

Mortgage Interest Reduction and Consumption: Evidence from Credit Bureau Data

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Abstract

This paper investigates the simultaneous and dynamic relationships between consumption and unanticipated mortgage interest reduction caused by expansionary monetary policy, using comprehensive borrower-level information on mortgages and credit card purchases from a credit bureau company in South Korea. The main findings are as follows: (i) the significant and negative relationship between mortgagors' interest payments and consumption comes from borrowers with ARMs, (ii) among mortgagors with ARMs, those with low liquidity and credit accessibility show high interest-induced MPCs, (iii) compared to liquidity and credit accessibility, the debt burdens of mortgagors have a weaker effect on the interest-induced MPC heterogeneity due to active deleveraging behaviors of borrowers with high debt burden, (iv) while unconstrained borrowers show low and insignificant MPCs consistently, constrained borrowers (low liquidity and credit accessibility) maintain long-lasting high MPCs for eight quarters after interest reduction, and (v) the MPC of those with low liquidity has become lower as time goes by, indicating that windfall gains by mortgage interest reduction help relaxing the liquidity constraints they face. These results imply that financial characteristics of mortgage borrowers can affect the magnitude and persistence of the cash flow channels of expansionary monetary policy.

Keywords: Mortgage Interest Reduction, Consumption, Adjustable Rate Mortgage, Liquidity Constraint, Credit Accessibility, Debt Burden

JEL Codes: D14, E21, E52

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1 Introduction

It has been long sought to understand the channels through which the changes in monetary policy affect households' consumption. A fundamental question on this issue is to which degree monetary policy affect aggregate demands. Recently, beyond the fundamental question, heterogeneous effects of monetary policy on consumption have been paid much attention, focusing particularly on cash-flow channel of monetary policy (e.g., Di Maggio et al., 2017; Floden et al., 2017; Jappelli and Scognamiglio, 2018). Despite the efforts to figure out the heterogenous effects via the cash-flow channel, researchers have met with a difficulty in fully accounting for the sources of them due to insufficient data and potential measurement errors. In this paper, we investigate the heterogenous effects of unanticipated expansionary monetary policy on mortgage borrowers' consumption across their financial characteristics, using comprehensive credit bureau data of South Korea.

The monetary loosening can affect mortgage borrowers' consumption via several channels.¹ The decrease in interest rates raises the value of current consumption more than that of future consumption, which leads to the increase in aggregate consumption in the current period (intertemporal substitution channel). The changes in asset prices can also affect mortgage borrowers' consumption. Lower interest rates can lead to the rise in asset prices, which is translated to increase the life-time resources of borrowers, that encourages them spend more (wealth effect channel). The last one is the cash-flow channel, which is the main interest of this paper. The decline in interest rates can directly influence mortgage borrowers' cash flows through the reduction of interest expenses, which leads to increase in their consumption.

To observe the cash flow channel of monetary policy, we first show that the consistent expansionary monetary policy over the period 2012-2017 is unanticipated by the difference between actual and forecasted base rates, using the conventional VAR method. We then examine whether the consumption of borrowers with Adjustable Rate Mortgages (ARMs) responds more sensitively to the expansionary monetary policy than those with Fixed Rate Mortgages (FRMs). If the cash flow channel works, borrowers with ARMs respond more sensitively to mortgage interest reductions than those with FRMs. After identifying the borrowers with ARMs who show the high correlation

¹For more general explanations on the channels through which the monetary policy affects households' consumption, See Floden et al. (2017) and La Cava et al. (2016).

between COFIX (Cost Of Fund IndeX) and their mortgage rates, we conduct the regressions to capture the differential responses between ARM and FRM borrowers.² Next, We explore the heterogeneous interest-induced Marginal Propensity to Consume (MPC) for ARM borrowers by their liquidity, credit accessibility, and debt burden. Lastly, we investigate the persistence of interest-induced MPCs. Since an interest rate is an economic variable that shows high persistence, mortgage interest reductions are likely to affect the consumption of mortgage borrowers across a span of time. We check this possibility, using the local projection methodology of Jordà (2005).

Empirical results show that the significant and negative relationship between mortgagors' interest payments and consumption comes from the borrowers with ARMs. This implies that the share of ARMs can be a source of the transmission mechanism of monetary policy to the real economy. We also find the significant heterogeneity of consumption responses to the mortgage interest reductions across different types of mortgagors. Those who faced by liquidity- or credit-constraints show higher interest-induced MPCs than others. That is, constrained borrowers use the windfall gains by interest reductions to spend rather than to pay down mortgages, implying that these constraints hamper the attainment of optimal consumption level of them. In terms of debt burden, those who with higher debt burden show lower interest-induced MPCs, and this is due to their active deleveraging behaviors. Lastly, the persistence of the effects of interest reduction is also differential across different types of mortgagors. While unconstrained borrowers (high liquidity or credit accessibility) have insignificant or short-term low interest-induced MPCs, constrained borrowers maintain the long-lasting high interest-induced MPCs for eight quarters after interest reductions. These results imply that financial characteristics of mortgage borrowers can affect both the magnitude and the persistence of the cash flow channels of expansionary monetary policy.

Our study complements previous empirical studies in four ways. First, unlike some developed countries such as the U.S., the South Korea has seen the high growth of household debts since the Great Recession and a high proportion of ARM borrowers.³ These two situations provide us a good circumstance to explore mortgage borrowers' consumption responses to declines in interest rates. Second, we overcome several potential measurement error issues other studies have: (i) compared to

²The COFIX is the main reference rate for Korean mortgage rate. See section 3.2 for details.

³According to the OECD statistics, while household debt to net disposable income ratio dropped from 136.87% to 108.78% between 2008 and 2017 in the U.S., it rose from 143.27% to 185.88% in the corresponding periods in South Korea. In terms of ARM shares, according to Bank of Korea and Financial Supervisory Service of Korea, the average share of outstanding balances of fixed-rate mortgages loans is only 14.2% in the end of 2012.

survey data, the card purchase data from the credit bureau company, the measure of consumption, have relatively small measurement errors, and include all kinds of consumption expenditure. This means that card purchases of mortgage borrowers can be a good measure of their durable and non-durable consumption,⁴ (ii) in terms of mortgage loans and their rates, our data are more accurate than previous studies. For instance, Floden et al. (2017) cannot identify mortgage loans in their data, they assume that the main share of homeowners' debts consists of mortgage debt; Jappelli and Scognamiglio (2018) use the self-reported mortgage rates that are likely to have large measurement errors. Third, the data used in this paper gathered by one of credit bureau companies have the comprehensive information on loan- (e.g., principal and interest expenses and sectors mortgages are originated) and borrower-level characteristics (e.g., annual income and credit score). This allows us to analyze the heterogeneous effects of monetary policy on mortgage borrowers' consumption in several dimensions. Fourth, previous studies have not paid attention to the dynamic interest-induced MPCs. We estimate them by local projection method of Jordà (2005), providing the implication on the persistence of cash flow channel induced by the expansionary monetary policy.

From a broad perspective, this paper is related to the theoretical studies on the effects of income changes on consumption. According to traditional theory such as life-cycle and permanent income hypothesis model introduced by Modigliani and Brumberg (1954) and Friedman (1957), anticipated and transitory income shocks should not affect consumption. Furthermore, some papers show the effects of financial constraints on consumption responses to income changes theoretically. Deaton (1991) represent that, in the presence of borrowing constraints, consumption of households can responds forcefully to income changes; Carroll and Kimball (1996) and Carroll (1997) show that households with low income and wealth respond more sensitively to a positive income changes relative to households with high income and wealth. More recently, Kaplan and Violante (2014) provide a theoretical backgrounds for the effects of liquidity constraints on MPC heterogeneity, using a life-cycle model with liquid and illiquid assets. Our empirical works build on these theoretical predictions.

A number of empirical studies verify the theoretical prediction by using the policy changes

⁴The general payment method of Korean people is credit or debit cards, regardless of durable and non-durable goods. According to a survey conducted by the Bank of Korea, about 70.2% of payment transactions were done with credit or debit cards in 2014 and the share increased to 71.0% in 2016. The card transaction data of all card holders are gathered by a credit bureau company for the purpose of credit scoring.

such as tax rebates and Growth Dividend Programme (e.g., Johnson et al., 2006; Jappelli and Pistaferri, 2014; Agarwal and Qian, 2014).⁵ In addition, there is a variety of studies on the effects of financial characteristics on the relationship between income changes and consumption. Kaplan et al. (2014) focus on the effects of liquidity constraints to investigate differences in the MPCs among households by developing the concept of Hand-to-Mouth consumers. Baker (2018) and Mian et al. (2013) have analyzed the effect of a credit buffer on the MPC out of income or out of wealth. Furthermore, two recent papers have paid attention to MPC heterogeneity across the direction of income changes. Bunn et al. (2018) show that households with liquidity shortage, credit constraints, and a higher risk of lower income in the future have higher MPCs after a negative income changes than a positive one; Christelis et al. (2017) show that in the presence of liquidity constraints the MPC from negative income changes is larger than that from positive ones. These results imply that the interest-induced MPCs are also asymmetric by the direction of monetary policy, and thus the results in this paper have to be interpreted in case of expansionary monetary policy.

There is a relatively small body of literature that investigate the relationship between mortgage interest reduction and consumption. La Cava et al. (2016) show that the borrower cash flow channel is more stronger than lender cash flow channel in times of interest rate reduction, which lead to higher aggregate spending in Australia. Using the registry-based data on Swedish households, Floden et al. (2017) show that the consumption of highly indebted homeowners with ARMs responds more sensitively to a change in the monetary policy rate. Di Maggio et al. (2017) shows that a decline in mortgage payments associated with a drop in interest rates causes a significant increase in car purchase by focusing on mortgage borrowers who experience the resets of mortgage rates from fixed- to adjustable-rate in the U.S. They also reveal the heterogeneous responses of car purchase to the decline in mortgage payments across households' income, Loan-to-Value (LTV) ratio, and FICO scores. Unlike these two studies, Jappelli and Scognamiglio (2018) shows the insignificant differences of consumption responses between adjustable-rate (ARM) and fixed-rate mortgage (FRM) borrowers to a reduction in interest rates in Italy. They reveal that this is because since the positive income changes, associated with a reduction of mortgage rates, are perceived as temporary and they are counterbalanced by a drop in income from financial assets.

The remainder of this paper is structured as follows. The next section investigate whether the

⁵See Jappelli and Pistaferri (2010) and Jappelli and Scognamiglio (2018) for more detailed reviews on this issue.

expansionary monetary policy between 2012 and 2017 is unanticipated by using the conventional VAR method. Section 3 introduces the data and main variables used in this study. We will provide details on the data, identification strategy for ARM borrowers, and some measures for key variables. Section 4 describes the empirical methodology used in this paper. We report empirical findings in Section 5 and Section 6 concludes.

2 Unanticipated Monetary Policy

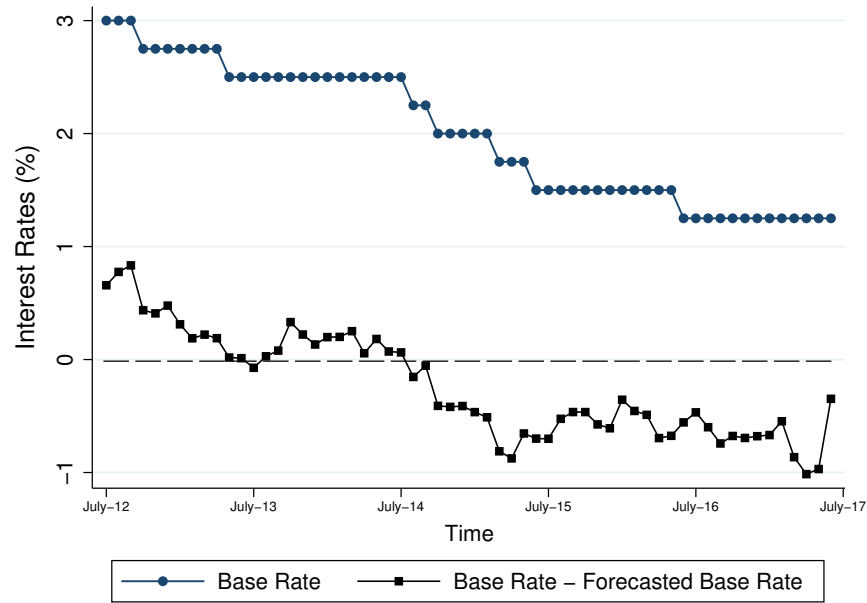
In analyzing the interest-induced MPCs associated with expansionary monetary policy, one of the important issues is whether the expansionary monetary policy is unanticipated. As pointed out by Jappelli and Pistaferri (2010), in the conventional Euler equation for consumption, an anticipated income change should not affect the consumption because consumers would have incorporated the anticipation of income changes in their optimal consumption path. According to the theoretical prediction, if the expansionary monetary policy over the period 2012-2017 is anticipated, the consumption of mortgage borrowers would not (or little) respond to interest payment reductions.

To explore whether the drops of base rates are unanticipated, we estimate a series of base rate shocks by adopting the conventional five-variable VAR with six lags of each variable.⁶ Following Christiano et al. (1999) and Coibion (2012), with monthly data from January 2000 to June 2017 drawn from the Economic Statistics System of Korea and the Commodity Research Bureau, we use the following ordering of five variables: the log of industrial production index (seasonally adjusted), the unemployment rate, the log of the consumer price index, the log of the commodity price index, and the BOK base rate. And then we compute the differences between the actual and forecasted base rates by one year ahead rolling method as a series of monetary policy shocks between July 2012 and June 2017. To allow the coefficients to vary with time, we re-estimate the VAR model every one year after 2012.

Figure 1 shows two trends of interest rates for five years between July 2012 and June 2017. The blue line marked with circle is the trend of BOK base rates. The BOK lowered the base rates by 175 basis points from 3% to 1.25% between July 2012 and June 2017. The black line marked with

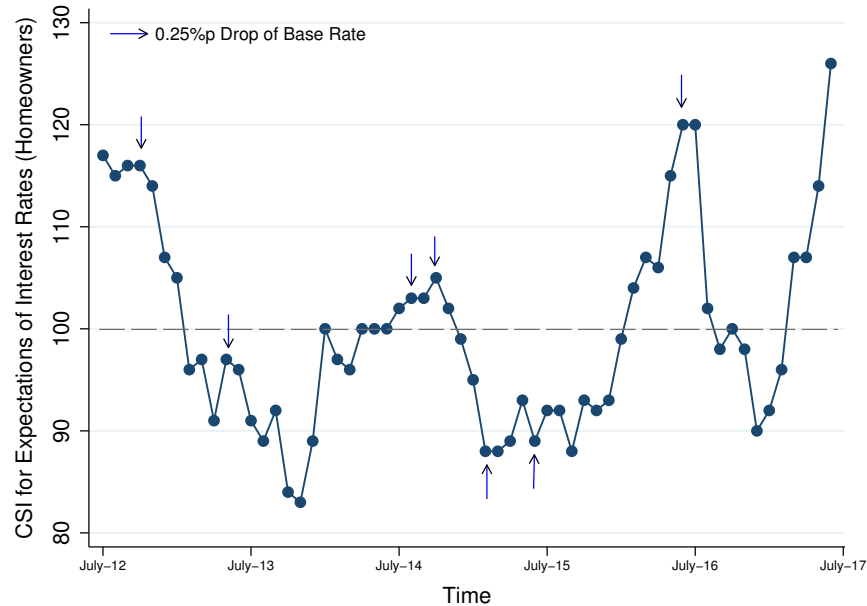
⁶In unreported analysis, we also conduct the VAR with two and twelve lags of each variable. The negative monetary policy shocks that have been shown since July 2014 (the line marked with square in Figure 1) are maintained regardless of lag lengths.

Figure 1: The Difference Between Actual and Forecasted Based Rate



Notes. This figure illustrates two trends of interest rates between July 2012 and June 2017: the BOK base rates and the difference between actual and forecasted based rate by the conventional five-variable VAR with monthly data from January 2000 to June 2017 and one year ahead rolling forecast method. The variables included in the VAR are the log of industrial production index (seasonally adjusted), the unemployment rate, the log of the consumer price index, the log of the commodity price index, the BOK base rate, and six lags of each variable.

Figure 2: Consumer Survey Index for Expectations of Interest Rates (Homeowners)



Notes. This figure illustrates Consumer Survey Index (CSI) for homeowners' expectations of interest rates. If the index is greater than 100, households that forecasted the current interest rates six months ago to rise outnumber those who predicted a fall of them. The blue arrows indicate the month when the BOK base rate have fallen by 0.25%p.

square is the trend of differences between actual and forecasted base rates. It has shown a sizable unanticipated drops in the BOK base rates since July 2014. Figure 2 shows the trend of Consumer Survey Index (CSI) for homeowners' expectations of interest rates, which have been surveyed by the BOK every month since 2008. If the index is greater than 100, households that forecasted the current interest rates six months ago to rise outnumber those who predicted a fall of them.⁷ The blue arrows indicate the month when the BOK base rate have fallen by 0.25%p. According to the CSI, of the seven base rate cuts, four turn out to be unexpected. In particular, the base rate drops in October 2012 and June 2016 seems to have never been anticipated by homeowners. This implies that since our analysis samples include borrowers who appear at least three consecutive years only, all borrowers in our samples experienced the unanticipated drops in the BOK base rate.⁸ Overall, the phenomena shown in Figure 1 and 2 imply that as the expansionary monetary policy are unanticipated, mortgage borrowers would not have considered the mortgage payment reductions associated with the monetary policy in their consumption path in advance.

3 Data and Main Variables

3.1 Data and Sample Selection

Data The data used in this paper come from one of credit bureau companies (NICE Information Service) in South Korea. The credit bureau company has loan-level data of all Korean populations who have debts, including the detailed information on credit card transactions as well as mortgages. The 5% random sample of data is anonymized for the removal of personal identifying information and provided to Bank of Korea (BOK) at a quarterly frequency on the purpose of monitoring the stability of household debt market and academic research. Specifically, the data used in this paper consist of three sets. The first one is loan-level information, including the deidentified borrower ID, financial sector (e.g., commercial bank and saving bank), principal, interest payment, balance, and default status of each mortgage loan. The second one is borrower-level information such as age groups, credit scores, and annual incomes of mortgage borrowers. The third one is the information on credit card, including credit card limit and credit and debit card purchases. To combine these

⁷The detailed formula for calculating the index is as follows: $[(\text{very positive} \times 1.0 + \text{somewhat positive} \times 0.5 + \text{similar} \times 0.0 - \text{somewhat negative} \times 0.5 - \text{very negative} \times 1.0) / \text{total number of household surveyed} \times 100] + 100$.

⁸See section 3.1 for detailed sample selection criteria.

datasets into one borrower-level dataset, we first aggregate the loan-level data into borrower-level data and then connect three datasets using borrower IDs and time variables.⁹ Our data cover from the first quarter of 2012 to the third quarter of 2017 at which monetary policy is expansionary.

Sample Selection Before combining these datasets, we restrict our attentions to obtain our analysis samples. We first drop mortgage loans in arrears. Since the borrowers with mortgage loans in arrears are not paying their interests, their mortgage rates may not be associated with their consumption behaviors. We also exclude the mortgage loans which have the increasing loan rates within sample periods. As mentioned in introduction section, since the purpose of this study is to analyze the effects of expansionary monetary policy on consumption, those who show the rising mortgage rates with some reasons (e.g., the drop of credit score) are not suitable for our study.¹⁰ Furthermore, some outliers are dropped. We first eliminate the mortgages with changes in mortgage rates within sample periods greater than 7.2%p (1% outliers). In addition, in the credit card dataset, we drop the borrowers with the top 1% (greater than 4.98) and the bottom 1% outliers (lower than -0.98) of credit card use growth. We treat such borrowers as extreme outliers or measurement errors. After these processes, we aggregate loan-level data into borrower-level one, and then combine three datasets. In the combined unbalance panel dataset, we restrict our analysis to borrowers who appear in the sample for at least three consecutive years (12 quarters) and have Expenditure to Income Ratio (EIR), defined as principal and interest expenses plus card purchases divided by income at a yearly basis, greater than 1.63 (top 1%) to be regarded as extreme outliers. We also drop the multiple borrowers who have both ARM and FRM to compare the response of consumption to interest payment changes between ARMs and FRMs more clearly.¹¹ The final sample has 106,236 observations over the period of 2012-2017.

⁹The difference between loan- and borrower-level data comes from those with more than one mortgage. To aggregate the loan-level data to borrower-level data, we sum principals, interest payments and balances of mortgage borrowers who have more than one mortgage account.

¹⁰Moreover, several recent studies show the significant MPC asymmetry by the direction of income changes (e.g., Bunn et al., 2018; Christelis et al., 2017). In our study, since the data do not cover the periods of tighten monetary policy and thus the observations of borrowers who show the rising mortgage rates are not sufficient, the MPC asymmetry induced by the sign of interest payment changes cannot be investigated.

¹¹Even though an ARM borrower is defined as those who have at least one ARM loans, the general results are not changed much. However, the differences of response of consumption to interest payment changes between two groups slightly shrink. See section 3.2 for details on identification of ARM and FRM.

3.2 Identification of Adjustable Rate Mortgage Borrowers

To identify ARM borrowers, we first calculate the loan- and borrower-level mortgage rates. The data obtained from the credit bureau company does not provide a loan-rate type of each mortgage. However, since outstanding balances and interest expenses of mortgage loans are provided on a quarterly basis, we can calculate loan-level mortgage rates of loan k held by borrower i at quarter t like this:

$$r_{k,i,t} = \frac{\text{interest expenses}_{k,i,t}}{(\text{mortgage balance}_{k,i,t-1} + \text{mortgage balance}_{k,i,t})/2} \quad (1)$$

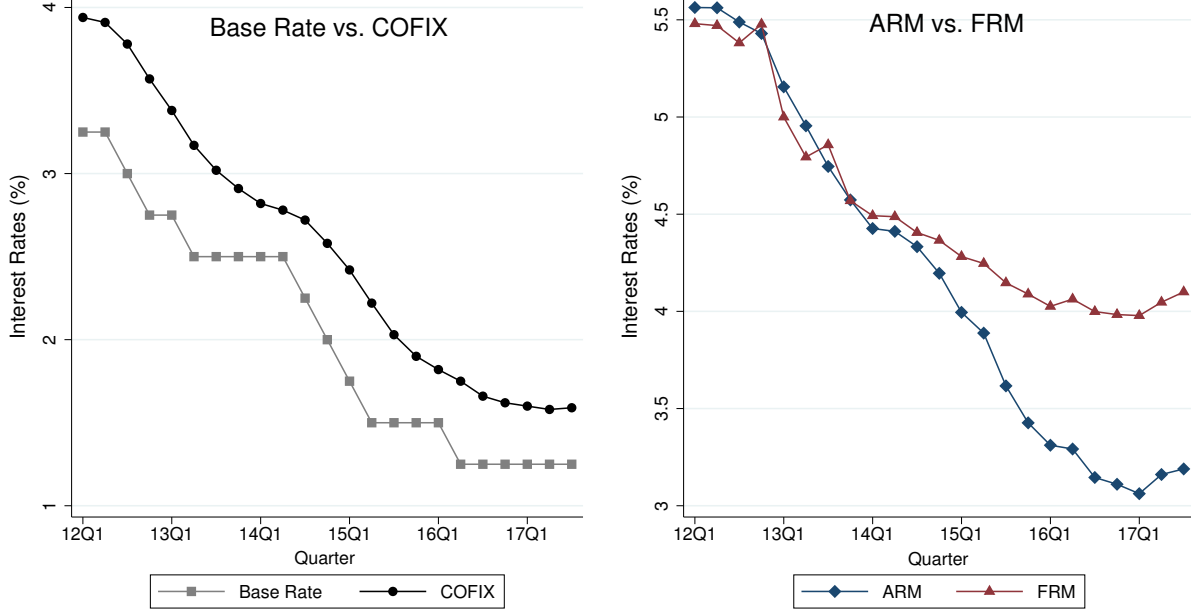
In general, the mortgage rates of this month are determined by the average mortgage balances of previous month and the interest payments of this month. Since we do not have the monthly data, to calculate the loan-level mortgage rates, we use the average balances between current and previous quarter for the denominator and interest expenses of this quarter for the nominator. As mentioned in section 3.1, our analysis data is not loan-level but the combined borrower-level data, it is necessary to calculate the borrower-level mortgage rates. To do it, we average loan-level into borrower-level rates weighted by outstanding balances. If one has a mortgage, two interest rates, loan- and borrower-level loan rates, are the same.

The identification of ARM borrowers is based on the loan- and borrower-level rates. To identify ARM borrowers, we adopt two conditions. The first one is that ARM borrowers have to have mortgage rates that show high correlation with COFIX (Cost of Fund Index), which is a main reference rate for Korean ARMs.¹² Since a loan rate of ARM is generally determined by the sum of COFIX and idiosyncratic spread of each borrower that reflects one's default risk, the variations of COFIX show high correlation with adjustable rates. When the calculated correlation is greater than the median (0.815), we regard the mortgage as a ARM. The average correlation of identified ARMs between COFIX and loan-level rates is 0.925, while that of FRMs shows only 0.333.¹³ If one has several mortgage loans, to be an ARM borrower, all mortgage loans have to meet this condition. The second one is that the variation of mortgage rates in the sample period is larger than half the

¹²The COFIX is calculated based on costs of funding information provided by 8 large banks in Korea. There are three different indexes, COFIX by outstanding balance, COFIX by monthly acquired new funds, and short-term COFIX. We use the COFIX by outstanding balance that is the weighted average of interest rates applied to the outstanding balance of funds at the end of the month. The Korea Federation of Banks (KFB) announces it monthly.

¹³Floden et al. (2017) also utilize this method to identify ARM households.

Figure 3: Trends in Interest Rates



Notes. This figure illustrates the several trends in interest rates. The left panel shows the trends in BOK base rate and COFIX (Cost of Fund Index) and the right one presents the trends in mortgage rates of ARM and FRM borrowers. The borrower-level mortgage rates are calculated by averaging loan-level mortgage rates weighted by outstanding balances. See the texts for details on identification of ARMs and FRMs.

variation of COFIX in the same period. This complements the first condition based on correlation coefficients. Since the correlation coefficients between COFIX and mortgage rates reflect the linear relationship between two variables, if we adopt the first condition only, FRMs can be erroneously identified as ARMs due to some reasons such as renewal of a loan contract. Overall, to be an ARM borrowers, these two conditions have to be satisfied, and conversely, to be an FRM borrowers, those have to violate both conditions.

Figure 3 illustrates the trend in several interest rates over the sample periods. The left panel shows the trends in BOK base rate (the same as the blue line marked with circle in Figure ??) and COFIX. Two interest rates have the similar trends, indicating that monetary policy have much impact on COFIX. The right panel presents the trends in mortgage rates of ARM and FRM borrowers. We can see that the mortgage rates of ARMs drop more steeply than those of FRM ones, suggesting that the consumption of ARM borrowers are likely to be more affected by the expansionary monetary policy.

Table 1: Insolvency and Cash Service Usage by Expenditure to Income Ratio

Groups by EIR	Average EIR (%)	Insolvency Experience Ratio (%)	Cash Service Experience Ratio (%)
Low	0.606	0.049	36.1
Middle	0.961	0.051	39.2
High	1.318	0.065	48.5

Notes. This table shows insolvency and cash service experience ratio (%) by EIR (Expenditure to Income Ratio) groups. The insolvency experience ratio means that the ratio of borrowers who have experience of insolvency more than 5 days overdue in sample periods. The cash service experience ratio indicates that the ratio of borrowers who have experience of using cash service provided by credit card companies within sample periods.

3.3 Some Measures

As mentioned in section 1, the previous theoretical and empirical literatures show that consumption responses to income changes can differ across borrowers' financial characteristics. In this section, We briefly introduce some measures employed in our study that show financial characteristics of mortgage borrowers.

Borrowers' Liquidity In lines of the intuitions of theoretical predictions mentioned in section 1 (e.g., Carroll and Kimball, 1996 and Kaplan and Violante, 2014), we adopt two liquidity measures. The first measure is annual income of borrowers. Those with low income are more likely to face the liquidity constraints that hamper the attainment of optimal consumption level. The second measure is the Expenditure to Income Ratio (EIR), which is defined as principal and interest expenses of all debts plus card purchases divided by their income. We judge that if the EIR of a borrower is higher, the one is likely to have less liquid asset on average. There are two evidence for the plausibility of EIR as a measure of liquidity of mortgage borrowers. The one is that the ratio of borrowers with experience in arrears within the sample periods is higher in borrowers with high average EIR. We divide borrowers into three groups using average EIR, and then calculate the share of borrowers who have experience of insolvency (more than 5 days overdue) of each group. The corresponding values of those groups are 0.049%, 0.051%, and 0.065%, respectively (column (3) in Table 1). This indicates that borrowers with high average EIR are likely to suffer more from liquidity constraints relative to those with low average EIR.

Another evidence for the robustness of EIR as a measure of mortgage borrowers' liquidity comes

from a financial product provided by credit card companies in Korea. The credit card holders can borrow the cash in Automated Teller Machine (ATM) using their credit cards, and repay it in their next settlement day with a high rate of interest.¹⁴ Using this service means that the borrower suffers from the scarce of cash liquidity. In column (4) of Table 1, we calculate the share of mortgage borrowers who have experiences of using the cash service by each EIR group. The corresponding values are 36.1%, 39.2%, and 48.5%, respectively. Like the insolvency ratio, the higher average EIR is, the higher the ratio of cash service users will be. From these two evidences, we judge that the EIR is a quite proper measure for mortgage borrowers' liquidity.

Credit Accessibility We employ two empirical proxies to capture the variation in credit accessibility of mortgage borrowers: credit bureau score of borrowers and sectors where mortgages are originated (e.g., commercial bank vs. non-commercial bank). The credit bureau scores are frequently used to capture the credit accessibility of borrowers in the previous studies. Since the mortgage borrowers with low credit score face the borrowing constraints that impede the consumption smoothing behaviors, their consumptions are likely to react more sensitively to mortgage interest reductions.

The second measure of credit accessibility, sectors where mortgages are originated, comes from the unique situation of household debt market of Korea. In general, all mortgage borrowers in Korea prefer commercial banks to non-commercial banks due to low financial costs.¹⁵ Some borrowers, however, have mortgages originated in non-commercial banks with two reasons. The first one is low quality of collaterals they have. Since mortgage applications with unqualified collaterals are likely to be rejected in the banking-sectors, ones with low quality of collaterals are forced to apply the mortgages in non-banking sectors. The second one is due to the differences of Loan-To-Value (LTV) regulation among sectors. Since LTV regulation in Korea is more loosened in non-commercial banks, if one wants to borrow more than LTV regulation applied to the banking sector, she/he may apply for loans in non-commercial banks with high mortgage rates. The borrowers with mortgages originated in non-commercial banks may face more tightened borrowing constraints because their credit histories of having loans in non-commercial banks may have negative effects on credit limits of them

¹⁴According to the Credit Finance Association in Korea, the interest rates of cash service provided by credit card companies vary with borrowers' credit scores. On average, the interest rates were close to 20% in the third quarter of 2013.

¹⁵The difference of mortgage rates between two sectors is about 0.96%p in our samples.

such as credit card limit and unsecured loan limit, and they cannot borrow additional loans using their houses as collateral due to high LTV ratio. These two factors may impede their consumption smoothing behaviors. We therefore judge that the sectors where mortgages are originated can be a plausible measure to capture the credit accessibility of mortgage borrowers.

Debt Burden Although a variety of studies have shown the relationship between debt burden and consumption, few works have studied the effects of debt burdens of borrowers on interest-induced MPCs. To investigate the link between debt burden of mortgage borrowers and interest-induced MPCs, we use Loan-To-Income (LTI) ratio as a measure of debt burden. While some studies adopt Loan-To-Value (LTV) ratio to capture the effects of loan amount on consumption of mortgage borrowers (e.g. Di Maggio et al., 2017; Andersen et al., 2014), others choose Debt-to-Service Ratio (DSR) or LTI to do it (e.g. Floden et al., 2017; Johnson et al., 2007). Since LTV ratio is a measure of debt burden which puts a bigger emphasis on collateral value rather than borrowers' income, it is more suitable for the economy in which housing prices show large fluctuation like the U.S. of the 2008 Great Moderation. Unlike the U.S., since the housing prices of Korea have risen over the sample period and this is one of the factors that lead to high debt burden of the Korean households due to the positive expectations on housing prices, we judge that LTI is a more compatible measure for debt burden of mortgage borrowers.

3.4 Summary Statistics

This section describes the summary statistics of main variables identified and defined in section 3.2 and 3.3. Table 2 reports the summary statistics for the main variables. Our sample consists of 72,393 ARM and 33,843 FRM borrowers. The first column in Table 2 show the statistics for all samples, and the second and third columns are for ARM and FRM borrowers, respectively. The fourth column shows the difference of each variable between ARM and FRM borrowers. According to t-test results for the differences, all differences are statistically significant at least at the 10% level. We report all monetary values in Korean Won (KRW) and amount unit is a hundred thousand won.¹⁶

On average, ARM borrowers use credit and debt cards slightly (Total Purchases) more than

¹⁶The average exchange rate to the U.S. dollar is about 1,116 KRW/USD over the period 2012-2017.

Table 2: Summary Statistics

	All	ARM	FRM	Difference
Card Purchases				
Total Purchases	47.91	50.07	43.29	6.78
Credit Card Purchases	44.38	46.56	39.72	6.84
Debit Card Purchases	3.34	3.29	3.43	-0.14
Credit Card Limit	150.31	159.22	131.26	27.95
Mortgage-related				
Mortgage Rates (%)	4.23	4.14	4.43	-0.28
Balance	928.45	1098.59	564.51	534.08
Interest Payments	9.36	10.95	5.97	4.98
Liquidity				
Income	453.97	469.55	420.65	48.90
Expenditure to Income Ratio	0.53	0.55	0.49	0.06
Credit Accessibility				
Credit Score	858.43	859.54	856.07	3.47
Share of Commercial Bank	0.70	0.68	0.76	-0.08
Loan-to-Income Ratio	2.09	2.42	1.38	1.04
Observations	106,236	72,393	33,843	-

Notes. This table shows the summary statistics of main variables used in this paper. We report all monetary values (card purchases, mortgage balance, interest payments, and Income) in Korean Won (KRW) and amount unit is a hundred thousand won. All differences between ARM and FRM in fourth column are statistically significant at least at the 10% level.

FRM ones. Moreover, credit card limits of ARM borrowers are also higher than FRM borrowers, indicating that the credit card limits have to be controlled to eliminate the effects of the limits on card purchases in analyzing the relationship between mortgage rates and consumption. In terms of mortgage-related variables, the FRM borrowers show higher average mortgage rate over the sample periods, as seen in Figure 3. The mortgage balance and interest payments show great gaps between two mortgage types, suggesting that borrowers who need large amounts of mortgage are likely to choose ARMs to reduce the financial costs in the short term.¹⁷

In terms of mortgage borrowers' liquidity, the ARM borrowers have higher average annual income level and EIR ratio than FRM borrowers. Despite higher incomes, ARM borrowers' higher EIR ratio is due in part to their high debt burden. With respect to the measures of credit accessibility, the credit score is slightly higher for ARM borrowers, and the share of mortgage originated

¹⁷Several studies show that the choices of mortgage types are myopic. Badarinza et al. (2017) show that households tend to take the longer-term rate movements lightly to maintain the level of current consumption. Using the Bank of Italy's Survey of Household Income and Wealth, Paiella and Pozzolo (2007) also reports that ARM borrowers do not fully consider the risk of a rise in the interest rates in the future.

commercial banks is lower in ARMs than FRMs. This is because almost all mortgages originated in non-commercial banks are ARMs. Lastly, LTI ratio, a measure of debt burden, is higher in ARM borrowers than FRM ones.

4 Econometric Methodology

As mentioned in introduction section, this paper aims at resolving these questions: 1) the different responses of consumption to mortgage rates between ARM and FRM borrowers, 2) the heterogeneous static and dynamic interest-induced MPCs within ARM borrowers across several groups divided by liquidity constraints, credit accessibility and debt burden. In this section, we introduce the econometric methodologies to answer these questions.

To examine whether the consumption of ARM borrowers is more sensitive to interest rates, we interact interest rates ($IR_{i,t}$)—COFIX or borrower-level mortgage rates—with a dummy variable (ARM_i) that has 1 if one is an ARM borrower. Consider the following regression:

$$CP_{i,t} = \alpha + \beta_1 IR_{i,t} + \beta_2 (IR_{i,t} \times ARM_i) + X_{i,t} \Phi + \delta_i + \varepsilon_{i,t} \quad (2)$$

where $CP_{i,t}$ denote the credit and debit card purchases of borrower i at period t . $X_{i,t}$ is a set of control variables including borrowers' income, credit card limit, credit score, age group dummies, year and season dummies. δ_i is fixed effects of borrowers. The focus in this equation is on the significances and signs of β_1 and β_2 . In this specification, since the intertemporal substitution channel of monetary policy, that affects all borrowers regardless of mortgage types, is absorbed by year fixed effects included in $X_{i,t}$, β_1 and β_2 capture the effects of cash flow channel of monetary policy on consumption of FRM and ARM borrowers, respectively. If β_1 and β_2 are negative and the absolute value of β_2 is greater than that of β_1 , this result suggests that the effects of expansionary monetary policy on consumption of mortgage borrowers are more larger in ARM than FRM borrowers. On the contrary, if the difference of consumption responses between ARM and FRM borrowers is not significant, the estimated β_2 will be insignificant.

In the second place, we conduct the regressions to estimate the heterogeneous interest-induced MPCs by splitting samples into several groups using the measures of liquidity, credit accessibility,

and debt burden. The empirical specification is as follows:

$$CP_{i,j,t} = \alpha_j + \beta_j INT_{i,j,t} + X_{i,j,t} \Phi_j + \delta_i + \varepsilon_{i,t} \quad (3)$$

where $INT_{i,j,t}$ denote interest expenses of borrower i who belongs to group j at period t . Other variables and indexes in the equation (3) are totally same as those in the equation (2), except for year dummies. Contrary to the equation (2), we do not include year dummies as one of control variables in the equation (3) to capture the effects of interest payment reduction on MPCs clearly.¹⁸ The main interest in the equation (3) is the heterogeneity of β_j across group j , which shows the interest-induced MPC. Moreover, if needed, we use the interaction terms between interest expenses and dummy variables for several groups to illustrate the statistical significances in differences of interest-induced MPCs among groups.

Lastly, we explore the dynamic interest-induced MPCs that would be caused by the reduction of interest expenses, using the local projection method developed by Jordà (2005). He shows that an impulse response function estimated by a local projection method is robust to a mis-specification of the data generating process and can accommodate nonlinearities that would be intractable in VARs. As we know, since interest rate is one of the economic variables that show high persistency, the changes in interest rate can affect mortgage borrowers' consumption throughout various periods. In particular, we focus on the different dynamics of interest-induced MPCs among borrowers with contrasting financial characteristics by using the various measures used in Section 3.3. Except for a dependent variable, the specification of local projections is quite similar with the equation (3):

$$CP_{i,j,t+k} = \alpha_j^k + \beta_j^k INT_{i,j,t} + X_{i,j,t} \Phi_j^k + \delta_i + \varepsilon_{i,j,t+k} \quad (4)$$

As seen in equation (4), a local projection method is based on simple regressions of the endogenous variable shifted forward. In equation (4), $CP_{i,t+k}$ denote the card purchases of borrower i at period $t + k$. The control variables, $X_{i,t}$, are totally same as the equation (3). The main interests in equation (4) are β_j^k for $k = 0, 1, 2, \dots, K$, that show the dynamic interest-induced MPCs. We restrict

¹⁸To be specific, this is due to two reasons. The first one is that if year dummies are included, the estimated interest-induced MPCs, β_j , are within-year estimates. Since interest payments show little variation within a year, the MPCs are not well-identified under this specification. The second one is that as interest payments decrease consistently within the sample periods, the year dummies can absorb the effects of reduction of interest payments on consumption.

our attention to eight quarters including $k = 0$ ($K = 7$). In the estimations of all equations mentioned above we use borrower-based cluster-robust standard errors.

5 Main Results

This section consists of three parts. In the first part, to observe the effects of mortgage interest reduction on consumption, we begin with regressions that illustrate the relationship between interest rates (COFIX and borrower-level loan rates) and card purchases. We will show the contrasting responses of consumption to interest rates between ARM and FRM borrowers. In the second part, we estimate the interest-induced MPCs for ARM borrowers by dividing samples into several groups using the measures of borrowers' liquidity, credit accessibility, and debt burden. We will show the heterogeneous interest-induced MPCs across those groups. In the third part, we observe the dynamics of interest-induced MPCs and their heterogeneity across groups using the local projection method of Jordà (2005).

5.1 Interest Rates and Consumption: ARM vs. FRM

The main interest of this section is whether the responses of consumption to interest rates differ between ARM and FRM borrowers. The results presented in column (1)-(3) of Table 3 show the effects of COFIX on mortgage borrowers' consumption in all samples. The column (1) includes only COFIX as a independent variable, and in column (2) we add the several control variables that can affect borrowers' consumption. The regression results show that while the unconditional association between COFIX and consumption is negative and significant (column (1)), the conditional one is not significant (column (2)). This indicates that the significant coefficient of COFIX in column (1) comes from the association between COFIX and control variables.¹⁹ In column (3), we add the interaction between COFIX and an ARM dummy variable to look at different responses of consumption between ARM and FRM borrowers. While the coefficient of COFIX is not significant, that of the interaction term is negative and significant at the 1% level. This result indicates that

¹⁹There may be several direct and indirect effects of expansionary monetary policy on control variables. For instance, the expansionary monetary policy may affect mortgage borrowers' income positively, and this can lead to the significant relationship between COFIX and mortgage borrowers' consumptions in column (1). Furthermore, such increase in annual income can affect the credit card limit of mortgage borrowers. The different result between column (1) and (2) may be attributed to these direct and indirect effects.

Table 3: Interest Rates and Consumption of Mortgage Borrowers

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All		Single Mortgage		All		Single Mortgage	
COFIX	-2.088*** (0.214)	0.067 (0.920)	1.119 (0.966)	1.098 (0.987)				
COFIX \times ARM			-1.478*** (0.430)	-1.352*** (0.439)				
Mortgage Rate					-1.470*** (0.162)	-0.518*** (0.176)	0.33 (0.260)	0.21 (0.264)
Mortgage Rate \times ARM							-1.142*** (0.345)	-0.996*** (0.350)
Income		0.021*** (0.002)	0.021*** (0.002)	0.021*** (0.002)		0.021*** (0.002)	0.021*** (0.002)	0.021*** (0.002)
Credit Card Limit		0.059*** (0.004)	0.060*** (0.004)	0.061*** (0.004)		0.059*** (0.004)	0.060*** (0.004)	0.060*** (0.004)
Credit Score		0.028*** (0.004)	0.028*** (0.004)	0.027*** (0.004)		0.028*** (0.004)	0.027*** (0.004)	0.027*** (0.004)
Constant	53.122*** (0.535)	-4.597 (5.309)	-4.581 (5.306)	-4.294 (5.421)	54.133*** (0.686)	-1.192 (3.767)	-1.308 (3.765)	-0.659 (3.834)
Year Dummy	X	O	O	O	X	O	O	O
Season Dummy	X	O	O	O	X	O	O	O
Age Dummy	X	O	O	O	X	O	O	O
Overall R^2	0.001	0.25	0.24	0.24	0.01	0.249	0.232	0.235
Observation	106,236	106,236	106,236	101,288	106,236	106,236	106,236	101,288

Notes. This table shows the effects of interest rates (COFIX and borrower-level mortgage rates) on credit and debit card purchases. The dependent variable is total amount of card purchases. The COFIX (Cost Of Fund IndeX) is a reference rate of mortgage rates, calculated based on costs of funding information provided by 8 Korean domestic banks. The mortgage rate is a borrower-level rate. *Single Mortgage* means those who have single mortgage loan. Standard errors clustered by borrowers are in parentheses. *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.

the insignificant coefficient of COFIX presented in column (2) is attributed to FRM borrowers, and the consumptions of borrowers with ARM respond more sensitively to COFIX.

In column (5)-(7), we conduct the same regressions as in column (1)-(3), but we alter COFIX into borrower-level mortgage rates. The regression result of column (5) is similar to that of column (1). The unconditional relationship between mortgage rate and consumption is significant and negative. Contrary to the result of column (2), in column (6), the association between mortgage rate and consumption is significant even after controlling for the several variables that can affect mortgage borrowers' consumption. This is because while COFIX is highly uncorrelated with the consumption of borrowers with FRMs, the mortgage rate is relatively more correlated with both the consumptions of borrowers with ARM and those with FRM. Like column (3), the result of column (7) shows that

while the coefficient of borrower-level mortgage rate is insignificant, that of interaction term between mortgage rate and an ARM dummy variable is negative and significant at the 1% level.²⁰

Lastly, in column (4) and (8), we conduct the same regressions as column (3) and (7) for those with single mortgage. The purpose of these regressions is to observe whether the significant coefficients of interaction term between interest rates and ARM are mainly attributed to those with multiple mortgages. If the above results are dominated by those with multiple mortgages that show much smaller share than those with single mortgages (4.6% vs 95.4%), the empirical analysis that will go on would not be meaningful. Since borrowers with multiple mortgages are likely to buy houses for investment purposes rather than a primary residence, their consumption can be far more sensitive to drops in interest payments than that of those with single mortgage. This is due to two reasons. The first one is that multiple mortgage debtors are likely to have low liquidity or credit accessibility owing to their high debt. This can make their consumption to be sensitive to interest payments. The second one is wealth effects. If the decrease in interest rates led to the increase of house prices in our sample period, the estimated coefficients of interaction terms would be largely affected by wealth effects of those with multiple mortgages.²¹ The results show that while the estimated coefficients of interaction terms are slightly changed, these changes are not meaningful statistically. This means that the results shown in column (1)-(3) and (5)-(7) are dominated by those with single mortgage who are likely to be less affected by wealth effects by changes in housing prices.

The results in Table 3 can be summarized like this. The decrease in COFIX caused by the expansionary monetary policy is translated into the drop in mortgage rates of ARMs borrowers, this leads to the increase in consumption of them. While the consumption of borrowers with FRM is less sensitive to mortgage rates, that of borrowers with ARM responds forcefully to reduction in mortgage rates. These results imply that the cash flow channel of expansionary monetary policy is valid only for the borrowers with ARM.

²⁰In Table A1 of Appendix, we conduct the same regression as model (3) and (6) in Table 3, using several alternative definitions of ARM borrowers. According to the results, when the definition of ARM borrowers becomes more tightened (e.g., those who have a correlation between mortgage rates and COFIX greater than 75% percentile rather the median), the estimated coefficients of interaction terms between interest rates and ARM tend to be larger. This result indicates that the conditions for definition of ARM borrowers are plausible to observe the different consumption responses to interest rates between ARM and FRM borrowers. See the notes in Table A1 for details.

²¹Choi et al. (2015) show that the effect of housing prices on consumption of those with single mortgage is modest in South Korea economy.

Table 4: Interest Expenses and Consumption by Income Level

	(1)	(2)	(3)	(4)	(5)	(6)
	ARM					
	All	All		High Income		Low Income
Interest	-0.292*** (0.080)	-0.302*** (0.086)	-0.456*** (0.083)	-0.563*** (0.138)	-0.186* (0.109)	-0.626*** (0.080)
Interest \times High Income			0.201*** (0.044)			
Interest \times Income				0.034* (0.078)		
Income	0.021*** (0.002)	0.022*** (0.003)	0.019*** (0.003)	0.017*** (0.004)	0.018*** (0.005)	0.047*** (0.004)
Credit Card Limit	0.056*** (0.004)	0.058*** (0.005)	0.058*** (0.005)	0.058*** (0.005)	0.059*** (0.007)	0.049*** (0.006)
Credit Score	0.034*** (0.004)	0.032*** (0.005)	0.031*** (0.005)	0.031*** (0.005)	0.039*** (0.009)	0.023*** (0.004)
Constant	-6.845* (3.949)	-4.115 (5.084)	-0.917 (5.061)	0.642 (5.249)	-6.089 (10.434)	-3.73 (4.688)
Overall R^2	0.172	0.167	0.17	0.162	0.121	0.033
Observation	106,236	72,393	72,393	72,393	35,465	36,928

Notes. This table shows the effects of mortgage interest payments on card purchases by income level. The dependent variable is total amount of card purchases. *High Income* is a dummy variable, which equals 1 if a borrower's income is larger than the median within each period. All models include age and season dummies. Standard errors clustered by borrowers are in parentheses. *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.

5.2 The Heterogeneity of Interest-Induced MPCs

From now on, we investigate the interest-induced MPC and its heterogeneity by liquidity constraints, credit accessibility, and debt burden. Since we in the above section show that the significant association between mortgage rates and consumption comes only from borrowers with ARM, we will focus on them.

5.2.1 Liquidity Constraints

In this section, we explore the role of liquidity constraints, measured by mortgage borrowers' income and EIR ratio, in the association between interest payment reduction and consumption. Table 4 presents the interest-induced MPCs by income level of mortgage borrowers. In column (1) of Table 4, we first estimate the interest-induced MPC for all samples. The result shows that on average the estimated interest-induced MPC is 0.292. That is, lowering mortgage interest expenses by 100 KRW

is associated with card purchases rising by 29.2 KRW. In column (2), we run the same regression as column (1) for ARM borrowers. The estimated MPC (0.302) is similar to that of the whole sample, indicating that the significantly estimated MPC in column (1) stems from ARM borrower.²²

The column (3) to (6) of Table 4 demonstrate the robust link between borrowers' incomes and interest-induced MPCs. As seen in column (3), the interaction between interest expenses and a dummy variable, which equals 1 if a borrower's income is larger than the median within each period, enters positively and significantly. In column (4), we add the interaction between interest expenses and borrowers' incomes instead of the dummy variable for borrowers with high income. The coefficient of interaction term is also positive and significant at the 10% level. In column (5) and (6), to allow the control variables to respond differently across income level, we divide the samples into those with high and low income and conduct the regressions separately. According to the results, the interest-induced MPC is about three times larger for borrowers with low income than those with high income. These results of column (3) to (6) reveal that consumption of borrowers with high income is less sensitive to mortgage interest payments.

In Table 5, we investigate the relationship between interest-induced MPC and mortgage borrower's EIR. To do it, we divide the sample into two groups, low and high EIR borrowers, using the median of EIR within each period. Column (1) and (4) in Table 5 show that the interest-induced MPC of low EIR borrowers (0.343) is lower than that of high EIR ones (0.603). This result provides the possibility that the level of EIR, one of the measure of borrowers' liquidity, affects the response of consumption to mortgage interest reduction significantly.

However, since the EIR is a ratio variable, the effects of EIR on MPC heterogeneity can be also affected by income levels of mortgage borrowers. For instance, though borrowers have the same EIR, if income levels are different, their responses of consumption can vary with their income levels. To check the possibility, in column (2), (3), (5) and (6), we conduct the same regression as column (1) and (4) by income levels of borrowers. Three results are noteworthy. The first one is that the result shown in column (1) and (4) is maintained within two income groups. Regardless of income level, the interest-induced MPC of borrowers with high EIR is larger than that of those with low EIR. The second one is that although the borrowers belong to low income group, if their EIR is not high,

²²In unreported regression, we also conduct the same regression for FRM borrowers. The estimated MPC of them is not significant. This result is natural because the variations in interest expenses of FRM borrowers are little.

Table 5: Interest Expenses and Consumption by EIR Ratio and Income Level

	(1)	(2)	(3)	(4)	(5)	(6)
	Low EIR			High EIR		
	All	Low Income	High Income	All	Low Income	High Income
Interest	-0.343*** (0.043)	-0.422*** (0.049)	-0.300*** (0.054)	-0.603*** (0.102)	-0.988*** (0.097)	-0.453*** (0.129)
Income	0.029*** (0.002)	0.035*** (0.003)	0.031*** (0.003)	0.097*** (0.005)	0.111*** (0.006)	0.097*** (0.009)
Credit Card Limit	0.017*** (0.003)	0.017*** (0.003)	0.016*** (0.004)	0.052*** (0.006)	0.040*** (0.007)	0.055*** (0.008)
Credit Score	0.025*** (0.003)	0.022*** (0.003)	0.029*** (0.005)	0.017*** (0.006)	0.010** (0.005)	0.018 (0.013)
Constant	-12.447*** (3.169)	-13.818*** (2.879)	-15.604** (7.724)	4.438 (6.385)	10.533* (5.376)	0.684 (14.939)
Overall R^2	0.422	0.159	0.312	0.452	0.247	0.298
Observation	36,211	17,492	18,719	36,182	19,436	16,746

Notes. This table shows the effects of mortgage interest payments on card purchases by Expenditure to Income Ratio (EIR) and income level. The dependent variable is total amount of card purchases. *Low (high) EIR* means borrowers with EIR smaller (greater) than the median EIR within each quarter. All models include age and season dummies. Standard errors clustered by borrowers are in parentheses. *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.

their interest-induced MPC (0.422) is modest. In particular, it is analogous with that of borrowers with high EIR and income (0.453). The third one is that the difference of interest-induced MPC between borrower with sufficient liquidity (high income and low EIR) and those with insufficient liquidity (low income and high EIR) is exceedingly large (0.300 vs. 0.988). These results indicate that borrowers' liquidity plays a critical role in the heterogeneity of interest-induced MPCs across mortgage borrowers.

5.2.2 Credit Accessibility

We here explore the effect of credit accessibility on the relationship between mortgage payment reduction and consumption. Table 6 presents the interest-induced MPCs by splitting samples into several groups by the measures of credit accessibility, credit scores and sectors where mortgages are originated. Column (1) and (2) of Table 6 show that the consumption of borrowers with low credit scores has a much stronger response to mortgage interest reduction than that of those with high credit scores (0.430 vs. 0.06). Moreover, the estimated interest-induced MPC of borrowers with low

Table 6: Interest Expenses and Consumption by Credit Accessibility

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	All		Commercial Bank		Non-Commercial Bank		Low Liquidity		High Liquidity	
Credit Scores	Low	High	Low	High	Low	High	Low	High	Low	High
Interest Expenses	-0.430*** (0.110)	-0.06 (0.124)	-0.311 (0.194)	0.046 (0.137)	-0.549*** (0.104)	-0.518*** (0.162)	-1.033*** (0.129)	-0.703*** (0.146)	-0.323** (0.137)	-0.013 (0.136)
Annual Income	0.026*** (0.005)	0.017*** (0.003)	0.022*** (0.005)	0.014*** (0.004)	0.040*** (0.008)	0.034*** (0.010)	0.113*** (0.009)	0.103*** (0.008)	0.029*** (0.006)	0.020*** (0.004)
Credit Card Limit	0.072*** (0.010)	0.054*** (0.005)	0.061*** (0.012)	0.054*** (0.006)	0.098*** (0.015)	0.054*** (0.012)	0.047*** (0.011)	0.039*** (0.008)	0.066*** (0.012)	0.053*** (0.006)
Credit Score	0.021*** (0.005)	0.214*** (0.022)	0.020*** (0.007)	0.238*** (0.024)	0.021*** (0.007)	0.130*** (0.048)	0.006 (0.006)	0.173*** (0.029)	0.025*** (0.007)	0.206*** (0.027)
Constant	0.787 (5.824)	-158.726*** (21.365)	6.865 (7.953)	-191.103*** (22.748)	-6.661 (8.461)	-70.725 (43.741)	16.379*** (6.301)	-134.227*** (27.566)	-14.056* (7.602)	-154.893*** (25.794)
Overall R^2	0.149	0.222	0.153	0.221	0.149	0.188	0.272	0.282	0.245	0.288
Observations	36,931	35,462	21,687	27,325	15,244	8,137	11,176	8,260	25,755	27,202

Notes. This table shows the effects of interest payment reduction on card purchases by credit accessibility of mortgage borrowers. The dependent variable is total amount of card purchases. *Low (high) credit score* means borrowers with credit score smaller (greater) than the median score within each quarter. *Low liquidity* means borrowers with low income and high EIR ratio and *high liquidity* means others than those with low liquidity. All models include age and season dummies. Standard errors clustered by borrowers are in parentheses. *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.

credit scores is statistically significant at 1% level, while the corresponding estimate of those with high credit scores is not. This result provides the possibility that the credit accessibility measured by credit scores is one of the sources that affect the heterogeneity of interest-induced MPCs across mortgage borrowers.

In column (3)-(6) of Table 6, to observe the effects of sectors mentioned above, we additionally divide the sample into two groups, borrowers with mortgages originated in commercial banks (column (3) and (4)) and non-commercial banks (column (5) and (6)). According to the results, the consumption of those with mortgages in commercial banks are less sensitive to interest reduction than that of those with mortgages in non-commercial banks. While the interest-induced MPCs of borrowers with mortgages in commercial banks are not statistically significant, those of borrowers with mortgages in non-commercial banks are highly significant, regardless of credit scores. While the results of column (4) and (5) are plausible, those of column (3) and (6) need more explanations to interpret them. The result of column (3), insignificant interest-induced MPCs of borrowers with commercial bank mortgages and low credit scores, may come from the tightened LTV regulation of commercial banks. As mentioned in section 3.3, since the LTV regulation is more tightened in commercial banking sector than others, those with mortgages in commercial bank can borrow the second loan in other sectors. This enhances access to credit of those with mortgages in commercial bank, although they have low credit scores. The result of column (6), high and significant MPCs of borrowers with non-commercial bank and high credit score, may stem from two reasons. First, in spite of high credit score, having debts in non-commercial bank is a bad signal to credit suppliers in the household debt market of Korea. As mentioned in section 3.3, this can restrict other credit activities such as borrowing unsecured loans. Second, since the LTV regulation for non-commercial banks is relatively loosened, the mortgages originated in non-commercial banks have higher LTV ratio on average. The high LTV ratio of borrowers with mortgages originated in non-commercial banks may restrict the additional loans using their houses as collaterals.

Finally, in column (7) to (10) of Table 6, we estimate the interest-induced MPCs by dividing samples into additional two groups by liquidity constraints, borrowers with low liquidity (low income and high EIR) and those with high liquidity (other than those with low liquidity). In the regression results of in column (7) to (10), two things are noteworthy. The first one is that the consumption of borrowers with low credit scores is more sensitive to mortgage interest reduction within each

liquidity group. This implies that liquidity constraints and credit accessibility are complementary sources of heterogeneous interest-induced MPCs. The second one is that the interest-induced MPC of borrowers with low liquidity and high credit score is higher than that of those with high liquidity and low credit score (0.703 vs. 0.323). This means that although liquidity constraint and credit accessibility are complementary factors of MPC heterogeneity, liquidity constraints affect interest-induced MPCs more largely than credit accessibility.

Overall, the results of Table 6 show that credit accessibility, which is measured by credit score of mortgage borrowers and sectors where mortgages are originated, is a significant factor that affect MPC heterogeneity, together with liquidity constraints of mortgage borrowers.

5.2.3 Debt Burden

In this section, we investigate the effects of mortgage borrowers' debt burden on interest-induced MPCs, using Loan-To-Income (LTI) ratio as a measure of it. The LTI ratio can have high correlation with liquidity constraints and credit accessibility. For instance, low LTI ratio can be due to low credit accessibility. In this case, if the borrowers with low LTI ratio show higher interest-induced MPCs than others, it is due to not LTI ratio but credit accessibility. In addition, since the borrowers with high LTI ratio are likely to have tightened liquidity constraints due to high financial costs, the interest-induced MPC of them would be similar to that of liquidity-constrained borrowers. Hence, we estimate the interest-induced MPCs for borrowers with high liquidity (excluding those with low income and high EIR) and credit accessibility (excluding those with low credit score and non-commercial banking sector mortgages) as well as the whole sample.

In columnn (1)-(4) of Table 7, we first divide the samples into two groups, borrowers with lower and higher LTI than the median LTI within each period. And then we estimate the interest-induced MPCs for the whole sample (All) and for the unconstrained borrowers (Uncons.). In column (1) and (2), we run the regressions for mortgage borrowers with low LTI in the whole sample and in the restricted sample. According to the results, The interest-induced MPC (0.62) is significant at the 10% level in column (1), while it is not significant in column (2). These results indicate that the significant interest-induced MPC of borrower with low LTI is due to the effects of liquidity constraints and credit accessibility. In column (3) and (4), we conduct the same regression as the column (1) and (2) for the mortgage borrowers with high LTI. The estimated interest-induced MPCs

Table 7: Interest Expenses and Consumption by Debt Burden

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Card Purchases				Principal Payments			
	Low LTI		High LTI		Low LTI		High LTI	
	All	Uncons.	All	Uncons.	All	Uncons.	All	Uncons.
Interest Expenses	-0.620*	-0.579	0.04	0.225	-0.018	-0.012	-0.063***	-0.052***
	(0.323)	(0.369)	(0.124)	(0.147)	(0.011)	(0.013)	(0.015)	(0.019)
Annual Income	0.021***	0.024***	0.031***	0.035***	0.021***	0.024***	0.033***	0.038***
	(0.004)	(0.005)	(0.004)	(0.007)	(0.004)	(0.005)	(0.004)	(0.007)
Credit Card Limit	0.029***	0.041***	0.018***	0.014	0.033***	0.043***	0.021***	0.017*
	(0.007)	(0.010)	(0.006)	(0.011)	(0.007)	(0.010)	(0.006)	(0.010)
Credit Score	0.061***	0.052***	0.056***	0.049***	-	-	-	-
	(0.007)	(0.007)	(0.007)	(0.010)	-	-	-	-
Constant	3.46	-1.906	1.475	2.537	6.505	0.324	7.391	12.77
	(8.111)	(10.270)	(6.099)	(11.129)	(7.777)	(9.585)	(5.505)	(10.604)
Overall R^2	0.209	0.301	0.274	0.311	0.125	0.217	0.191	0.236
Observations	29,740	19,744	42,653	24,047	29,740	19,744	42,653	24,047

Notes. This table shows the effects of interest payment reduction on card purchases by debt burden of mortgage borrowers. The dependent variables of column (1)-(4) and column (5)-(8) are total amount of card purchases and principal payments, respectively. LTI is Loan-To-Income ratio, and *Uncons.* means mortgage borrowers with high liquidity and credit accessibility. All models include age and season dummies. Standard errors clustered by borrowers are in parentheses. *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.

are not significant in both samples, indicating that the consumption of those with high LTI are not sensitive to interest payment reduction.

The next question from the results of column (3) and (4) is why the consumption of borrowers with high LTI are not sensitive to interest payment reduction. A plausible explanation for this is that borrowers with high debt burden may be more active for deleveraging of the debts to reduce the financial costs. The possibility of this explanation can be checked by investigating the association between interest payment reduction and principal repayments of borrowers with high LTI. If the explanation is true, principal repayments of borrowers with high debt burden respond more to interest payment reduction than those with low debt burden. To look at it, in column (5) to (8), we conduct the regressions with principal payments as a dependent variable. Since credit card limits do not affect the principal payments of mortgages, they are excluded from a set of independent variables. The other specifications of column (5)-(8) is the same as those of column (1)-(4). According to the regression results, the principal payments of borrowers with low LTI levels

show insignificant responses to interest expense reduction, while those with high LTI level present the significant response in both models. These results imply that the insignificant interest-induced MPCs of borrowers with high LTI ratio may come from the active deleveraging behaviors of them.

Overall, the results of Table 7 provide two implications. The first one is that, compared to liquidity constraints and credit accessibility, the effect of debt burden of mortgage borrowers on MPC heterogeneity is modest. The divided groups by LTI ratio do not show the big differences of interest-induced MPCs. The second one is that the mortgage borrowers with high LTI ratio show more active deleveraging behaviors using windfall gains from interest payment reduction than those with low LTI ratio .

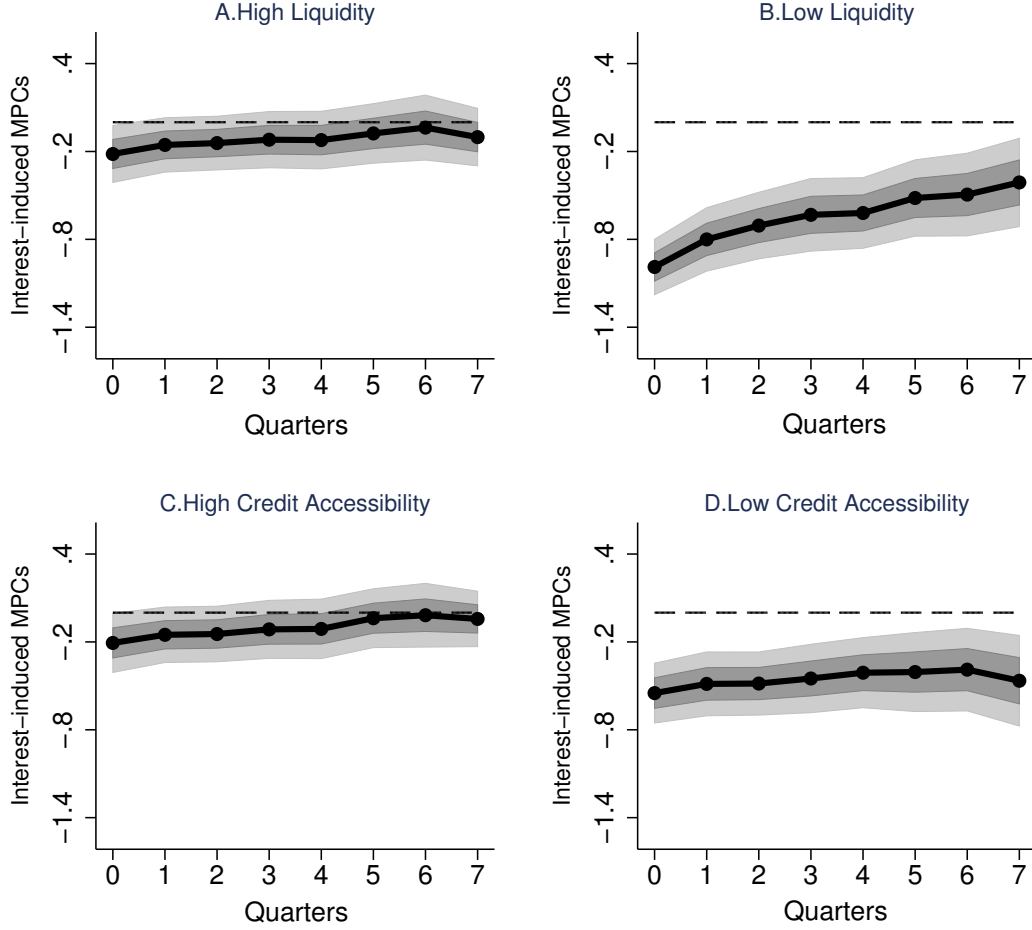
5.3 Dynamic Interest-Induced MPC

We so far stick to the simultaneous relations between mortgage interest reduction and interest-induced MPCs. The dynamic interest-induced MPCs can provide the additional implications for the persistence of cash flow channels of expansionary monetary policy. In this section, we investigate the heterogeneity of dynamic interest-induced MPCs using the local projection method of Jordà (2005). Since the MPC heterogeneity is not large across LTI ratio levels, we focus on the groups divided by liquidity constraint and credit accessibility.²³ Figure 4 shows the impulse responses of interest-induced MPCs estimated by equation (4). The X-axis of Figure 4 show eight quarters including quarter 0, and the y-axis is the interest-induced MPCs. The black lines marked with circles present the point estimates of interest-induced MPCs in the corresponding quarters. The dark (light) regions are for 68% (95%) confidence intervals of the MPCs.

According to the results of impulse responses in Figure A and C, borrowers with high liquidity or credit accessibility show the insignificant interest-induced MPCs over the periods. The 68% confidence intervals of them include zero after three quarters of interest reduction shocks, and 95% confidence intervals include zero at all periods. Meanwhile, as seen in Figure B and D, borrowers with low liquidity or credit accessibility show relatively long-lasting and significant responses of consumption to mortgage interest reduction. Their confidence intervals of interest-induced MPCs do not include the zero at all periods, even at the 95% level. This result implies that liquidity-

²³In unreported analysis, we also conduct the local projections by LTI ratio levels. All of estimated MPCs are not statistically insignificant, regardless of LTI ratio levels and time periods.

Figure 4: Dynamic Interest-Induced MPCs



Notes. This figure shows the dynamic interest-induced MPCs across the groups divided by liquidity constraints and credit accessibility. The borrowers with high (low) liquidity are those with lower (higher) EIR or with higher (lower) income than the median of each variable; The borrowers with high (low) credit accessibility are those with higher (lower) credit scores than the median or with mortgages originated in commercial (non-commercial) banks. The black lines marked with circles present the point estimates of interest-induced MPCs in the corresponding quarters. The dark (light) regions are for 68% (95%) confidence intervals of the MPCs.

and credit-constraints borrowers face cannot be resolved by interest payment reduction. If the windfall gains by interest payment reductions lead to addressing the two constraints within the short periods and thus constrained borrowers achieve the optimal consumption level, their dynamic interest-induced MPCs would be close to zero as time goes by.

Next, we can see that the slope of dynamic interest-induced MPCs of borrowers with low liquidity is more steeper than that of those with low credit accessibility. One possible explanation for this phenomenon is that while the windfall gains from interest payment reductions affect the

positive effects on mortgage borrowers' liquidity as time goes by, the low credit accessibility cannot be resolved within the short periods. This may be in part due to the term of validity of credit information. According to Use and Protection of Credit Information Act of South Korea, as credit bureau companies can use the credit information to establish credit scores up to five years, once lost, the credit score is practically hard to rise within the short periods.

6 Concluding Remarks

Drawing on the credit bureau data that have comprehensive information on the debt-side and the demographic characteristics of mortgage borrowers, we explore the relationship between mortgage interest reduction and consumption, focusing on the period 2012-2017 of unanticipated expansionary monetary policy. Our regression analysis uncover five main results: (i) the borrower cash flow channel operates only for mortgage borrowers with ARMs, (ii) among mortgagors with ARMs, those with low liquidity and credit accessibility show high interest-induced MPCs, (iii) compared to liquidity and credit accessibility, the debt burdens of mortgagors have a weaker effect on the interest-induced MPC heterogeneity. Those with high debt burden show low or insignificant interest-induced MPCs due to their active deleveraging behaviors, and those with low debt burden show insignificant MPCs, (iv) while unconstrained borrowers show low and insignificant MPCs consistently, constrained borrowers (low liquidity and credit accessibility) maintain long-lasting high MPCs for eight quarters after interest reduction, and (v) the MPC of those with low liquidity has become lower as time goes by, indicating that windfall gains by mortgage interest reduction help relaxing the liquidity constraints they face.

Our empirical findings provide several meaningful implications on the borrower cash flow channel of expansionary monetary policy. First, the share of those with ARMs can affect the magnitude of cash flow effects of reduction in mortgage rates caused by expansionary monetary policy. Although a low share of ARMs can have positive effects on financial and economic stability in the long term (e.g., Rubio, 2011), it can attenuate the short-term positive consumption effects of expansionary monetary policy. Second, the cash flow channel of expansionary monetary policy can improve mortgage borrowers' balance sheets, in particular liquidity-constrained ones. However, monetary authorities have to know that the cash flow channel of tight monetary policy can damage the balance sheets

of mortgagors. While this channel, in general, can function as an automatic stabilizer of macroeconomic conditions, as pointed out by Di Maggio et al. (2017), the function can show asymmetric effects across the direction of monetary policy. It is worth noting that some recent studies have found that the MPC from negative income changes is much higher than that from positive ones (e.g., Bunn et al., 2018; Jappelli and Scognamiglio, 2018). Third, high debt burdens of mortgage borrowers with ARMs can neutralize the positive consumption effects of expansionary monetary policy by their active deleveraging behaviors. If mortgage borrowers feel that their debt levels are excessive to hamper future consumption under their expected income path, they would use the windfall gains to redeem their debts. Hence, policy makers need to carefully consider the optimum debt level that borrowers can repay them using their life-time resources without a big burden.

Lastly, this paper has a few limitations in observing the relationship between consumption and monetary policy. First, since we focus only on the borrower cash flow channel of expansionary monetary policy, other direct and indirect pass-through of changes in interest rates such as lender cash flow channel and the effects of labor supply are not considered.²⁴ Hence, the response of aggregate demand to expansionary monetary policy cannot be assessed in our framework. Second, whether mortgage interest reductions are permanent or temporary is not considered. To the best of my knowledge, Jappelli and Scognamiglio (2018) is the sole paper that accounts for it, using a survey of household income and wealth data in Italy. However, as pointed out by Elena Carletti in the Discussion Section of the paper, as a large portion of respondents are undecided in judging the length of income shocks, the results are tentative. Overall, in future studies, we need to measure the contribution of the borrower cash flow channel to the entire effects of monetary policy on aggregate consumption, and find the ways how to decompose the interest reductions into permanent and temporary components.

²⁴Using a New Keynesian DSGE model, Rubio, 2011 shows that the consumption responses to monetary policy shocks can be affected by labor supply and the presence of savers. Park (2018) also shows that the labor supply can be a source that affects mortgagors' consumption in the South Korea economy.

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Table A1: Interest Rates and Consumption Using Alterantive ARM Definitions

	(1)	(2)	(3)	(4)	(5)	(6)
	Alternative Definition 1		Alternative Definition 2		Alternative Definition 3	
COFIX	1.592 (1.169)		0.892 (0.864)		0.524 (0.793)	
COFIX * ARM	-1.503*** (0.500)		-1.356*** (0.412)		-0.652* (0.350)	
Loan Rate		0.298 (0.253)		0.489* (0.265)		-0.230* (0.125)
Loan Rate * ARM		-1.347*** (0.431)		-1.053*** (0.316)		-0.425* (0.242)
Income	0.020*** (0.003)	0.020*** (0.003)	0.021*** (0.002)	0.021*** (0.002)	0.021*** (0.002)	0.021*** (0.002)
Credit Card Limit	0.061*** (0.005)	0.061*** (0.005)	0.059*** (0.004)	0.059*** (0.004)	0.059*** (0.004)	0.059*** (0.004)
Credit Score	0.027*** (0.004)	0.027*** (0.004)	0.027*** (0.003)	0.027*** (0.003)	0.029*** (0.003)	0.029*** (0.003)
Constant	-5.119 (6.514)	0.648 (4.673)	-3.027 (4.626)	-1.632 (3.266)	-5.036 (4.383)	-1.493 (3.084)
Overall R^2	0.246	0.232	0.258	0.251	0.266	0.265
Observation	74,790	74,790	133,602	133,602	144,610	144,610

Notes. This table shows the effects of interest rates (COFIX and borrower-level mortgage rates) on credit and debit card purchases, using alternative definitions of ARM borrowers. We conduct the same regressions as model (3) and (6) in Table 3 by each alternative definition of ARM borrowers. In alternative definition 1 and 2, we define ARMs as those who have a correlation between mortgage rates and COFIX greater than 75% percentile (about 0.96) and 25% percentiles (about 0.58), respectively. In these definitions, the second condition for ARMs, who have the variation of mortgage rates is larger than half the variation of COFIX in the sample period, is maintained. In alternative definition 3, we define them as those who have the correlation greater than the median (the same as Table 3), but the second condition is excluded. The dependent variable is total amount of card purchases. The COFIX (Cost Of Fund Index) is a base rate of mortgage rates, calculated based on costs of funding information provided by 8 Korean domestic banks. The mortgage rate is a borrower-level rate. All models include year, season, and age group dummies as independent variables. Standard errors clustered by borrowers are in parentheses. *, **, and *** indicate the 10%, 5%, and 1% significance levels, respectively.