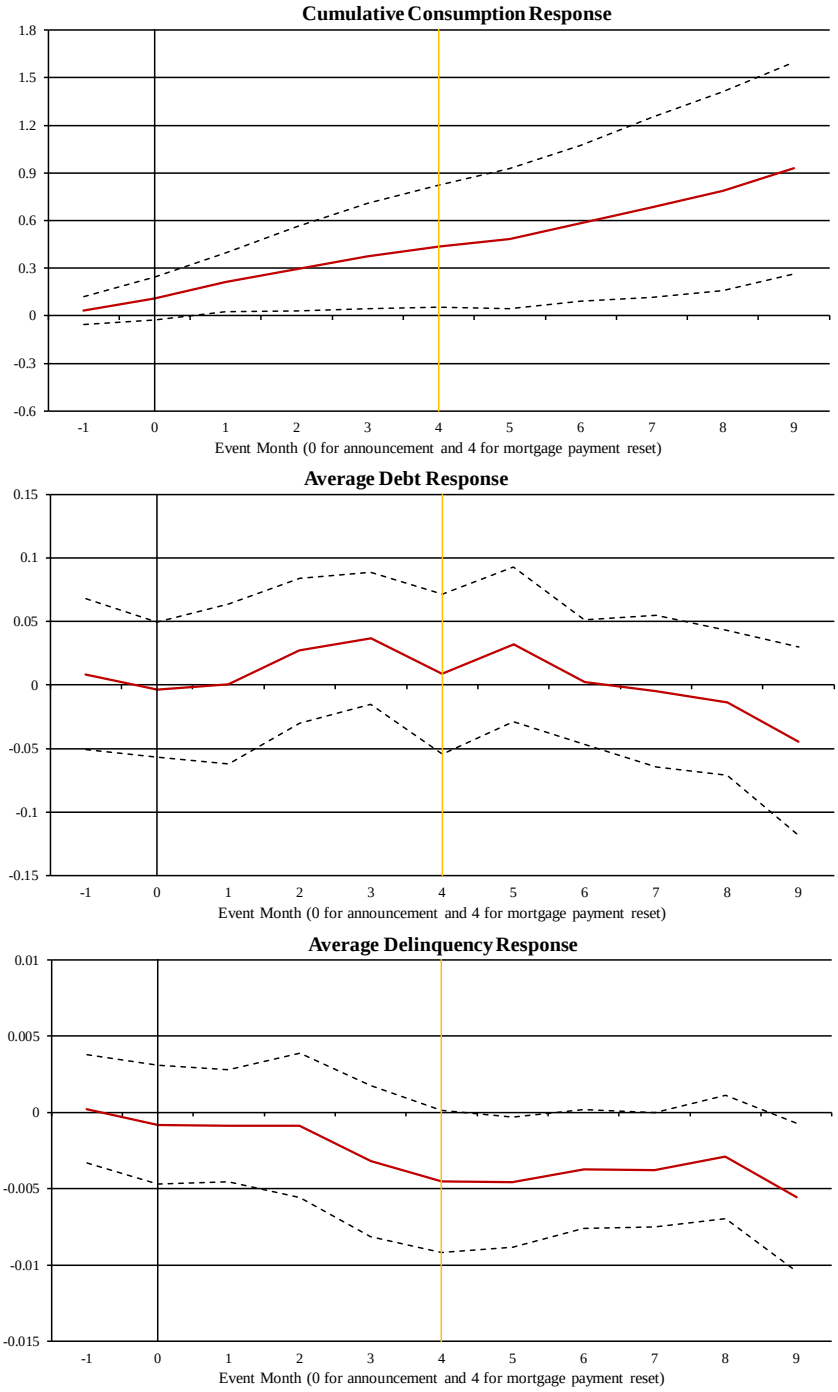
FIGURE 1. UNCONDITIONAL MEAN OF CREDIT CARD SPENDING, DEBT, AND DELINQUENCY RATE SURROUNDING THE MONETARY POLICY SHOCK



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 groups during the period of March 2008–June 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 β_s as estimated from Equation (2). The dashed lines show the corresponding 95% confidence intervals.

TABLE 1. —SUMMARY STATISTICS

Variable	Mortgage borrower (Treatment)		Outright homeowner (Control)	
	Mean	SD	Mean	SD
	(1)	(2)	(3)	(4)
Age	33.7	6.7	36.4	8.1
# of dependents	0.43	0.8	0.63	0.8
Married (%)	82.2	-	87.8	-
Credit limit	17,903	33,240	14,772	26,933
Credit card spending	3,085	6,064	2,841	6,258
Debt	624	2,518	451	2,152
Delinquency	0.017	0.130	0.017	0.129
# of consumers	7,790		41,050	

This table reports the summary statistics of our treatment and control sample during the pre-event window (2008:01–2008:08). 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 18 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	5.810	4.907	-0.902***	0.094***
Control	5.490	4.493	-0.997***	(3.41)
Log(debt)				
Treatment	1.028	1.332	0.304***	-0.009
Control	0.840	1.153	0.313***	(-0.45)
Delinquency				
Treatment	0.013	0.034	0.020***	-0.006***
Control	0.013	0.039	0.027***	(-4.19)

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., January 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 $\times 1_{announce}$	0.079**	0.014	-0.001
	(2.13)	(0.63)	(-1.05)
Mortgage $\times 1_{reset}$	0.086***	-0.005	-0.004***
	(2.81)	(-0.23)	(-3.05)
Fixed effects	Individual, city×year-month		
# of individual	48,835	48,835	48,835
Observations	751,622	751,622	751,622
R^2	0.308	0.493	0.288

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 January 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). January 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. —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 $\times 1_{pre}$	0.034	0.008	0.000
	(0.77)	(0.28)	(0.13)
Mortgage $\times 1_{announce}$	0.086**	0.015	-0.001
	(2.23)	(0.69)	(-0.98)
Mortgage $\times 1_{reset}$	0.092***	-0.003	-0.004***
	(2.76)	(-0.15)	(-2.85)
Fixed effects	Individual, city×year-month		
# of individual	48,835	48,835	48,835
Observations	751,622	751,622	751,622
R^2	0.308	0.493	0.288
Panel B: Matched sample			
Mortgage $\times 1_{pre}$	-0.005	0.000	-0.003
	(-0.10)	(0.01)	(-1.39)
Mortgage $\times 1_{announce}$	0.091*	-0.002	-0.003
	(1.83)	(-0.06)	(-1.53)
Mortgage $\times 1_{reset}$	0.088**	-0.039	-0.007***
	(2.23)	(-1.49)	(-3.69)
Fixed effects	Individual, city×year-month		
# of individual	15,566	15,566	15,566
Observations	242,611	242,611	242,611
R^2	0.308	0.493	0.288

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 January 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). January 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 5. — THE AVERAGE RESPONSE: MORTGAGE BORROWERS ONLY

	(1) Credit card spending	(2) Credit card debt	(3) Delinquency%
1_{pre}*Δ disposable income (100 RMB)	10.694	2.696	-0.020
	(0.64)	(0.47)	(-0.36)
$1_{announce}$*Δ disposable income (100 RMB)	30.122**	-0.848	-0.041
	(2.41)	(-0.09)	(-1.56)
1_{reset}*Δ disposable income (100 RMB)	28.592*	-10.343	-0.061**
	(1.91)	(-0.98)	(-2.03)
Fixed effects	Individual, city×year-month		
# of individual	2,421	2,421	2,421
Observations	38,937	38,937	38,937
R^2	0.420	0.582	0.298

This table shows the average credit card spending, debt, and delinquency (in percentage) response to the monetary policy announced on September 15, 2008. The sample period runs from January 2008 to June 2009. We restrict to the mortgage borrowers who have both mortgage loan information and credit card spending information in our dataset. *Delinquency%* is equal to 100 if a consumer is 60 days past due, and equal to 0 if otherwise. *Δ disposable income (100 RMB)* is the amount (in 100 RMB) of mortgage payment reduction due to the interest rate cut. Refer to Table 1 for definitions of variables. 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 $\times 1_{announce\_decrease}$	0.067*	0.021		
	(1.85)	(0.98)		
Mortgage $\times 1_{reset\_decrease}$	0.104***	-0.001		
	(3.55)	(-0.06)		
Mortgage $\times 1_{announce\_increase}$	0.024	-0.032	-0.034	-0.017
	(0.51)	(-1.13)	(-1.10)	(-0.73)
Mortgage $\times 1_{2011}$	0.001	0.060	-0.054**	0.074*
	(0.04)	(1.29)	(-1.97)	(1.95)
Mortgage $\times 1_{2012}$	-0.059	0.229***	-0.116***	0.232***
	(-1.41)	(3.32)	(-3.24)	(4.08)
Fixed effects		Individual, city×year-month		
# of individuals	48,838	48,838	44,165	44,165
Observations	2,194,753	2,194,753	1,037,342	1,037,342
R^2	0.316	0.429	0.436	0.530

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 January 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, January 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-CREDIT-LIMIT CONSUMERS

	(1) Log (credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{announce} \times$ low credit limit	0.086*	-0.009	-0.003
	(1.89)	(-0.26)	(-0.94)
Mortgage $\times 1_{reset} \times$ low credit limit	0.099**	-0.009	-0.010***
	(2.33)	(-0.20)	(-2.87)
Mortgage $\times 1_{announce} \times$ high credit limit	0.074	0.025	-0.001
	(1.35)	(0.98)	(-0.64)
Mortgage $\times 1_{reset} \times$ high credit limit	0.065	0.004	-0.001
	(1.54)	(0.17)	(-0.38)
Fixed effects	Individual, city×year-month×high credit limit, city×year-month×low credit limit		
# of individuals	48,826	48,826	48,826
Observations	751,433	751,433	751,433
R^2	0.308	0.493	0.289

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 January 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 is 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 8. — 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	0.126	0.045	-0.012
	(1.17)	(0.49)	(-1.34)
Mortgage $\times 1_{reset} \times$ CoH constrained	0.377***	-0.032	-0.019**
	(3.78)	(-0.32)	(-2.44)
Mortgage $\times 1_{announce} \times$ CoH unconstrained	0.078**	0.012	-0.001
	(1.98)	(0.47)	(-1.20)
Mortgage $\times 1_{reset} \times$ CoH unconstrained	0.055*	0.011	-0.003***
	(1.71)	(0.45)	(-2.62)
Fixed effects	Individual, city×year-month×CoH unconstrained, city×year-month×CoH constrained		
# of individuals	48,802	48,802	48,802
Observations	750,992	750,992	750,992
R^2	0.310	0.500	0.304

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 January 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 months before the event is 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 9. — 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	0.075	0.125
	(0.57)	(0.79)
Mortgage $\times 1_{reset} \times$ CoH constrained	0.485***	0.276*
	(3.64)	(1.87)
Mortgage $\times 1_{announce} \times$ CoH unconstrained	0.092*	0.068
	(1.70)	(1.29)
Mortgage $\times 1_{reset} \times$ CoH unconstrained	0.053	0.043
	(1.19)	(0.96)
Fixed effects	Individual, city×year-month×CoH unconstrained, city×year-month×CoH constrained	
# of individuals	18,901	29,829
Observations	286,894	462,735
R^2	0.299	0.308

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 January 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 is 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 10. —HETEROGENEITY IN SPENDING RESPONSE: BY SPENDING CATEGORIES

	(1) Discretionary	(2) Non-discretionary	(3) Durable	(4) Nondurable
Mortgage $\times 1_{announce}$	0.054	0.026	0.011	0.052
	(1.36)	(1.14)	(0.59)	(1.48)
Mortgage $\times 1_{reset}$	0.084***	0.013	0.012	0.068**
	(2.90)	(0.43)	(0.67)	(2.00)
Fixed effects	Individual, city×year-month			
# of individuals	48,331	48,331	48,331	48,331
Observations	744,289	744,289	744,289	744,289
R^2	0.324	0.343	0.317	0.205

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 January 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%.

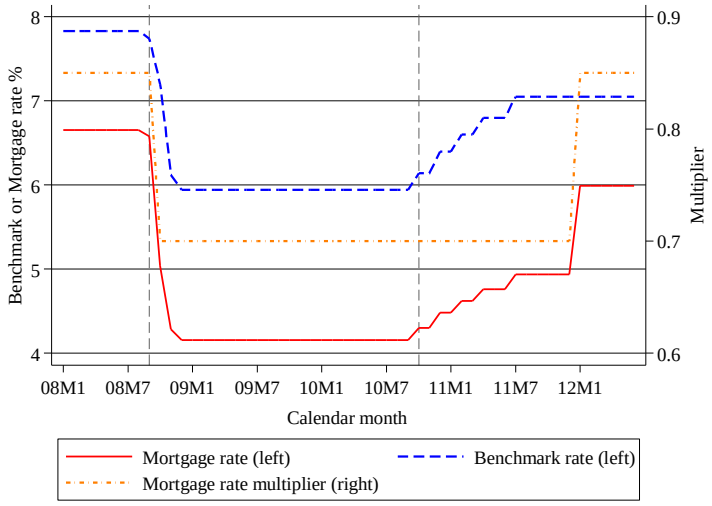
Internet Appendix

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

Sumit Agarwal, Yongheng Deng, Quanlin Gu, Jia He, Wenlan Qian, Yuan Ren

Not Intended for Publication

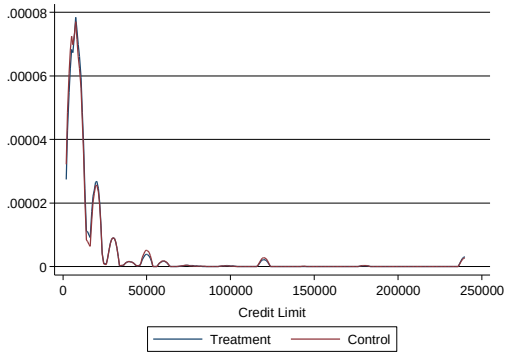
FIGURE A1. DYNAMIC OF MORTGAGE RATE, BENCHMARK RATE, AND MORTGAGE RATE MULTIPLIER



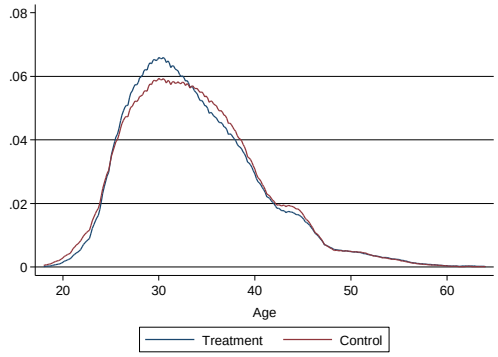
This figure shows the dynamic of mortgage rate (red line, left axis), long-term benchmark rate (blue line, left axis), and mortgage rate multiplier (orange line, right axis) for commercial mortgage loans during our sample period. The two vertical dash lines respectively indicate the beginning of the expansionary (contractionary) monetary policy regime in September 2008 (October 2010).

FIGURE A2. —KERNEL DENSITY PLOTS FOR THE MATCHED SAMPLE

Panel A, Credit limit as of August 2008



Panel B, Age as of August 2008



Panel C, Monthly income as of August 2008

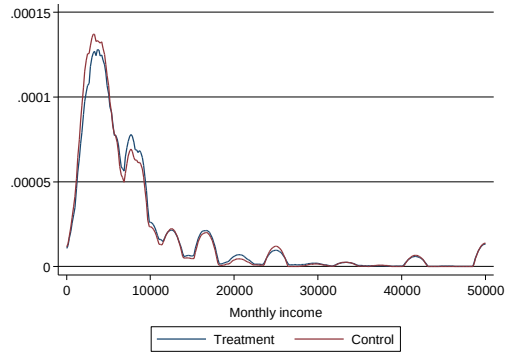


Figure A2 compares the distribution of the continuous matching variables in the treatment group and the control group, after the propensity score matching. Panel A, B and C respectively compare the distribution of credit card limit, age, and monthly income, based on the latest updated information before the announcement of the 2008 interest rate reduction.

FIGURE A3. —AVERAGE HOUSING PRICE INDEX AROUND THE EVENT

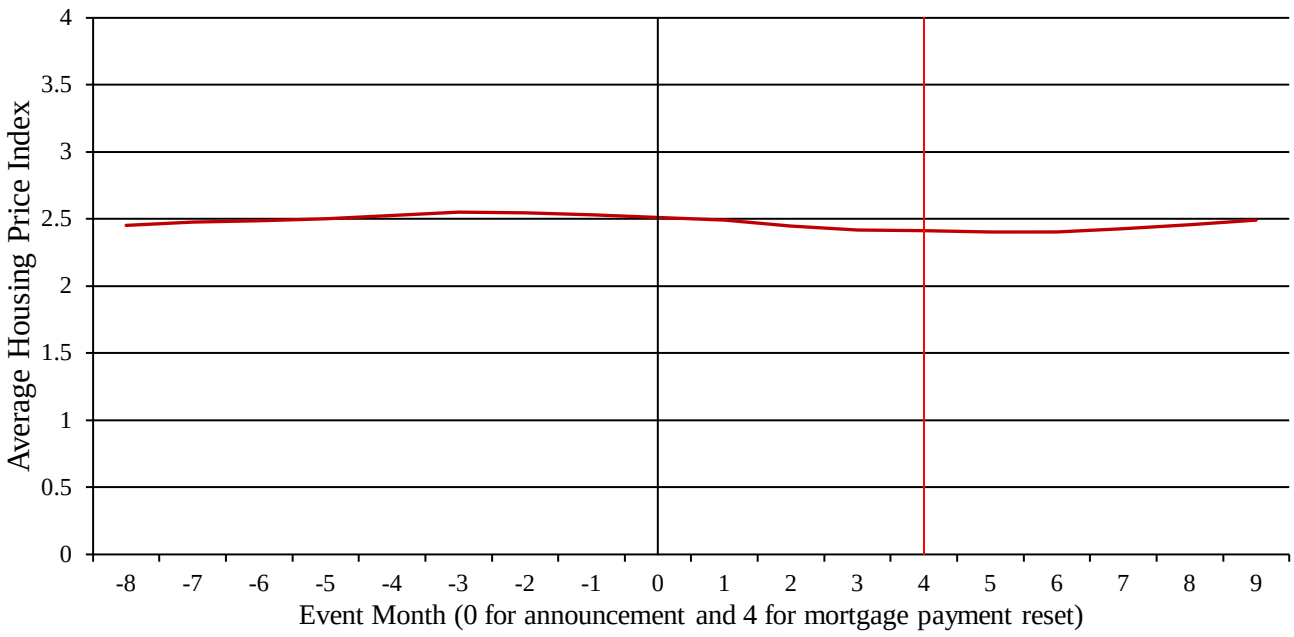


Figure A3 shows the trend of the average house-price index around the event, based on the house-price indices estimated by Fang et al. (2015). Specifically, for each month, we calculate the average house-price indices across all the cities, weighted by the number of consumers in each city from our unmatched 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

	Mortgage borrower
Credit limit	0.000***
	(3.30)
Credit limit, quadratic	-0.000***
	(-2.67)
Age	0.102***
	(6.51)
Age, quadratic	-0.002***
	(-9.99)
# of dependents	0.058
	(1.47)
# of dependents, quadratic	-0.270***
	(-6.94)
Married	0.066***
	(5.11)
Fixed Effects	City
Observations	48,043
Pseudo R-squared	0.104

Panel B: Post-matching characteristics

	Matched Treatment		Matched Control		Diff.
	Mean	SD	Mean	SD	
Age	33.7	6.7	33.8	6.8	-0.1
# of dependents	0.43	0.8	0.41	0.7	0.01
Married (%)	82.2	-	83.0	-	-0.8
Credit limit	17,903	33,240	17,838	32,811	65
Income (monthly)	8,761	9,732	8,340	9,722	420
# of consumers	7,790		7,790		

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 18 as of 2008. Significant at *** 1%, **5%, and *10%.

TABLE A2. —PARALLEL-TREND: ALTERNATIVE PRE-EVENT WINDOW

	(1) Log(credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{pre3}$	0.016	-0.004	0.001
	(0.44)	(-0.16)	(0.61)
Mortgage $\times 1_{announce}$	0.087**	0.012	-0.001
	(2.04)	(0.49)	(-0.54)
Mortgage $\times 1_{reset}$	0.093**	-0.007	-0.004**
	(2.33)	(-0.28)	(-2.16)
Fixed effects	Individual, city×year-month		
# of individual	48,835	48,835	48,835
Observations	751,622	751,622	751,622
R^2	0.308	0.493	0.288

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 January 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). "1_{pre3}" is a dummy that equals 1 for the three months immediately before the announcement of the monetary policy (i.e., June 2008-August 2008). January 2008 to May 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 A3. — THE AVERAGE RESPONSE: A LONGER POST-EVENT WINDOW

	(1) Log(credit card spending)	(2) Log(debt)	(3) Delinquency
Mortgage $\times 1_{announce}$	0.071*	0.020	-0.000
	(1.94)	(0.95)	(-0.15)
Mortgage $\times 1_{reset}$	0.105***	-0.003	-0.004***
	(3.60)	(-0.11)	(-2.72)
Fixed effects	Individual, city×year-month		
# of individual	48,835	48,835	48,835
Observations	1,415,925	1,415,925	1,415,925
R^2	0.318	0.472	0.338

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 January 2008 to September 2010. 1_{reset} is a dummy that equals 1 for the months after mortgage rates were reset (i.e., January 2009– September 2010). Refer to Tables 1 and 3 for definitions of other variables. January 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 ROLE OF CASH-ON-HAND CONSTRAINTS: MORTGAGE BORROWERS ONLY

	(1) Credit card spending	(2) Credit card debt	(3) Delinquency%
$1_{announce}$*Δ disposable income (100 RMB) × CoH constrained	58.649*	-7.751	-0.018
	(1.79)	(-0.59)	(-0.34)
1_{reset}*Δ disposable income (100 RMB) × CoH constrained	65.889*	-31.150	-0.119***
	(1.85)	(-1.29)	(-2.66)
$1_{announce}$*Δ disposable income (100 RMB) × CoH unconstrained	15.593	-0.918	-0.05
	(0.89)	(-0.09)	(-1.322)
1_{reset}*Δ disposable income (100 RMB) × CoH unconstrained	8.120	-2.727	-0.034
	(0.57)	(-0.36)	(-0.645)
Fixed effects	Individual, city×year-month×CoH unconstrained, city×year-month×CoH constrained		
# of individual	2,397	2,397	2,397
Observations	38,477	38,477	38,477
R^2	0.424	0.583	0.297

This table shows the average credit card spending, debt and delinquency response grouped by cash-on-hand constraints. The sample period runs from January 2008 to June 2009. We restrict to the mortgage borrowers who have both mortgage loan information and credit card spending information in our dataset. *Δ disposable income (100 RMB)* is the amount (in 100 RMB) of mortgage payment reduction due to the interest rate cut. 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 mortgage-debt-to-income ratio in the month immediately before the mortgage rate reset is in the top quartile of the sample distribution. 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 A5. — ADDITIONAL ROBUSTNESS ANALYSIS

	(1)	(2)	(3)	(4)	(5)
	Log(credit card spending)			credit card spending	Log(credit card spending)
Mortgage $\times 1_{announce}$	0.073**	0.083**	0.082**		
	(2.01)	(2.31)	(2.22)		
Mortgage $\times 1_{reset}$	0.087***	0.095**	0.100***		
	(2.83)	(2.03)	(2.78)		
Mortgage × disposable income growth	0.566				
	(0.98)				
Mortgage × 3-month SHIBOR rate		0.284			
		(0.19)			
Mortgage × Money supply shock			-1.236		
			(-1.11)		
$1_{announce}\times\Delta$ disposable income (100 RMB)				28.864**	
				(2.43)	
$1_{reset}\times\Delta$ disposable income (100 RMB)				26.613*	
				(1.95)	
$1_{announce}\times$LTV ratio				-129.953	
				(-0.18)	
$1_{reset}\times$ LTV ratio				43.719	
				(0.07)	
Mortgage $\times 1_{announcement\_falsified}$					-0.001
					(0.03)
Mortgage $\times 1_{reset\_falsified}$					0.033
					(0.82)
Observations	751,622	751,622	751,622	38,937	535,787
R^2	0.321	0.308	0.308	0.420	0.438

This table shows the additional robustness analysis of our main results. For Column 1, 2, and 3, the sample is based on the unmatched full sample which runs from January 2008 to June 2009. "*disposable income YoY growth*" is the year-over-year growth rate of China's disposable income per capita at the quarterly level (source: Chang, Chen, Waggoner, and Zha, 2016). "*3-month SHIBOR rate*" is the 3-month Shanghai interbank offered rate at the end of each month (source: CEIC). "*Money supply shock*" is the quarterly change of M2 growth rate shock identified by Chen, Ren, and Zha (2018). For column 4, the sample is based on the mortgage borrowers with both mortgage loan information and credit card spending information in our dataset, from January 2008 to June 2009. "*LTV ratio*" is a mortgage borrower's loan-to-debt ratio as of the mortgage contract time. For Column 5, the sample period runs from July 2009 to June 2010. "$1_{announcement\_falsified}$" is a dummy that equals 1 for September 2009 - December 2009. "$1_{reset\_falsified}$" is a dummy that equals 1 for the months after mortgage rates for January 2010–June 2010. Refer to Table 1 and Table 5 for definitions of other variables. 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 A6. — ADDITIONAL HETEROGENEOUS ANALYSIS

	(1) Log(credit card spending)
Panel A: Heterogeneity across mortgage debt burden	
Mortgage $\times 1_{announce}$ × high mortgage debt burden	0.145*
	(1.94)
Mortgage $\times 1_{reset}$ × high mortgage debt burden	0.275***
	(10.14)
Mortgage $\times 1_{announce}$ × low mortgage debt burden	0.076*
	(1.96)
Mortgage $\times 1_{reset}$ × low mortgage debt burden	0.073**
	(2.19)
Observations	751,622
R^2	0.308
Panel B: Heterogeneity across cities	
Mortgage $\times 1_{announce}$ × High appreciation	-0.045
	(-0.92)
Mortgage $\times 1_{reset}$ × High appreciation	0.069
	(1.15)
Mortgage $\times 1_{announce}$ × Low appreciation	0.117***
	(3.14)
Mortgage $\times 1_{reset}$ × Low appreciation	0.091***
	(2.68)
Observations	751,622
R^2	0.308
Panel C: Heterogeneity across economic sectors	
Mortgage $\times 1_{announce}$ × SOE	-0.000
	(-0.00)
Mortgage $\times 1_{reset}$ × SOE	0.072
	(0.50)
Mortgage $\times 1_{announce}$ × Non- SOE	0.085**
	(2.37)
Mortgage $\times 1_{reset}$ × Non- SOE	0.088***
	(2.97)
Observations	750,838
R^2	0.308
Panel D: Heterogeneity across export-dependent versus independent cities	
Mortgage $\times 1_{announce}$ × export dependent	0.087
	(1.32)
Mortgage $\times 1_{reset}$ × export dependent	0.075
	(1.53)
Mortgage $\times 1_{announce}$ × export independent	0.076*
	(1.71)
Mortgage $\times 1_{reset}$ × export independent	0.094**
	(2.34)
Observations	746,297
R^2	0.309

This table shows the additional heterogeneity analysis of our main results. In Panel A, we respectively interact the main effects with the "high mortgage debt burden" dummy equal to 1 if a consumer is from a first-tier city and is in the bottom quartile of the age distribution among mortgage borrowers (i.e., under 30), and the "*low mortgage debt burden*" dummy equal to 1 minus the "*high mortgage debt burden*" dummy. In Panel B, we respectively interact the main effects 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 C, we respectively interact the main effects 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 Panel D, we respectively interact the main effects with a dummy "*export dependent*" equal to 1 if the city's export-to-GDP ratio in 2007 is in the top decile of the sample distribution, and a dummy "*export independent*" equal to 1-"*export dependent*" (source: China statistical yearbook for regional economy). In all regressions, we include the individual fixed effects and the city×year-month fixed effects interacting with the "*high mortgage debt burden*" dummy (in Panel A), "*high appreciation*" dummy (in Panel B), "*SOE*" dummy (in Panel C), or "*export dependent*" dummy (in Panel D). 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 A7. — SUPPLY OF CREDIT TO CONSUMERS AROUND THE SHOCK

	Log (credit limit)
Mortgage $\times 1_{announce}$	-0.003
	(-1.01)
Mortgage $\times 1_{reset}$	-0.005
	(-1.46)
Fixed effects	Individual, city×year-month
# of Individuals	48,835
Observations	751,591
R^2	0.964

This table shows the change in the credit card limit of mortgage borrowers 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 January 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). January 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 A8. —THE FREQUENCY OF CREDIT CARD USAGE AROUND THE SHOCK

	Frequency of credit card spending
Mortgage $\times 1_{announce}$	-0.029
	(-0.92)
Mortgage $\times 1_{reset}$	0.011
	(0.24)
Fixed effects	Individual, city×year-month
# of Individuals	48,835
Observations	751,622
R^2	0.410

This table shows the change in credit-card-spending frequency of mortgage borrowers 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 January 2008 to June 2009. The dependent variable is the monthly frequency of credit card spending of a consumer. Refer to Table 3 for definitions of other variables. January 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%.