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Household Indebtedness and the Consumption Channel of Monetary Policy: Evidence from China

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Abstract

This paper studies the impact of household indebtedness on the consumption channel of monetary policy using the Chinese household-level survey data. We employ a panel smooth transition regression model to investigate the non-linear role of indebtedness. We find that housing-related indebtedness weakens the monetary policy transmission, and this effect is non-linear as there is a much larger counteraction of consumption in response to monetary policy shocks when household indebtedness increases from a low level rather than from a high level. Moreover, the weakened monetary policy transmission from indebtedness is stronger in urban households than in rural households. This can be explained by the investment good characteristic of houses in China.

Keywords: Consumption; Household Debt; Monetary Policy, Panel Smooth Transition Regression, China
JEL classification: E21, E52, C23

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1. Introduction

Concerns over rising household debt in China have intensified in recent years. Rapid urbanization and a mortgage lending boom have resulted in soaring Chinese household debt. In June 2018, household debt loans and debt securities corresponded to 50.3% of GDP, a fourfold increase from its March 2006 level (People's Bank of China, 2018). Concerns about rising household debt are not a phenomenon unique to China.[1] That said, the rise in Chinese household debt since the global financial crisis has been the most pronounced among all Bank for International Settlements (BIS) - reporting countries.[2]

For policymakers, the takeaway from the global financial crisis was that a household debt crisis can precipitate a large systemic financial crisis with global implications. According to Mian and Sufi (2009, 2018) and Mian et al. (2017), household debt expansions unconditionally predict declines in real GDP growth. Household debt also foreshadows recession severity should a recession occur. The precise mechanism involves mutual reinforcement and amplification of credit supply shocks and the household demand channel. Martin and Philippon (2017) demonstrate that household debt expansion was a precursor of economic downturns across geographical areas. In other words, highly indebted households are more vulnerable to adverse shocks, which could force households to deleverage abruptly with significant macro-financial impacts. Another common perception among many academics and policymakers is that monetary policy in advanced economies has been less effective since the crisis because of higher household debt and associated credit constraints. Finally, a growing body of theoretical modelling work has recently revived interest in alternative monetary policy transmission channels, for example, through balance sheet differences across households (e.g. Auclert, 2019; Kaplan et al., 2018; Mitman et al., 2016).

A related and similarly important aspect is the question of whether and, if so, how the effectiveness of monetary policy changes in the face of increased household indebtedness. In recent years, a small number of studies have examined the role of household balance sheets in monetary transmission of advanced economies, generally finding that more indebted and less liquid households are more responsive to monetary policy surprises (e.g. Aladangady, 2017; Cloyne et al., 2020; Di Maggio et al., 2017; Flodén et al., 2017). In other words, the evidence for advanced economies suggests that households are unequally affected by monetary policy depending on their balance sheet positions. In particular, heterogeneity in liquid asset holdings can account for heterogeneity in consumption responses to monetary policy shocks. The empirical

[1] One indication is the availability of regularly updated global household debt trackers, which are published by international institutions such as the IMF. See, for example, https://www.imf.org/external/datamapper/HH_LS@GDD/CAN/GBR/USA/DEU/ITA/FRA/JPN

[2] See https://www.bloomberg.com/news/articles/2017-11-21/china-s-debt-surge-may-increase-risk-of-financial-crisis and https://www.ceicdata.com/en/indicator/china/household-debt--of-nominal-gdp. America and Europe experienced household debt booms in the 2000s; neither experiences these phenomena today. The most significant run up in household debt in the current cycle has taken place in China (https://www.imf.org/external/datamapper/datasets/GDD).

findings are also compatible with the argument that having a mortgage reduces the uncertainty that the household faces regarding how much to save to be able to buy a house at some future date, and this reduced uncertainty leads to lower monthly savings.

Despite the discernible interest in these important issues, the literature is lacking a perspective from the emerging market countries. This is particularly relevant for China, whose household debt has risen exceptionally fast. It can be presumed that monetary policy has significantly heterogeneous effects on private consumption, which depends on the household's debt and balance sheet position. However, will the different institutional settings of the Chinese economy lead to a different role of household indebtedness in monetary policy transmission? How do monetary policy surprises in China affect household consumption? How important is household debt compared to the traditional intertemporal substitution channel in terms of the ability of the People's Bank of China (PBoC) to influence the economy? To our knowledge, this paper is the first attempt to investigate the dependence of the transmission of monetary policy on the level of household indebtedness in China. We take a fresh look at these issues with a view to filling this research gap.

Using a panel smooth transition regression (PSTR) model, we find that Chinese households with more debt respond less to monetary policy shocks in terms of consumption expenditure. More importantly, the role of indebtedness only holds for housing-related debt, and we do not find robust evidence to claim that total debt has a significant role in affecting monetary policy transmission efficiency. In addition, the magnitude of housing debt in a weakened monetary policy transmission is stronger in urban households than that in rural households. These findings can be explained by the investment product characteristics of real estate in China. Credit constraints tend to allocate the mortgage and housing-related credit to households with more assets and collaterals, and these households are more likely to own more than one house as investment, and their consumption expenditures are less affected by the liquidity change from monetary policy shocks.

This study contributes to the literature in three ways. First, we provide empirical evidence from an emerging market economy on the household finance–monetary policy nexus. Current studies rely on the household data from the US and Europe.[3] Except in the case of Alpanda and Zubairy (2019), most papers conclude that higher indebtedness is associated with more sensitive responses to monetary policy due to the wealth effect and liquidity constraint. Using Chinese household survey data, we show that the opposite is true for China and our findings are consistent with Alpanda and Zubairy (2019). More housing debt leads to weakened monetary policy transmission to consumption expenditure. This is related to the severe credit constraint in China and the fact that many wealthy households view real estate as an investment and at the

[3] The paper contributes to a growing literature on the importance of household debt in recent years. Baker (2018), Alpanda and Zubairy (2019) and Gelos et al., 2019 use US data; Cloyne et al. (2020) use US and UK data; Slacalek et al. (2020) use the data from four EU countries, Loukoianova et al., 2019 employ Australian data, and Calza et al. (2013) employ cross-country data of 19 industrialized countries. Agarwal and Qian (2014) use Singapore data without focusing on household debt. Research in the field has provided mixed results depending on the stage of economic development, institutional arrangements, and structural realities.

same time they are less liquidity constrained. Second, we explore the different impact on urban and rural households. As a large transitional economy, different economic structures in urban and rural areas tend to result in different results from the same monetary policy shock. We find that household indebtedness plays a larger role in urban areas than in rural areas in counteracting the consumption channel of monetary policy. Third, the use of PSTR illustrates the non-linearity of the heterogeneity of indebtedness.

The remainder of the paper is organised as follows. Section 2 introduces the panel non-linear model and describes the estimation and testing procedures with our empirical application in mind. Section 3 presents the data set and the construction of variables used in this study. Section 4 reports the empirical results and interprets the findings with unique characteristics of the Chinese economy. Section 5 concludes and discusses the implications for Chinese monetary policy.

2. Econometric Methodology

For this empirical study, an important aspect is the question of the appropriate functional form of the relationship between consumption, indebtedness, and monetary surprises. In panel data models it is typically assumed that the household heterogeneity can be captured completely by means of household fixed effects and time effects. However, this poolability assumption may be violated or at least viewed as questionable. The sensitivity of consumption to monetary shocks can be expected to vary across households according to their indebtedness level. Thus, a heterogeneous panel data model may be required for modelling consumption behaviour in such a situation.[4]

To investigate non-linear effects of household debt on private consumption, we employ the panel smooth transition regression (PSTR) model with fixed individual effects introduced by González et al. (2005, 2017). The model generalizes the panel threshold regression (PTR) model developed by Hansen (1999), allowing the regression coefficients to change smoothly and gradually between two regimes.[5] Two PSTR model properties in particular are worth highlighting: first, it allows for a smooth transition between the extreme regimes; and second, the threshold value is not given a priori, but is calculated in the model. In the present application, this means that the model allows heterogeneity in the regression coefficients assuming that the coefficients are continuous functions of household debt. The reasoning behind this is that it seems difficult to argue that there is an exact level of household debt defining two groups of households, each with different

[4] The grouping of households by their level of debt can be motivated by various theoretical models, including Iacoviello (2015) and Kaplan et al. (2018).

[5] Since the first appearance of the PSTR working paper in 2005, the PSTR model has been applied to quite a wide variety of economic modelling problems. These include the inflation–growth nexus (Espinoza et al., 2012), the effects of oil prices on the current account of oil-exporting countries (Allegret et al., 2014), the borrowing costs of European countries during the recent financial crisis (Delatte et al., 2017), and the behaviour of exchange rates (Cho, 2015). For a review, see González et al. (2017), pp. 3-4. The large number and variety demonstrate that the PSTR model offers an attractive possibility of capturing heterogeneity in panel data.

sensitivity of consumption to monetary shocks. Rather, it seems more realistic to assume that the sensitivity of consumption changes gradually as a function of the level of household debt. This is exactly what the PSTR model tries to accomplish.

The PSTR modelling cycle includes various stages of model specification, parameter estimation and model evaluation. For a start, the PSTR model with two regimes is given by

$$y_{it} = \mu_i + \beta_0' x_{it} + \beta_1' x_{it} g(z_{it};\, \gamma, c) + \varepsilon_{it} \tag{1}$$

where $i = 1,2,\cdots,N$, and $t = 1,2,\cdots,T$, where N and T denote the cross section and time series dimensions of the panel data set, respectively. μ_i is the fixed individual effect; and the error term ε_{it} is independently and identically distributed. The dependent variable y_{it} is a scalar, and x_{it} is a k-dimensional vector of exogenous variables. The continuous transition function $g(\cdot)$ governs the speed of reversion between two regimes, where z_{it} is the observable transition variable, $\gamma > 0$ is the slope parameter, and c is the location parameter. The slope parameter γ denotes the smoothness of the transition from one regime to the other.[6]

Following Granger and Teräsvirta (1993) and Teräsvirta (1994), the transition function is chosen to be the logistic function

$$g(z_{it};\, \gamma, c) = \frac{1}{1 + \exp\{-\gamma(z_{it} - c)\}} \tag{2}$$

The continuous logistic function is bounded between 0 and 1, depending on the transition variable z_{it} for individual *i* at time *t*. More precisely,

$$g(z_{it};\, \gamma, c) \to 0 \text{ as } z_{it} \to -\infty \tag{3}$$

$$g(z_{it};\, \gamma, c) = 0.5 \text{ as } z_{it} \to c \tag{4}$$

$$g(z_{it};\, \gamma, c) \to 1 \text{ as } z_{it} \to +\infty \tag{5}$$

When γ tends to infinity ($\gamma \to \infty$), the transition is sharp and the PSTR model turns into the two-regime PTR threshold model introduced by Hansen (1999). If, on the contrary, γ tends to zero ($\gamma = 0$), the

[6] The PSTR model is an extension of the smooth transition regression model for cross-sectional data. See van Dijk et al. (2002). Furthermore, the PSTR model can be generalized to allow for the case of more than two different regimes. This multilevel PSTR model is then a generalization of the multi-regime PTR model in Hansen (1999).

transition function $g(z_{it};\ \gamma, c)$ is constant and the PSTR model reduces to a linear panel regression model with individual fixed effects. The values taken by the transition variable z_{it} and transition parameter γ determine the speed of reversion between both regimes. The rule is that lower values of the transition parameter imply slower transitions. Estimating the coefficients of the PSTR model in equation (1) involves eliminating the individual effects μ_i by removing individual-specific means and then applying non-linear least squares to the transformed data.

Prior to estimating the PSTR model, it is important to test the appropriateness of the chosen model. These include unit root tests, linearity tests and tests on the number of regimes. The unit root tests are a necessity to avoid spurious regressions. Once the suitability of the variables has been tested, we follow the sequential PSTR testing procedure suggested by González et al. (2005, 2017). Another crucial issue to consider is the selection of starting values of γ and c since this notably determines the convergence procedure. To select good starting values, a comprehensive two-dimensional grid search is carried out. Given these grids, the vector with the minimum residual sum of squares is used to estimate the model parameters. The subsequent PSTR model estimation involves eliminating the individual effects and then applying non-linear least squares to the transformed data. The final evaluation step then consists of specification tests for remaining non-linearities. This is tantamount to determining the appropriate number of transition functions.

3. Data

3.1 Monetary Policy Shocks

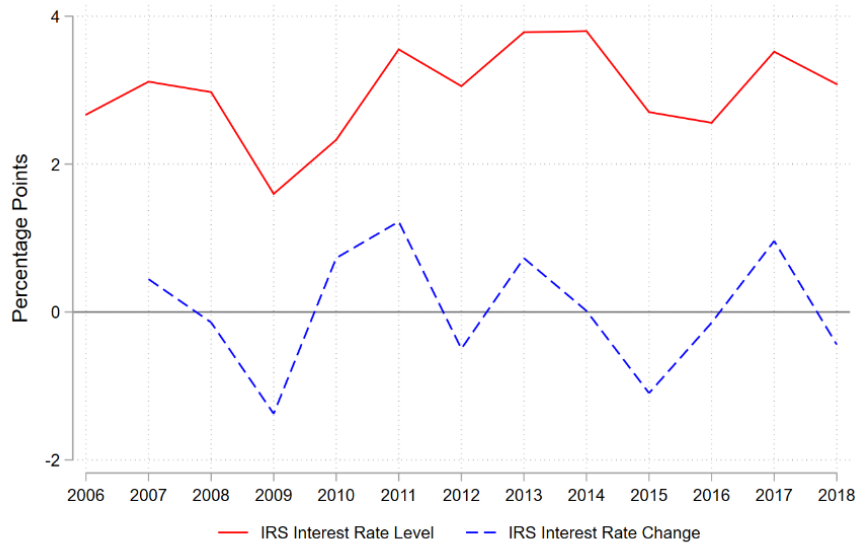
An obvious problem in the context of this project is the endogeneity and macro-economic reverse causation problem: the economy responds to movements in monetary policy, but monetary policy also responds to the business cycle stance. To identify unanticipated changes in the short-term interest rate, we need a monetary policy shock series that can be used for estimation. To identify monetary policy shocks, we will resort to the technique developed by Kamber and Mohanty (2018). Their approach exploits the fact that data on futures or swap contracts contain information on market expectations about monetary policy in China, and they have shown that the daily changes in the one-year 7-day repo interest rate swap (IRS) are effective in measuring monetary policy surprises.[7]

We follow the methodology and construct a price-based monetary policy shock indicator. Specifically, we obtain the IRS rates data, and calculate the change in the rates. Figure 1 presents the time series of the

[7] The advantage of identifying monetary policy shocks using data on market expectations is that one does not need to make further assumptions to disentangle the endogenous and exogenous components of monetary policy. Recent applications of this approach are in Gertler and Karadi (2015) and Nakamura and Steinsson (2018) for the US, Gerko and Rey (2017) for the UK, and Ranaldo and Rossi (2010) for Switzerland.

level and change of IRS rates. A higher level and a positive change indicate contractionary monetary policy, and a lower level and a negative change indicate expansionary monetary policy. In our analysis period, 2010–2018, the monetary policy in China is expansionary in 2012, 2015–2016 and 2018, while contractionary in 2010–2011, 2013–2014 and 2017. This classification also coincides with the phase classification in Funke and Tsang (2020) and Funke and Tsang (2021).

Figure 1: Monetary Policy Shocks in China



3.2 Household Indebtedness and Consumption Data

A challenge in previous studies on the impact of monetary policy on consumption is the lack of data sets that feature both consumption expenditures and high-quality measures on households' wealth and balance sheets. We overcome this problem by using the China Family Panel Studies (CFPS) database, which provides a nationally representative and annual longitudinal survey of Chinese communities, families and individuals.[8] This database allows us to uncover in detail how differences in assets and liabilities affect the transmission of monetary policy shocks. The CFPS survey design is similar to the Panel Study of Income Dynamics (PSID) in the US and is implemented by the Institute of Social Science Survey at Peking University in collaboration with the Survey Research Center at the University of Michigan, with an

[8] See http://www.isss.pku.edu.cn/cfps/en/data/public/index.htm

approximate response rate of 79%. This database has been widely used in the literature to study Chinese household wealth, income inequality and household consumption.[9]

The panel data started in 2010 and there are follow-up surveys in 2012, 2014, 2016 and 2018.[10] Each survey represents information in the past year, so we have household-level data for the year 2009, 2011, 2013, 2015, and 2017. In the family economic data set in the five waves, we can access rich information on the household income, expenditure, debt, and assets.[11] Specifically, we construct our key variables in the way shown in the appendix Table A1. Every financial variable is deflated using the national consumer price index to make them comparable across years.

We conduct a cautious data cleaning procedure. First, we drop the households without province information. Second, we drop the observations whose family identification codes change across years. Third, we drop the observations from Inner Mongolia, Hainan, Qinghai, Ningxia and Xinjiang, because the number of observations is too small to be representative for these provinces. Fourth, we drop the observations of which the values of total expenditure, consumption expenditure and non-mortgage expenditure are zero or negative.[12] After data cleaning, we have 62,262 household-year observations coming from 14,907 households, of which 9,164 are tracked in each survey wave. The observations cover 25 provinces in China.[13] We then exclude the outliers by trimming the ratios of housing debt, non-housing debt and total debt to wage income, total income, and total assets, as well as the ratio of mortgage expenditure to total income within the 1st and 99th percentile. Table 1 presents the summary statistics of the key variables used in this study.

[9] See IMF (2019); Li and Wu (2014); Xie and Hu (2014); Xie and Zhou (2014); Xie and Jin (2015); Xu et al. (2015); Zhou et al. (2014).

[10] There was a pilot survey conducted in 2008 and a re-survey in 2009 covering only a few cities and provinces. Due to this limitation, we did not exploit the data.

[11] In CFPS, the total income is after tax income, and it is the sum of after-tax salary income (including bonuses and benefits), business income (business operation net profits), transfer income (including pension, subsidy, and other social security transfer), asset income (from financial investment or renting land and property) and other income (such as cash gifts from friends and relatives).

[12] In CFPS, the total expenditure is the sum of expenditures on consumption, mortgage, transfer, and welfare. Non-mortgage expenditure is calculated as the difference between total expenditure and mortgage expenditure.

[13] The 25 provinces are: Beijing, Tianjin, Hebei, Shanxi, Liaoning, Jilin, Heilongjiang, Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, and Gansu.

Table 1: Summary Statistics of Key Household Variables

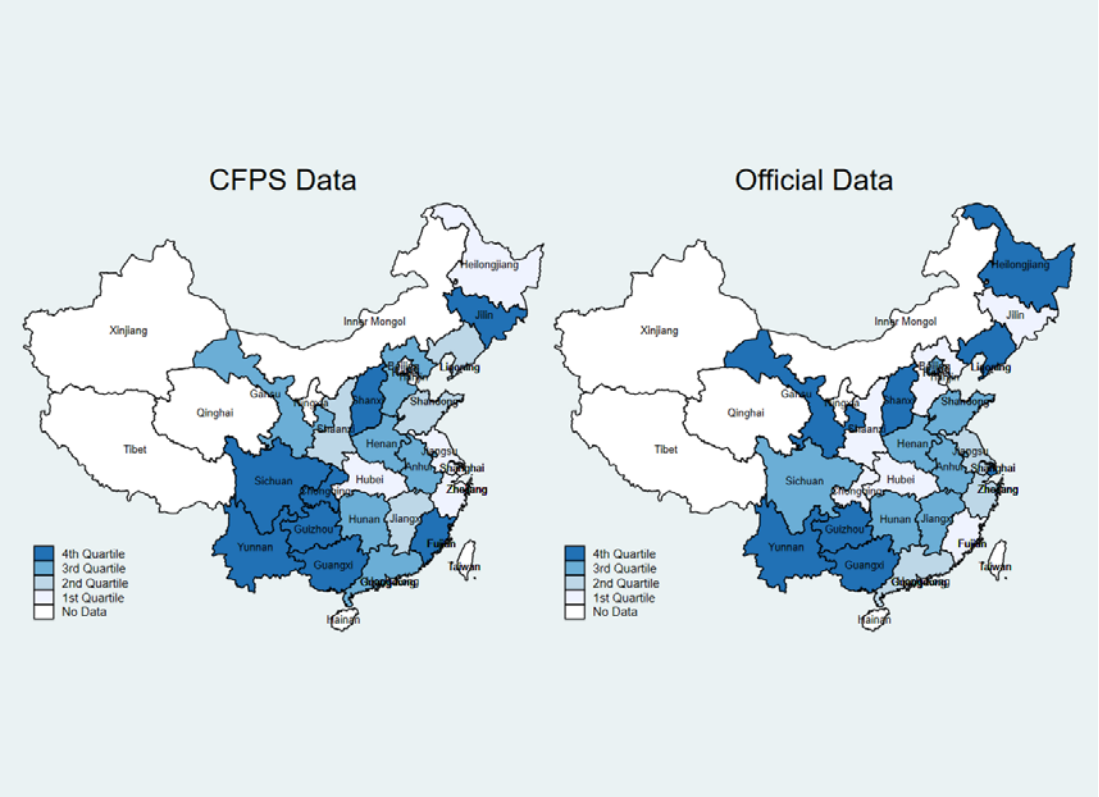
	Full Sample			Urban Sample			Rural Sample		
Variable	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**
Housing Debt	17,905.93	334,959.10	61,886	23,235.41	123,623.30	29,175	12,896.75	446,724.70	32,486
Non-Housing Debt	10,921.72	74,381.40	61,823	11,738.47	96,122.26	29,174	10,176.83	47,107.80	32,419
Total Income	57,993.10	141,337.40	60,143	74,437.33	164,742.60	28,399	42,790.38	113,091.80	31,519
Total Expenditures	53,817.78	87,710.02	58,389	67,857.85	105,369.10	27,507	40,995.93	65,128.15	30,660
Non-Mortgage Expenditures	52,224.57	84,374.77	58,279	65,292.42	100,680.80	27,470	40,262.49	63,705.23	30,588
Mortgage Expenditures	1,606.73	18,616.45	61,979	2,565.81	24,275.02	29,262	742.42	11,292.68	32,490
Consumption Expenditures	43,857.06	58,522.00	56,748	55,076.07	71,215.98	26,639	33,663.33	41,107.35	29,891
Total Debt	28,820.30	345,016.20	61,629	34,972.01	160,828.50	29,074	23,052.52	450,748.60	32,330
Housing Asset	389,220.50	1,100,479.00	62,088	624,538.00	1,433,164.00	29,291	174,225.80	577,829.10	32,568
Financial Asset	46,070.51	192,847.70	61,665	74,275.44	265,917.00	28,967	20,425.44	69,606.34	32,468
Total Asset	495,072.40	1,267,175.00	60,560	757,366.70	1,631,826.00	28,415	257,289.60	712,291.70	31,921
Housing Debt-to-Income Ratio	0.21	0.77	59,330	0.21	0.80	28,014	0.20	0.75	31,100
Non-Housing Debt-to-Income Ratio	0.23	0.80	59,271	0.18	0.72	28,086	0.28	0.86	30,960
Total Debt-to-Income Ratio	0.52	1.46	59,101	0.47	1.40	27,973	0.57	1.51	30,908
Housing Debt-to-Asset Ratio	0.02	0.08	59,491	0.02	0.08	27,925	0.03	0.09	31,357
Non-Housing Debt-to-Asset Ratio	0.05	0.18	59,432	0.03	0.15	27,834	0.06	0.19	31,387
Total Debt-to-Asset Ratio	0.08	0.24	59,274	0.07	0.21	27,749	0.10	0.26	31,317
Mortgagors	1	0	3,479	1	0	2,116	1	0	1,342
Outright Owners	1	0	51,433	1	0	22,418	1	0	28,874
Renters	1	0	2,680	1	0	2,225	1	0	429

Notes: The entries in the last three rows represent (0,1) - dummy variables on the household types.

To show the validity of the CFPS survey data set, we present the quartile distribution of the consumption-to-income ratio and the household debt-to-income ratio of each province and compare it with the official

data.[14] The left panels of Figure 2 and Figure 3 respectively show the quartile distribution of the consumption-to-income ratio and the household debt-to-income ratio using the median value for each province in the CFPS data in 2017, which is from the latest wave of the survey, and the right panel shows the ratios obtained from the official data.[15] In Figure 2, we can see that the pattern in the left resembles that in the right, as they both show higher consumption-to-income ratios in the south-west and north-east provinces, and furthermore lower consumption-to-income ratios along the east coast. In Figure 3, though the darkest two groups vary more between the CFPS and official data, possibly due to the inclusion of non-bank debt in the CFPS data, the provinces with the most severe household debt issues in the official data (Gansu and Zhejiang) also show high debt-to-income ratio in the CFPS data, and the provinces with the lowest debt-to-income ratio are similar in the left and right panels.

Figure 2: Distribution of Consumption-to-Income Ratio Across Provinces in 2017

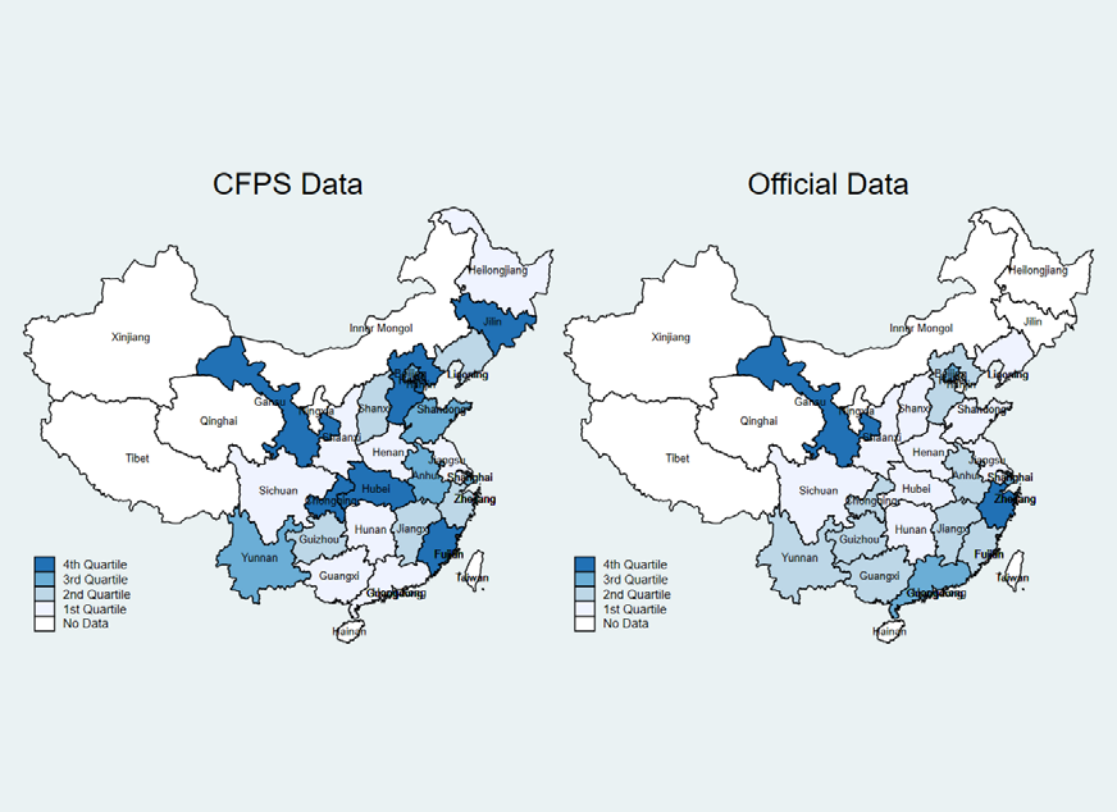


[14] By 'official' data, we mean the statistics disclosed by national agencies. Specifically, the official province–year–level consumption and GDP data is from the National Bureau of Statistics of China. The province-year-level household debt data is from the PBoC and is defined as the household loans in the sheets of the sources and uses of credit funds of depository institutions (People's Bank of China, 2018). Due to data availability, the official household debt data for the provinces of Liaoning, Shandong and Henan only include renminbi loans, while the data for the other provinces include both renminbi and foreign currency loans.

[15] To compare with the distribution in CFPS data, we drop the observations for Inner Mongolia, Hainan, Qinghai, Ningxia, and Xinjiang in the official data.

Note: The consumption-to-income ratio using CFPS data is calculated as the median value of total income divided by total income in each province. The consumption-to-income ratio using official data is calculated as the total consumption divided by GDP in each province. The consumption and GDP official data is from the National Bureau of Statistics of China.

Figure 3: Distribution of Household Debt-to-Income Ratio Across Provinces in 2017

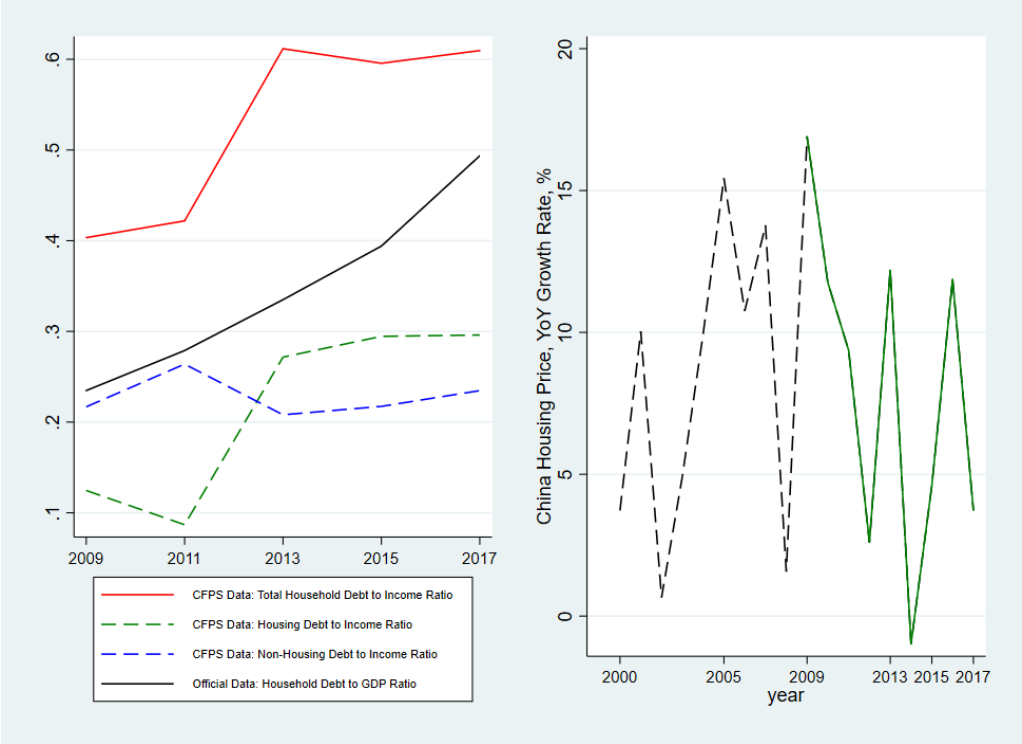


Notes: The household debt-to-income ratio using CFPS data is calculated as the median value of total debt divided by total income in each province. The household debt-to-income ratio using official data is calculated as the total household debt divided by GDP in each province. The province-year-level total household debt is from the People's Bank of China and is defined as the household loans in the sheets of the sources and uses of credit funds of depository institutions. Due to data availability, the official household debt data for the provinces of Liaoning, Shandong and Henan only include renminbi loans, while the data for the other provinces include both renminbi and foreign currency loans.

The red, green, and blue lines in the left panel of Figure 4 show the average national ratios of total debt to income and its components of housing and non-housing debt from the CFPS survey. The total household debt increased from 40% of total income in 2009 to over 60% in 2017, and it is the housing-related debt that drove the increase, whereas the non-housing debt-to-income ratio even decreased a little in 2013 and stabilized after that. In 2013, there was a sharp increase in the housing debt, which is consistent with the booming housing market in that year, as shown in the housing price growth rate in the right panel.

Comparing the red and black lines in the left panel shows that the CFPS debt-to-income ratio is about 10 to 15 percentage points higher than that from official data. Two explanations are attributable to this. First, the household debt in our data comprises not only loans from commercial banks, but also includes private borrowings from shadow banks, friends and/or relatives. On the contrary, the debt in the official data only covers the loans from financial institutions to households. Second, as the CFPS survey counts children as core family members, the total income per household member is 10,257.77 yuan in 2009 and 25,012.04 yuan in 2017 from the survey data, while the GDP per capita is 26,180 and 60,014, respectively. The focus on households thus leads to lower per capita incomes.

Figure 4: Household Debt-to-Income Ratio and Housing Price Growth



Note: The housing price growth rate is calculated based on the average housing price in each year. The original data are the per square price based on accumulated sale of commercial residence in each month. CEIC item code: CEGA.

Similarly to the IMF (2019), we also find that the CFPS data show a large share (89.3%) of households are outright owners, meanwhile the mortgagors and renters each account for 6.0% and 4.7% of households.[16] On one hand, the high house ownership issue is consistent with other data. According to another household survey (China Household Finance Survey, CHFS), China's homeownership is 90%, which is similar to the

[16] These numbers are slightly different from those shown in Table 1 because we have excluded the cases that are empty entries and that are both mortgagors and renters.

results in the CFPS data. Also, the homeownership rate of China is far higher than the 65.3% of US and 61.2% of Japan.[17] On the other hand, this may result from some specifics of survey data. As years go by, households living in temporary residence and rented residence are usually less likely to be interviewed again, and this issue is not weight-adjusted in the sampling.

There is another point to bear in mind regarding the data. The transmission of monetary policy is also influenced by characteristics of the mortgage market, as studies such as Calza et al. (2013) have shown. In China, most mortgage rates have a fixed rate, and refinancing is costly (IMF, 2019, p.18; Fan and Yavas, 2020). Although mortgages with adjustable rates exist in principle, they have played a subordinate role during the period under consideration.[18]

3.3 Control Variables

We use household-level and provincial-level characteristics as additional regressors in the panel estimations. Specifically, at the province-year level, we use the housing price-to-income ratio, the inflation rate, the change in the GDP growth rate and the newly added bank deposits to control for region-specific effects. At the household-year level, we use the family size, and the marital status and education level of the household head to control the effects from demographic changes. Table 2 reports the summary statistics of the control variables.

Table 2: Summary Statistics of Control Variables

	Full Sample			Urban Sample			Rural Sample		
Variable	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**
Housing price-to-income-ratio	0.10	0.03	62,262	0.11	0.03	29,376	0.10	0.03	32,656
CPI	102.07	2.05	62,262	102.01	2.05	29,376	102.13	2.06	32,656
GDP Growth Rate	0.10	0.06	62,262	0.10	0.06	29,376	0.11	0.06	32,656
Newly Added Bank Deposits	559.08	547.80	59,419	641.81	617.13	27,837	484.41	462.96	31,359
Family Size	3.85	1.83	62,262	3.55	1.66	29,376	4.13	1.92	32,656
Marital Status	0.79	0.41	61,140	0.78	0.42	28,741	0.80	0.40	32,176
Education Level	6.87	4.66	60,018	8.29	4.70	28,236	5.59	4.23	31,565

Notes: 'Marital status' is a bivariate variable where '1' implies married and '0' implies all the other status, including Unmarried, Cohabitation, Divorced or Widowed; The 'education level' represents the number of years the household head has been educated.

[17] See https://en.wikipedia.org/wiki/List_of_countries_by_home_ownership_rate

[18] Kim and Lim (2020) have shown in cross-country VARs that monetary policy has a stronger effect when a larger share of mortgages has adjustable rates. Rubio (2011) has built a New Keynesian model with a housing market and collateral-constrained households, allowing for both adjustable and fixed rate mortgages. Monetary policy has a stronger effect when a larger share of mortgages has adjustable rates.

Equipped with these micro data and estimates of monetary policy shocks for China, we are able to estimate the dynamic consumption responses to monetary policy at a high level of disaggregation.

4. Empirical Results

4.1 Linear Panel Regression Results

Before showing the estimates from the panel smooth transition regression (PSTR) model, we first conduct a linear panel regression with an interaction term between monetary policy shocks and household indebtedness to test whether the heterogeneity of indebtedness plays a significant role in monetary policy transmission. Specifically, we estimate the following panel regression model:

$$(6) \quad \Delta\ln(\text{Expenditures})_{it} = \alpha + \beta_1 \text{DTI}_{it-1} + \beta_2 \text{DTI}_{it-1} \times \Delta\text{MP}_t + \beta_3 \Delta\text{MP}_t + \beta_4 X_{jt} + \beta_5 Y_{it} + \gamma_i + \varepsilon_{it}$$

where *i* and *t* refer to household and year, respectively, and *j* indicates the province the household live in. The dependent variable is the growth of household consumption expenditure. DTI_{it-1} is the lagged indebtedness variable proxied by the household debt-to-income ratio, and ΔMP_t is the change in monetary policy shocks between the current year and the last survey wave year (every two years from 2010 to 2018), with a negative value indicating monetary policy loosening. The debt-to-income ratio is lagged to rule out a potential endogeneity bias. We control province-year characteristics such as the housing price-to-income ratio, inflation rate, GDP growth rate and the newly added bank deposits, and household-year characteristics such as family size, marital status and education level, in X_{jt} and Y_{it}.[19] γ_i captures the household fixed effect to account for any time-invariant household characteristics that are left out.

The estimates of main interest in this study are β_2 and β_3. The total effect of monetary policy shock on consumption for household i is $(\beta_2 \text{DTI}_{it-1} + \beta_3)$, where β_3 captures the unconditional impact of monetary policy shocks, and β_2 captures the ΔMP_t impact conditional on household indebtedness. One can also say that β_3 captures the immediate, partial-equilibrium consequences of unexpected change in monetary policy on consumption.[20]

[19] We limit ourselves to provincial data because national macroeconomic variables would contaminate our identification strategy. One has to assume that nationwide macroeconomic variables affect monetary policy decisions and, at the same time, are influenced by them so that these variables are endogenous.

[20] As explained above, the monetary policy shock variable is based on the 7-day repo interest rate swap change. The impacts of macroprudential measures are therefore included only insofar as they are reflected in the interest rate changes.

We expect to observe an overall negative change in consumption expenditures when monetary policy tightens. A special focus is on the significance and magnitude of β_2. If household indebtedness does not play a role in affecting monetary policy transmission, then β_2 should be statistically insignificant. In other words, given that the unconditional effect β_3 is negative, a significantly positive (negative) β_2 indicates that more indebted households respond less (more) to monetary policy shocks and thus household indebtedness weakens (amplifies) monetary policy transmission. In the equation above, we do not control for time fixed effect as this would exclude the estimate of the unconditional monetary shock. However, in the estimates including time dummies the interaction term can still be estimated. Analogous to the above, in that case a positive (negative) β_2 indicates that indebtedness weakens (amplifies) monetary policy transmission.

The estimates for the transmission channels are shown in Tables 3 and 4, where we separately use the total debt-to-income ratio and housing debt-to-income ratio as our DTI_{it-1} variable to test whether housing debt has a different role from non-housing debt. In addition to the results using the full sample as shown in columns (1) – (4), we present the subsample estimates for urban households in columns (5) – (8) and rural households in columns (9) – (12).

Table 3: Total Debt-to-Income Ratio, Monetary Policy and Household Expenditures

	Dep: ΔLn(Total Expenditures)											
	Full Sample				Urban Subsample				Rural Subsample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag (Total Debt-to-Income Rate)	-0.068*** (0.000)	-0.070*** (0.000)	-0.069*** (0.000)	-0.070*** (0.000)	-0.066*** (0.000)	-0.066*** (0.000)	-0.066*** (0.000)	-0.066*** (0.000)	-0.075*** (0.000)	-0.078*** (0.000)	-0.077*** (0.000)	-0.078*** (0.000)
Lag (Total Debt-to-Income Ratio)*ΔIRS 7-day Rate	0.009 (0.140)	0.009 (0.158)	0.009 (0.120)	0.008 (0.160)	0.014* (0.099)	0.014* (0.094)	0.014* (0.098)	0.014 (0.111)	0.002 (0.794)	0.002 (0.836)	0.003 (0.719)	0.002 (0.806)
ΔIRS 7-day Rate	-0.002 (0.781)	-0.103** (0.025)			-0.007 (0.425)	-0.173*** (0.009)			0.018* (0.054)	-0.039 (0.555)		
House Price-to-income Ratio		-0.252 (0.718)		-0.322 (0.641)		0.654 (0.531)		-0.269 (0.795)		-1.390 (0.155)		-0.798 (0.440)
CPI		0.077*** (0.006)		0.082** (0.016)		0.129*** (0.001)		0.208*** (0.000)		0.021 (0.626)		-0.006 (0.900)
GDP Growth Rate		-0.497 (0.238)		-0.490 (0.244)		-0.690 (0.241)		-0.659 (0.261)		-0.077 (0.902)		-0.177 (0.777)
Ln (Newly added bank deposits)		-0.140*** (0.007)		-0.145*** (0.001)		-0.112* (0.060)		-0.174*** (0.006)		-0.275*** (0.000)		-0.231*** (0.002)
Family Size		0.098*** (0.000)		0.098*** (0.000)		0.097*** (0.000)		0.096*** (0.000)		0.095*** (0.000)		0.093*** (0.000)
Marital Status		-0.096 (0.114)		-0.095 (0.118)		-0.068 (0.405)		-0.061 (0.461)		-0.123 (0.194)		-0.130 (0.171)
Education Level		0.004 (0.575)		0.004 (0.594)		0.001 (0.905)		-0.001 (0.892)		0.009 (0.397)		0.010 (0.349)
Constant	0.247*** (0.000)	-7.003** (0.013)	0.246*** (0.000)	-7.546** (0.026)	0.259*** (0.000)	-12.568*** (0.001)	0.256*** (0.000)	-20.374*** (0.000)	0.230 (0.000)	-0.420 (0.923)	0.238*** (0.000)	2.019 (0.676)
Observations	39,445	34,980	39,445	34,980	17,859	15,557	17,859	15,557	20,567	18,474	20,567	18,474
Year FE	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES
Household FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Provincial Control	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Household Control	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Note: (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively.

Table 4: Housing Debt-to-Income Ratio, Monetary Policy and Household Expenditures

	Dep: ΔLn(Total Expenditures)											
	Full Sample				Urban Subsample				Rural Subsample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag (House Debt-to-Income Rate)	-0.110*** (0.000)	-0.117*** (0.000)	-0.115*** (0.000)	-0.117*** (0.000)	-0.123*** (0.000)	-0.133*** (0.000)	-0.124*** (0.000)	-0.130*** (0.000)	-0.104*** (0.000)	-0.108*** (0.000)	-0.117*** (0.000)	-0.113*** (0.000)
Lag (House Debt-to-Income Ratio)*ΔIRS 7-day Rate	0.067*** (0.000)	0.070*** (0.000)	0.069*** (0.000)	0.070*** (0.000)	0.070*** (0.000)	0.074*** (0.000)	0.070*** (0.000)	0.073*** (0.000)	0.063*** (0.000)	0.063*** (0.000)	0.065*** (0.000)	0.063*** (0.000)
ΔIRS 7-day Rate	-0.010 (0.107)	-0.121*** (0.008)			-0.015* (0.080)	-0.216*** (0.001)			0.009 (0.299)	-0.035 (0.599)		
House Price-to-Income Ratio		-0.395 (0.573)		-0.329 (0.646)		0.745 (0.490)		-0.150 (0.890)		-1.730* (0.075)		-0.881 (0.389)
CPI		0.083*** (0.003)		0.079** (0.019)		0.144*** (0.000)		0.219*** (0.000)		0.022 (0.606)		-0.017 (0.720)
GDP Growth Rate		-0.507 (0.227)		-0.514 (0.220)		-0.543 (0.355)		-0.510 (0.383)		-0.296 (0.636)		-0.428 (0.482)
Ln (Newly added bank deposits)		-0.141*** (0.001)		-0.136*** (0.003)		-0.130** (0.029)		-0.189*** (0.003)		-0.257*** (0.000)		-0.193** (0.012)
Family Size		0.097*** (0.000)		0.097*** (0.000)		0.096*** (0.000)		0.095*** (0.000)		0.092*** (0.000)		0.092*** (0.000)
Marital Status		-0.063 (0.295)		-0.063 (0.291)		-0.031 (0.708)		-0.023 (0.779)		-0.096 (0.297)		-0.106 (0.252)
Education Level		-0.001 (0.938)		-0.000 (0.954)		-0.009 (0.447)		-0.012 (0.336)		0.008 (0.442)		0.009 (0.368)
Constant	0.235*** (0.000)	-7.688*** (0.006)	0.232*** (0.000)	-7.325** (0.030)	0.254*** (0.000)	-13.973*** (0.000)	0.249*** (0.000)	-21.331*** (0.000)	0.211*** (0.000)	-0.625 (0.461)	0.216*** (0.000)	2.924 (0.540)
Observations	39,668	35,201	39,668	35,201	17,919	15,516	17,919	15,618	20,731	18,641	20,731	18,641
Year FE	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	YES	YES
Household FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Provincial Control	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES
Household Control	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

Note: (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively.

The empirical estimates in Tables 3 and 4 deliver interesting insights. The main findings from Tables 3 and 4 are threefold. First, household indebtedness reduces the growth of consumption expenditure. A one percentage point higher in total debt-to-income ratio is significantly associated with a consumption expenditure fall of 0.07 percentage points, and this effect is smaller in urban than that in rural areas. Furthermore, the comparison of total debt and housing debt shows that housing debt imposes a larger constraint for consumption growth, and this effect is particularly pronounced in the case of urban households. Second, housing-related indebtedness significantly weakens monetary policy transmission. When the housing debt-to-income ratio increases by one standard deviation from the average, the monetary policy transmission efficiency in terms of household consumption reduces by 51%.[21] Again, it is the housing debt

[21] Based on the results shown in column (2) of Table 4, we have $\{0.77 \times 0.07/(0.21 \times 0.07 - 0.121)\} = -0.51$. A possible counterargument is the target savings hypothesis suggesting that a household chooses a certain consumption

that drives the weakening effect as the coefficients of the interaction term become insignificant when we use the total debt-to-income ratio to measure indebtedness. Third, the weakened efficiency of monetary policy transmission from higher indebtedness is slightly stronger in urban areas than in rural areas. When the housing indebtedness increases by the same magnitude, the reduction in transmission from monetary policy to consumption growth is 0.01 percentage points larger for the urban subsample. In addition, the coefficients of other economic condition variables show that higher inflation is associated with higher consumption growth rates, while higher newly added bank deposits have the opposite impact. In terms of household characteristics, a larger family consumes more, but the marital status and education level of the household head do not show significant impact on consumption growth.

The most important observations from this linear panel regression estimation are the significant interaction terms between household housing indebtedness and monetary policy shocks, which are suggestive of a heterogeneous monetary policy transmission subject to indebtedness. This is what we turn to next.

4.2 Panel Smooth Transition Regression Results

Based on the above findings, from now on we focus on the effects of housing-related indebtedness (measured by the housing debt-to-income ratio) on monetary policy transmission in the PSTR analysis. To investigate the non-linearity of the household indebtedness–consumption nexus in China, the following two alternative PSTR models are estimated:

$$(7)\qquad \Delta \ln(\text{Expenditures})_{it} = \mu_i + \beta_{01}\text{DTI}_{it-1} + \beta_{02}\Delta\text{MP}_t + \beta_{03}X_{jt} + \beta_{04}Y_{it} + \beta_{12}\Delta\text{MP}_t \times g(\text{DTI}_{it-1};\, \gamma, c) + \varepsilon_{it}$$

$$(8)\qquad \Delta \ln(\text{Expenditures})_{it} = \mu_i + \beta_{01}\text{DTI}_{it-1} + \beta_{02}\Delta\text{MP}_t + \beta_{03}X_{jt} + \beta_{04}Y_{it} + (\beta_{11}\text{DTI}_{it-1} + \beta_{12}\Delta\text{MP}_t + \beta_{13}X_{jt} + \beta_{14}Y_{it}) \times g(\text{DTI}_{it-1};\, \gamma, c) + \varepsilon_{it}$$

where *i* and *t* refer to household and year, respectively, and *j* indicates the province the household live in. $g(\text{DTI}_{it-1};\gamma,c) = \{1 + \exp(-\gamma(\text{DTI}_{it-1} - c))\}^{-1}$ is the transition function, whose value is defined by the housing debt-to-income ratio. For this two-regime PSTR model, the response $\beta_{02} + \beta_{12} \times g(\text{DTI}_{it-1};\gamma,c)$ is the monetary policy shock impact on consumption. Equation (7) limits the heterogeneity effect to monetary

level in order to reach some targeted wealth-to-income ratio (Carroll, 2001). Higher interest rates after a monetary shock can then lead to lower savings and higher consumer spending. However, empirical support for this hypothesis in China is limited (Chamon and Prasad, 2010).

policy shocks, while Equation (8) allows for an indebtedness dependence of all variables. The PSTR estimates require the presence of a balanced panel. Thus, we reconstruct the data set as follows. First, we only keep the households that are surveyed every time in all the five waves, then we drop the households with a missing value of total expenditures in the year 2009, and we replace all missing observations with the average of the corresponding household's five-year survey data for respective variables. We report the summary statistics of the balanced panel used in PSTR analysis in Appendix A.

Before presenting the estimation results, we conduct several sequential tests to ensure that the PSTR model is correctly specified. The test statistics indicate that our data are stationary and reject the null hypothesis of linearity. Moreover, they indicate that a PSTR model with one monotonic transition function is appropriate and there are no remaining non-linearities beyond that. We report the details of these tests in Appendix B.

The parameter estimates for equation (7) and (8) are given in Table 5 and 6, respectively. In the first specification of equation (7), we only consider a non-linear effect of household indebtedness on monetary policy shocks. In Table 5, here the parameters in the linear part are similar, in terms of both direction and magnitude, to the estimates in the linear panel regression shown in Table 4. The non-linear effect of indebtedness on monetary policy shock (β_{12}) is significant and positive in the full sample, and in both the urban and rural subsamples. In the second specification of equation (8), we allow not only for a non-linear effect of household indebtedness upon monetary policy transmission, but also on the other variables. As we can see from Table 6, the opposite signs of the parameters in the linear and non-linear part for the ΔMP_t consistently imply that household indebtedness weakens the transmission efficiency of monetary policy to household expenditure. Moreover, the transmission-weakening effect is only significant for urban households.

Our results show that household balance sheets do matter for the strength of monetary policy transmission, and our PSTR estimation results underscore the notion that monetary policymakers need to pay close attention to them. Particularly noteworthy is that a deterioration of household balance sheets hampers Chinese monetary policy effectiveness. This is validated in the full sample as well as the urban and rural subsamples. However, it remains the case that the diminished effectiveness is more pronounced for urban households. It must be highlighted that this result is China-specific. The common empirical finding for advanced economies is that the rise in household debt has made household consumption more sensitive to monetary policy shocks. For instance, using the registry-based data on Swedish households, Flodén et al. (2017) argue that monetary policy will have a stronger effect when households are highly indebted. Our empirical results are consistent with the empirical stress testing evidence in Han et al. (2019). By stress testing Chinese households' debt repayment capacity, they find that low-income households are most vulnerable to adverse income shocks.

Table 5: Parameter Estimation Results (Specification 1; Equation 7)

	Full Balanced Panel		Urban Subsample		Rural Subsample	
	Estimate	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Parameters in the linear part β_{0k}						
DTI_{it-1}	-0.055***	0.008	-0.074***	0.015	-0.099***	0.014
$\Delta\mathrm{MP}_t$	-0.107***	0.012	-0.114***	0.018	-0.121***	0.017
PTI_{it}	-0.559	0.393	-0.552	0.543	-0.158	0.506
CPI_{jt}	0.109***	0.008	0.121***	0.012	0.088***	0.010
$\Delta\ln(GDP)_{jt}$	-0.500**	0.219	-0.810***	0.287	0.040	0.280
$\ln(NABD)_{jt}$	-0.031*	0.018	-0.039	0.025	-0.087**	0.039
$FamilySize_{it}$	0.026***	0.003	0.086***	0.010	0.084***	0.008
$Marital_{it}$	0.010	0.016	0.041	0.040	0.038	0.041
$Education_{it}$	0.003***	0.001	0.018***	0.006	0.000	0.005
Parameter in the non-linear part β_{12}						
$\Delta\mathrm{MP}_t$	0.067***	0.020	0.078**	0.033	0.085***	0.024
Non-linear Parameter Estimates						
γ	16.420**	8.063	16.510	22.030	16.260***	3.763
c	0.518***	0.167	0.549***	0.105	0.489***	0.104

Note: (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively.

Table 6: Parameter Estimation Results (Specification 2; Equation 8)

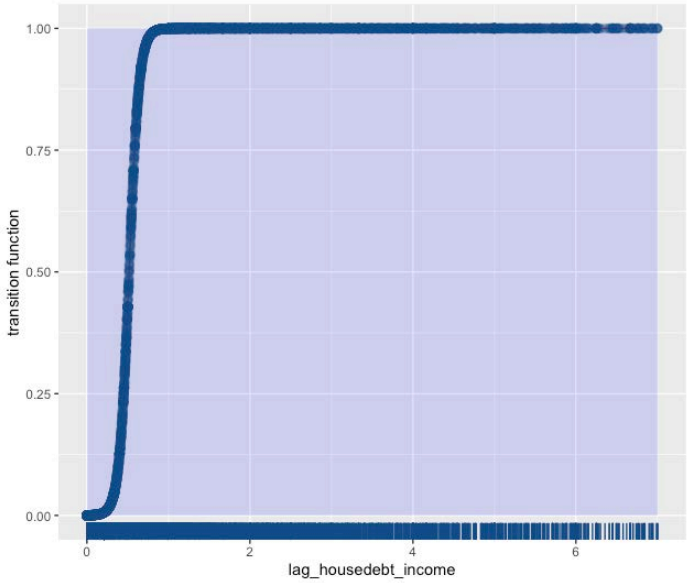
	Full Balanced Panel		Urban Subsample		Rural Subsample	
	Estimate	**SE**	**Estimate**	**SE**	**Estimate**	**SE**
Parameters in the linear part β_{0k}						
DTI_{it-1}	-0.335***	0.077	-0.513**	0.246	-0.475***	0.124
$\Delta\mathrm{MP}_t$	-0.108***	0.012	-0.154***	0.057	-0.112***	0.017
PTI_{it}	-0.806**	0.397	-0.863	0.647	-0.463	0.515
CPI_{jt}	0.109***	0.008	0.124***	0.012	0.087***	0.010
$\Delta\ln(GDP)_{jt}$	-0.505	0.222	-0.518	0.535	-0.105	0.288
$\ln(NABD)_{jt}$	-0.027	0.019	-0.058	0.039	-0.076*	0.039
$FamilySize_{it}$	0.026***	0.003	0.084***	0.012	0.083***	0.009
$Marital_{it}$	0.013	0.016	0.043	0.048	0.020	0.042
$Education_{it}$	0.003**	0.001	0.021**	0.008	-0.001	0.005
Parameters in the non-linear part β_{1k}						
DTI_{it-1}	0.333***	0.080	0.525**	0.237	0.438***	0.124
$\Delta\mathrm{MP}_t$	0.076**	0.032	0.224***	0.084	0.012	0.049
PTI_{it}	1.091	0.889	0.426	1.753	2.012	1.471
CPI_{jt}	-0.001	0.002	-0.007	0.005	-0.002	0.003
$\Delta\ln(GDP)_{jt}$	-0.158	0.474	-1.975*	1.028	1.570**	0.711
$\ln(NABD)_{jt}$	-0.041	0.031	0.095	0.079	-0.099*	0.051
$FamilySize_{it}$	0.016	0.011	0.008	0.028	0.016	0.017
$Marital_{it}$	-0.021	0.063	0.004	0.130	0.182*	0.101
$Education_{it}$	0.002	0.004	-0.019	0.014	0.007	0.008
Non-linear Parameter Estimates						
γ	16.380	13.400	4.131	3.314	16.060***	4.078
c	0.466***	0.075	0.469**	0.213	0.524***	0.092

Note: (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively.

Using the non-linear parameters γ and c, we can disclose the transition function, $g(\mathrm{DTI}_{it-1};\gamma,c) = \{1+\exp(-\gamma(\mathrm{DTI}_{it-1}-c))\}^{-1}$. To interpret the function, we visualize it in Figure 5, where each dot represents an observation. It is evident that the function of the housing debt-to-income ratio is entirely smooth but increases rapidly. The function value reaches 0.5 when housing debt is 51.8% of household income and approximates 1 when the housing debt-to-income ratio approaches 1.5.[22] Afterwards, a horizontal pattern is discernible.

To sum up, at low housing-debt levels a small increase in housing debt is associated with a perceptible reduction of the consumption response pattern in the wake of a contractionary monetary policy shock. On the contrary, household indebtedness does not play a role in changing the monetary policy transmission efficiency when housing debt falls within the range of the upper limit of the logistic function.

Figure 5: Transition Function with $r = 1$ and $m = 1$



4.3 Discussion

To explain our finding that household indebtedness weakens monetary policy transmission, we need to understand a unique characteristic of the Chinese financial market. Many Chinese households purchase real

[22] The 90th and 95th percentile of the housing debt-to-income share are 42.86% and 150%, respectively. Technically, the transition function would never touch 1 because this would imply $\exp(-\gamma(\mathrm{DTI}_{it-1}-c)) = 0$ and thus the housing debt-to-income ratio would be infinitive. Here we show the corresponding DTI when the function value is 0.999999.

estate not for their own use, but as an investment. Therefore, households with higher housing debt are not illiquid and hand-to-mouth consumers with large propensities to consume, as studies using data of advanced economies suggest (see Kaplan et al., 2014).

This relates to the limited range of assets available in China (Wu et al., 2016). In addition, the RMB 4 trillion economic stimulus package announced in 2008 to mitigate the shock from the global financial crisis comprised a massive expansion in housing projects and infrastructure constructions. Figure 6 shows the percentage of households owning more than one house, and we find that more than 16% of households owned multiple houses by 2018 and the number of urban households with multiple houses reached 20%.[23] Assuming that the households owning more than one house are more likely to be house-investors, housing as an investment is pervasive in China.

Figure 6: Share of Households Owning More than One House in Various CFPS Waves

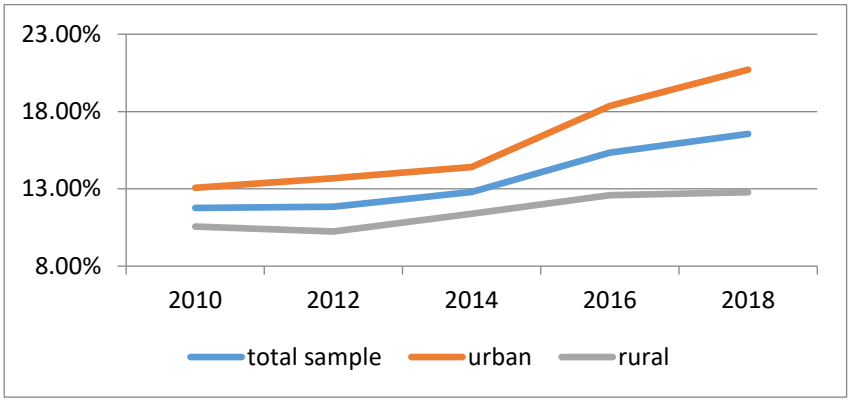


Table 7: Comparison between House-Investors and House-Dwellers

	House-Investors	House-Dwellers		t-Statistic
	Households Owning Multiple Properties	Households Owning One Property	Renters	
obs.	8,403	51,179	2,680	
Total Income	103,836.80	49,254.65	80,976.50	-31.74***
Total Assets	1,311,739.00	368,062,80	405,455.30	-64.16***
Financial Assets	105,132.3	35,523.84	64,082.43	-30.13***
Housing Debt/Total Income	0.5168	0.1641	0.1091	-38.54***
Housing Debt/Total Assets	0.0537	0.0206	0.0131	-33.01***

Notes: The figures in the table show the average values for all surveys. The t-test is an inferential statistic determining whether there are significant differences between the mean of households owning one property vs households owning multiple properties. (***) indicates significance at the 1% level. The definition of financial assets comprises the market value of deposits, bonds, stocks, and mutual funds.

[23] This is consistent with Gan (2018) who documents a nationwide urban housing vacancy rate of 21.4% in 2017.

However, even if it is clear that investing in the housing market is profitable, the regulation and credit constraint in China would not satisfy all the investing demands, and it is difficult for poorer households to borrow to invest in the housing market. The result is that multiple-property households are much richer than house-dwellers with one property for their own use or that of tenants. Table 7 shows the average income, housing and financial assets and indebtedness for house-investors and house-dwellers. It is apparent that the house-investors are significantly richer, in terms of both income and assets, and are also more indebted than the households owning just one property. Over and above, investor-households owning multiple properties possess more liquid financial assets. The investor-households are therefore not hand-to-mouth consumers with lower liquidity, direct exposure to interest rate risk and higher marginal consumption propensity. On the contrary, investor-households in China tend to have more liquid assets and thus the consumption response to monetary policy shocks is smaller because monetary policy changes households' saving incentives (intertemporal substitution).[24]

Digging deeper, we split the sample into liquidity constrained and unconstrained subsamples and examine whether the transmission-mitigating effects of housing indebtedness is smaller for households that are more constrained in liquidity. Following Zeldes (1989), we define a household is liquidity-constrained (LC=1) when the financial assets-to-income ratio is smaller than two, otherwise it is not constrained in liquidity (LC=0). As households change this group affiliation during the five waves and the PSTR estimation requires a balanced panel, we provide evidence of the role of liquidity constraint using linear panel estimates. Table 8 presents the results. We see that household indebtedness mitigates monetary policy transmission to consumption in both subsamples, but the effects are stronger when the households do not face a liquidity constraint. These results reconcile the different findings in this study compared to the literature, and confirm the Chinese-specific interpretation that higher housing indebtedness does not indicate higher liquidity constraint.

[24] The estimation results are in accord with the explanations of monetary policy transmission in recent HANK models. The models predict that households differ in their response to monetary policy due to a different holding of liquid assets, which can be withdrawn quickly at little or no cost. Intuitively, households with few liquid assets do not have a large enough buffer to smooth consumption when interest rate changes let their income fluctuate. If these households face borrowing costs or constraints, then their consumption is affected particularly strongly.

Table 8: Housing Debt-to-Income Ratio, Monetary Policy, and Household Expenditures Depending on the Degree of Liquidity Constraints

	Dep: ΔLn(Total Expenditures) (Full Sample)							
	LC=0				LC=1			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lag (House Debt-to - Income Rate)	-0.110*** (0.001)	-0.112*** (0.001)	-0.112*** (0.001)	-0.111*** (0.001)	-0.159*** (0.000)	-0.158*** (0.000)	-0.164*** (0.000)	-0.158*** (0.000)
Lag (House Debt-to-Income Ratio)*ΔIRS 7-day Rate	0.070*** (0.000)	0.077*** (0.000)	0.070*** (0.000)	0.077*** (0.000)	0.054*** (0.002)	0.055*** (0.003)	0.055*** (0.002)	0.055*** (0.003)
ΔIRS 7-day Rate	0.009 (0.285)	-0.189*** (0.005)			-0.017 (0.158)	-0.017 (0.841)		
House Price-to-Income Ratio		0.729 (0.480)		0.339 (0.749)		-1.492 (0.224)		-1.418 (0.273)
CPI		0.129*** (0.002)		0.158*** (0.001)		0.011 (0.837)		0.007 (0.916)
GDP Growth Rate		-0.125 (0.842)		-0.123 (0.844)		-0.551 (0.502)		-0.566 (0.490)
Ln (Newly added bank deposits)		-0.131** (0.027)		-0.155** (0.012)		-0.092 (0.283)		-0.086 (0.345)
Family Size		0.070*** (0.003)		0.070*** (0.003)		0.116*** (0.000)		0.116*** (0.000)
Marital Status		0.056 (0.556)		0.059 (0.530)		-0.077 (0.476)		-0.078 (0.473)
Education Level		0.002 (0.873)		0.001 (0.932)		-0.018 (0.216)		-0.017 (0.221)
Constant	0.225*** (0.000)	-12.552*** (0.002)	0.229*** (0.000)	-15.512*** (0.002)	0.246*** (0.000)	-0.404 (0.941)	0.242*** (0.000)	-0.012 (0.998)
Observations	18,083	15,707	18,083	15,707	15,319	13,395	15,319	13,395
Year FE	NO	NO	YES	YES	NO	NO	YES	YES
Household FE	YES	YES	YES	YES	YES	YES	YES	YES
Provincial Control	NO	YES	NO	YES	NO	YES	NO	YES
Household Control	NO	YES	NO	YES	NO	YES	NO	YES

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

5. Conclusion

The transmission of monetary policy is at the core of the research agenda in economics. We add a dimension by looking at responses across the debt-to-income distribution. In other words, we offer an empirical evaluation of the influence of household debt on the efficacy of monetary policy in China. A particular strength of the analysis is that we employ granular micro-level household data.

We extend the literature by investigating the change of consumption of Chinese households in response to a well-identified monetary policy. Notwithstanding the different econometric modelling methodological approaches, all estimates suggest that housing-related indebtedness weakens the monetary policy transmission. The China-specific root cause is that less indebted and low-liquidity households (higher indebted and high-liquidity) households show stronger (weaker) responses to monetary policy shocks. A spatially differentiated view shows that indebtedness has a stronger impact upon the consumption response of urban households than on that of rural households. These findings can be explained by the limited range of assets available in China. Credit constraints tend to allocate the mortgage and housing-related credit to

households with more assets and collateral, and these households are less exposed to monetary policy shocks. Taken together, the micro-level household data yield a number of new insights that may guide monetary policymakers and future HANK models alike.

References:

Agarwal, S. and Qian, W. (2014), "Consumption and debt response to unanticipated income shocks: evidence from a natural experiment in Singapore", *American Economic Review,* Vol. 104 pp. 4205–4230.

Aladangady, A. (2017), "Housing wealth and consumption: evidence from geographically-linked microdata", *American Economic Review,* Vol. 107, pp. 3415–3446.

Allegret, J.-P., Couharde, C., Coulibaly, D. and Mignon, V. (2014), "Current accounts and oil price fluctuations in oil-exporting countries: the role of financial development", *Journal of International Money and Finance,* Vol. 47, pp. 185–201.

Alpanda, S. and Zubairy, S. (2019), "Household debt overhang and transmission of monetary policy", *Journal of Money, Credit and Banking,* Vol. 51, pp. 1265–1307.

Auclert, A. (2019), "Monetary policy and the redistribution channel", *American Economic Review,* Vol. 109, pp. 2333–2367.

Baker, S.R. (2018), "Debt and the response to household income shocks: validation and application of linked financial account data", *Journal of Political Economy,* Vol. 126, pp. 1504–1557.

Calza, A., Monacelli, T. and Stracca, L. (2013), "Housing finance and monetary policy", *Journal of the European Economic Association,* Vol. 11, pp. 101–122.

Carroll, C. D. (2001), "A theory of the consumption function, with and without liquidity constraints", *Journal of Economic Perspectives,* Vol. 15, pp. 23–45.

Chamon, M. D. and Prasad, E. (2010), "Why are saving rates of urban households in China rising?" *American Economic Journal: Macroeconomics,* Vol. 2, pp. 93–130.

Cho, D. (2015), "The role of covered interest parity in explaining the forward premium anomaly within a nonlinear panel framework", *Journal of Empirical Finance,* Vol. 34, pp. 229–238.

Cloyne, J., Ferreira, C. and Surico, P. (2020), "Monetary policy when households have debt: new evidence on the transmission mechanism", *Review of Economic Studies,* Vol. 87, pp. 102–129.

Colletaz, G. and Hurlin, C. (2006), "Threshold effect in the public capital productivity: an international panel smooth transition approach", *Carnegie Rochester Conference Series on Public Policy,* Vol. 39, pp. 95–140.

Delatte, A.-L., Fouquau, J. and Portes, R. (2017), "Regime-dependent sovereign risk pricing during the euro crisis", *Review of Finance,* Vol. 21, pp. 363–385.

Di Maggio, M., Kermani, A., Keys, B.J., Piskorski, T., Ramcharan, R., Seru, A. and Yao, V. (2017), "Interest rate pass-through: mortgage rates, household consumption, and voluntary deleveraging", *American Economic Review,* Vol. 107, pp. 3550–3588.

Espinoza, R., Leon, H. and Prasad, A. (2012), "When should we worry about inflation?", *World Bank Economic Review,* Vol. 26, pp. 100–127.

Fan, Y. and A. Yavas, (2020), "How does mortgage debt affect household consumption? Micro evidence from China", *Real Estate Economics*, Vol. 48, pp. 43–88.

Flodén, M., Kilström, M., Sigurdsson, J. and Vestman, R. (2017), "Household debt and monetary policy: revealing the cash-flow channel", *CEPR Discussion Paper No.*, 12270, London.

Funke, M. and Tsang, A. (2020) "The People's Bank of China's Response to the Coronavirus Pandemic: A Quantitative Assessment", *Economic Modelling* 93, 465-473.

Funke, M. and Tsang, A. (2021) "The Direction and Intensity of China's Monetary Policy: A Dynamic Factor Modelling Approach", *Economic Record* 97, 100-122.

Gan, L. (2018), "Analysis of China's urban housing vacancy in 2017", China Household Finance Survey.

Gelos, G., Grinberg, F., Mancini-Griffoli, T., Khan, S., Narita, M. and Rawat, U. (2019), "Has higher household indebtedness weakened monetary policy transmission?", *IMF Working Paper No.*, WP/19/11, Washington DC.

Gertler, M. and Karadi, P. (2015), "Monetary policy surprises, credit costs, and economic activity", *American Economic Journal: Macroeconomics*, Vol. 7, pp. 44–76.

Gerko, E. and Rey, H. (2017), "Monetary policy in the capitals of capital", *Journal of the European Economic Association*, Vol. 15, pp. 721–745.

González, A., Teräsvirta, T. and van Dijk, D. (2005), "Panel smooth transition regression models", *Stockholm School of Economics, Working Paper Series in Economics and Finance, No*. 604, Stockholm.

González, A., Teräsvirta, T., van Dijk, D. and Yang, Y. (2017), "Panel smooth transition regression models", *CREATES Research Paper No*. 2017–2036, Aarhus.

Granger, C.W.J. and Teräsvirta, T. (1993), *Modelling Nonlinear Economic Relationships*, Oxford (Oxford University Press).

Han, F., Jurzyk, E., Guo, W., He, Y. and Rendak, N. (2019), "Assessing macro-financial risks of household debt in China", *IMF Working Paper No*. WP/19/258, Washington DC.

Hansen, B.E. (1999), "Threshold effects in non-dynamic panels: estimation, testing, and inference", *Journal of Econometrics*, Vol. 93, pp. 345–368.

Iacoviello, M. (2005), "House prices, borrowing constraints, and monetary policy in the business cycle", *American Economic Review*, Vol. 95, pp. 739–764.

Im, K., Pesaran, M. and Shin, Y. (2003), "Testing for unit roots in heterogeneous panels", *Journal of Econometrics*, Vol. 115, pp. 53–74.

IMF (2019), "*People's Republic of China – Selected Issues*", Washington DC.

Kamber, G. and Mohanty M.S. (2018), "Do interest rates play a major role in monetary policy transmission in China?", *BIS Working Paper No*. 714, Basel.

Kaplan, G., Violante, G.L and Weidner, J. (2014), "The wealthy hand-to-mouth", *Brookings Papers on Economic Activity*, Vol. 48, pp. 77–153.

Kaplan, G., Moll, B. and Violante, G.L. (2018), "Monetary policy according to HANK", *The American Economic Review,* Vol. 108, pp. 697–743.

Kim, Y. and Lim, H. (2020) "Transmission of Monetary Policy in Times of High Household Debt", *Journal of Macroeconomics,* Vol. 63, 103168.

Li, L. and Wu, X. (2014), "Housing price and entrepreneurship in China", *Journal of Comparative Economics,* Vol. 42, pp. 436–449.

Loukoianova, E., Wong, Y.C. and Hussiada, I. (2019), "Household debt, consumption, and monetary policy in Australia", *IMF Working Paper No*. WP/19/11, Washington DC.

Luukkonen, R., Saikkonen, P. and Teräsvirta, T. (1988), "Testing linearity against smooth transition autoregressive models", *Biometrika,* Vol. 75, pp. 491–499.

Martin, P. and Philippon, T. (2017), "Inspecting the mechanism: leverage and the great recession in the eurozone," *American Economic Review,* Vol. 107, pp. 1904–1937.

Mian, A. and Sufi, A. (2009), "The consequences of mortgage credit expansion: evidence from the US mortgage default crisis", *Quarterly Journal of Economics,* Vol. 124, pp. 1449–1496.

Mian, A. and Sufi, A. (2018), "Finance and business cycles: the credit-driven household demand channel", *Journal of Economic Perspectives,* Vol. 32, pp. 31–58.

Mian, A.R., A. Sufi and Verner, E. (2017), "Household debt and business cycles worldwide", *Quarterly Journal of Economics,* Vol. 132, pp. 1755–1817.

Mitman, K. (2016), "Macroeconomic Effects of Bankruptcy and Foreclosure Policies", *American Economic Review,* Vol. 106, pp. 2219–2255.

Nakamura, E. and Steinsson, J. (2018), "High frequency identification of monetary nonneutrality: the information effect", *Quarterly Journal of Economics,* Vol. 133, pp. 1283–1330.

People's Bank of China (2018), *China Financial Stability Report 2018*, Beijing.

Ranaldo, A. and Rossi, E. (2010), "The reaction of asset markets to Swiss National Bank communication", *Journal of International Money and Finance*, Vol. 29, pp. 486–503.

Rubio, M. (2011), "Fixed- and variable-rate mortgages, business cycles, and monetary policy", *Journal of Money, Credit and Banking,* Vol. 43, pp. 657–688.

Slacalek, J., Tristani, O. and Violante, G.L. (2020), "Household balance sheet channels of monetary policy: a back of the envelope calculation for the euro area", *NBER Working Paper No*. 26630, Cambridge (Mass.).

Teräsvirta, T. (1994), "Specification, estimation and evaluation of smooth transition autoregressive models", *Journal of the American Statistical Association,* Vol. 89, pp. 208–218.

van Dijk, D., Teräsvirta, T. and Franses, P.H. (2002), "Smooth transition autoregressive models – a survey of recent developments", *Econometric Reviews,* Vol. pp. 21, 1–47.

Wu, J., Gyourko, J. and Deng, Y. (2016), "Evaluating the risk of Chinese housing markets: what we know and what we need to know", *China Economic Review*, Vol. 39, pp. 91–114.

Xie, Y. and Hu, J. (2014), "An introduction to the China family panel studies (CFPS)", *Chinese Sociological Review*, Vol. 47, pp. 3–29.

Xie, Y. and Jin, Y. (2015), "Household wealth in China", *Chinese Sociological Review*, Vol. 47, pp. 203–229.

Xie, Y. and Zhou, X. (2014), "Income inequality in today's China", *Proceedings of the National Academy of Sciences*, Vol. 111, pp. 6928–6933.

Xu, H., Liu, A. and Zhang, Y. (2015), "Inequality in children's well-being and development: evidence from a national panel study", *Chinese Journal of Sociology*, Vol. 1, pp. 88–107.

Zeldes, S.P. (1989), "Consumption and liquidity constraints: an empirical investigation", *Journal of Political Economy*, Vol. 97(2), pp. 305–346.

Zhou, G., Fan, G. and Shen, G. (2014), "The income disparity, the social capital and health: a case study based on China family panel studies", *Management World*, Vol. 7, pp. 12–21 (in Chinese).

Appendix A: Data and Summary Statistics

Table A1: Variable Construction from CFPS

Variable	Definition	2010	2012	2014	2016	2018
Total income	Family net income. This is the sum of salary income, operational income, transfer income, property income and other income. All comparable with 2010 value.	FAMINC_NET	FINCOME2_ADJ	FINCOME2	FINCOME2	FINCOME2
Total expenditure	The sum of consumption expense, transfer expense, welfare expense and mortgage expense.	EXPENSE (by definition EXPENSE=PCE+EPTRAN+EPWELF+MORTAGE)	EXPENSE (by definition EXPENSE=PCE+EPTRAN+EPWELF+MORTAGE)	EXPENSE (by definition EXPENSE=PCE+EPTRAN+EPWELF+MORTAGE)	EXPENSE (by definition EXPENSE=PCE+EPTRAN+EPWELF+MORTAGE)	EXPENSE (by definition EXPENSE=PCE+EPTRAN+EPWELF+MORTAGE)
Mortgage expenditure	Mortgage expense.	MORTAGE	MORTAGE	MORTAGE	MORTAGE	MORTAGE
Non-mortgage expenditure	Non-mortgage expense. This is the sum of consumption expense, transfer expense and welfare expense.	EXPENSE-MORTAGE	EXPENSE-MORTAGE	EXPENSE-MORTAGE	EXPENSE-MORTAGE	EXPENSE-MORTAGE
Consumption expenditure	The sum of expenses on food, clothing, daily necessities, medicine, transportation and communication, education and entertainment, and others. By definition, consumption expenditure is a part of non-mortgage expenditure.	PCE	PCE	PCE	PCE	PCE
Housing debt	The amount of debt for purchase, construction, or decoration of houses, including loans from banks and borrowing from relatives, friends, or other non-bank financial institutions.	HOUSE_DEBTS	HOUSE_DEBTS	HOUSE_DEBTS	HOUSE_DEBTS	HOUSE_DEBTS

Non-housing debt	The amount of debt for reasons except the purchase, construction or decoration of houses, including loans from banks and borrowing from relatives, friends, or other non-bank financial institutions.	NONHOUSING_DEBTS	NONHOUSING_DEBTS	NONHOUSING_DEBTS	NONHOUSING_DEBTS	NONHOUSING_DEBTS
Total debt	The sum of housing and non-housing debt.	HOUSE_DEBTS+ NONHOUSING_DEBTS	HOUSE_DEBTS+ NONHOUSING_DEBTS	HOUSE_DEBTS+ NONHOUSING_DEBTS	HOUSE_DEBTS+ NONHOUSING_DEBTS	HOUSE_DEBTS+ NONHOUSING_DEBTS
Housing asset	The market price value for all the houses the family own.	RESIVALUE_NEW+OTHERHOUSEVALUE	HOUSEASSET_GROSS	HOUSEASSET_GROSS	HOUSEASSET_GROSS	HOUSEASSET_GROSS
Total asset	The net total assets of the family. This is the sum of housing assets, land assets, financial assets, fixed assets and durable assets.	HOUSE_ASSET+ LAND_ASSET+FINANCE_ASSET+ FIXED_ASSET+DURABLES_ASSET	HOUSE_ASSET+ LAND_ASSET+FINANCE_ASSET+ FIXED_ASSET+DURABLES_ASSET	HOUSE_ASSET+ LAND_ASSET+FINANCE_ASSET+ FIXED_ASSET+DURABLES_ASSET	HOUSE_ASSET+ LAND_ASSET+FINANCE_ASSET+ FIXED_ASSET+DURABLES_ASSET	HOUSE_ASSET+ LAND_ASSET+FINANCE_ASSET+ FIXED_ASSET+DURABLES_ASSET
House mortgagor	A dummy variable indicating the household is a mortgagor, if the mortgage expenditure is positive.	Dummy=1 if MORTAGE>0 & MORTAGE!=.	Dummy=1 IF MORTAGE>0 & MORTAGE!=.	Dummy =1 IF MORTAGE>0 & MORTAGE!=.	Dummy =1 IF MORTAGE>0 & MORTAGE!=.	Dummy =1 IF MORTAGE>0 & MORTAGE!=.
Outright owner	A dummy variable indicating the household is a right owner of houses, if the houses they live in are owned by themselves or co-owned with their employers, and the household has no mortgage.	Dummy=1 if (FD1==1 | FD1==2) & MORTAGE==0	DUMMY=1 IF (FQ1==1 | FQ1==2) & MORTAGE==0	DUMMY=1 IF (FQ2==1 | FQ2==2) & MORTAGE==0	DUMMY=1 IF (FQ2==1 | FQ2==2) & MORTAGE==0	DUMMY=1 IF (FQ2==1 | FQ2==2) & MORTAGE==0
Renter	A dummy variable indicating the household is a renter, if the houses they live in are rented.	Dummy=1 if FD1==3	DUMMY=1 IF FQ1==4 | FQ1==5 | FQ1==6	DUMMY=1 IF FQ2==4 | FQ2==5 | FQ2==6	DUMMY=1 IF FQ2==4 | FQ2==5 | FQ2==6	DUMMY=1 IF FQ2==4 | FQ2==5 | FQ2==6

Table A2: Summary Statistics of the Balanced Panel Data Set in the PSTR Analysis

	Full Sample			Urban Sample			Rural Sample		
Variable	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**	**Mean**	**SD**	**N**
$\Delta ln(Total\ Expenditures)_{it}$	0.16	0.85	36,656	0.18	0.79	14,376	0.14	0.89	18,700
DTI_{it-1}	0.19	0.72	36,656	0.20	0.75	14,376	0.19	0.69	18,700
IRS	0.48	1.09	36,656	0.48	1.09	14,376	0.48	1.09	18,700
PTI_{jt}	0.10	0.03	36,656	0.10	0.03	14,376	0.10	0.02	18,700
CPI_{jt}	102.76	1.66	36,656	102.75	1.63	14,376	102.76	1.68	18,700
$\Delta ln(GDP)_{jt}$	0.11	0.07	36,656	0.10	0.06	14,376	0.11	0.07	18,700
$Ln(New\_bank\_deposits)_{jt}$	5.96	0.74	36,656	6.08	0.78	14,376	5.87	0.68	18,700
$FamilySize_{it}$	3.95	1.86	36,656	3.65	1.71	14,376	4.18	1.94	18,700
$Marital_{it}$	0.84	0.36	36,656	0.84	0.37	14,376	0.85	0.36	18,700
$Education_{it}$	6.72	4.53	36,656	8.18	4.64	14,376	5.66	4.18	18,700

Appendix B: Tests of the PSTR Model Specification

To begin with, we have conducted the heterogeneous panel unit root test suggested by Im et al. (2003). The test results reported in Table B1 entail the rejection of the unit root null hypothesis at the 1% significance level. The next step consists of testing for linearity. If linearity is rejected, we must specify the number of transition functions. We follow Colletaz and Hurlin (2006) and employ Wald, Fisher, and Likelihood ratio tests. The linearity test statistics in Table B2 show that the null hypothesis that the model is linear is rejected. In other words, the efficacy of monetary policy varies according to the level of household indebtedness. The next step in the sequential test procedure consists of homogeneity tests to determine the number of switches in the transition function. In practice, it is usually sufficient to consider $m = 1$ or $m = 2$, which allows for commonly encountered types of variation in the parameters (González et al., 2005, 2017). When $m = 1$, the model has a logistic transition function; when $m = 2$, the model needs an exponential transition function. According to Teräsvirta (1994) and Luukkonen et al. (1988), linearity tests can also serve to determine the appropriate number of transition functions or equivalently the number of distinct regimes. The aim of the testing procedure is to determine the lowest order for which the null hypothesis of no remaining heterogeneity is accepted. Table B3 shows that a PSTR model with one monotonic transition function is appropriate. The final step in the sequential testing procedure are tests for remaining non-linearities after assuming a two-regime model. The test statistics in Table B4 confirm that the null hypothesis cannot be rejected, implying that the model has only one threshold and thus two regimes.

Table B1: Panel Unit Root Tests

	IPS - Statistics	Critical Values		
		1%	5%	10%
Main Regressors				
$\Delta ln(Total\ Expenditures)_{it}$	-7.2654***	-2.000	-1.840	-1.770
DTI_{it-1}	-9.2201***	-2.000	-1.840	-1.770
Provincial Control Variables				
PTI_{jt}	-4.9110***	-2.000	-1.840	-1.770
CPI_{jt}	-2.3971***	-2.000	-1.840	-1.770
$\Delta ln(GDP)_{jt}$	-3.1927***	-2.000	-1.840	-1.770
$ln(New\_bank\_deposits)_{jt}$	-3.3620**	-2.000	-1.840	-1.770
Household Control Variables				
$FamilySize_{it}$	-1.8537**	-2.000	-1.840	-1.770
$Marital_{it}$	-10.4816***	-2.000	-1.840	-1.770
$Education_{it}$	-5.5435***	-2.000	-1.840	-1.770

Notes: The IPS test for unit roots in heterogeneous panels has been developed by Im et al. (2003). It allows for individual effects, time trends, and common time effects and is based on the mean of the individual Dickey-Fuller *t*-statistics of each unit in the panel. The IPS (2003) test assumes that all series are non-stationary under the null hypothesis. (***), (**) and (*) denote significance at the 1%, 5% and 10% levels, respectively.

Table B2: Linearity Tests

	LM		LM_F		HAC		HAC_F	
	Statistic	Prob-Value	Statistic	Prob-Value	Statistic	Prob-Value	Statistic	Prob-Value
Specification 1 (Eq. 7)								
Full Balanced Panel	30.39	0.000	22.79	0.000	19.63	0.000	14.72	0.000
Urban Subsample	21.11	0.000	15.82	0.000	9.60	0.002	7.19	0.007
Rural Subsample	25.44	0.000	19.06	0.000	18.43	0.000	13.81	0.000
Specification 2 (Eq. 8)								
Full Balanced Panel	55.06	0.000	4.59	0.000	39.28	0.000	3.27	0.000
Urban Subsample	55.90	0.000	4.65	0.000	30.82	0.000	2.55	0.006
Rural Subsample	59.49	0.000	4.95	0.000	43.29	0.000	3.60	0.000

Notes: H_0: Linear model; H_1: PSTR model with at least two regimes. González et al. (2005, 2017) have outlined the Wald test, the Fisher test and two versions of HAC tests for testing linearity against the PSTR model.

- $\chi 2$-version LM test: the LM test with asymptotically $\chi 2$ distribution under the null hypothesis.
- F-version LM test: the LM test with asymptotically F distribution under the null hypothesis. The finite sample actual size is supposed to be improved.
- $\chi 2$-version HAC test: the HAC LM test with asymptotically $\chi 2$ distribution under the null hypothesis, which is heteroscedasticity- and autocorrelation-consistent.
- F-version HAC test: the HAC LM test with asymptotically F distribution under the null hypothesis, which is heteroscedasticity- and autocorrelation-consistent. The finite sample actual size is supposed to be improved.

Table B3: Sequence of Homogeneity Tests

	m	LM		LM_F		HAC		HAC_F	
		Statistic	**p-Value**	**Statistic**	**p-Value**	**Statistic**	**p-Value**	**Statistic**	**p-Value**
Specification 1:									
Full Balanced Panel	H_{01}	30.39	0.0000	22.79	0.0000	19.63	0.0000	14.72	0.0001
	H_{02}	0.09	0.7587	0.07	0.7903	0.07	0.7972	0.05	0.8239
	H_{03}	1.14	0.2851	0.86	0.3547	0.76	0.3824	0.57	0.4495
Urban Subsample	H_{01}	21.11	0.0000	15.82	0.0001	9.60	0.0020	7.19	0.0073
	H_{02}	4.00	0.0455	3.00	0.0834	2.49	0.1144	1.87	0.1719
	H_{03}	0.10	0.7544	0.07	0.7866	0.07	0.7917	0.05	0.8192
Rural Subsample	H_{01}	25.44	0.0000	19.06	0.0000	18.43	0.0000	13.81	0.0002
	H_{02}	0.33	0.5657	0.25	0.6190	0.24	0.6219	0.18	0.6695
	H_{03}	0.15	0.7022	0.11	0.7407	0.10	0.7552	0.07	0.7872
Specification 2:									
Full Balanced Panel	H_{01}	55.06	0.0000	4.59	0.0000	39.28	0.0000	3.27	0.0005
	H_{02}	32.86	0.0001	2.74	0.0034	19.67	0.0201	1.64	0.0985
	H_{03}	45.73	0.0000	3.81	0.0001	24.74	0.0033	2.06	0.0296
Urban Subsample	H_{01}	55.90	0.0000	4.65	0.0000	30.8	0.0003	2.56	0.0061
	H_{02}	39.08	0.0000	3.25	0.0006	20.1	0.0172	1.67	0.0897
	H_{03}	30.61	0.0003	2.54	0.0065	16.3	0.0610	1.35	0.2035
Rural Subsample	H_{01}	59.49	0.0000	4.95	0.0000	43.29	0.0000	3.60	0.0002
	H_{02}	23.86	0.0045	1.98	0.0369	20.26	0.0164	1.69	0.0867
	H_{03}	17.53	0.0411	1.46	0.1578	11.24	0.2598	0.93	0.4939

Notes: The listed null hypotheses are H01: $\beta1 = 0|\beta3 = \beta2 = 0$, H02: $\beta2 = 0|\beta3 = 0$, and H03: $\beta3 = 0$, respectively, in the auxiliary regression (by replacing the transition function by its first-order Taylor expansion around $\gamma=0$) with m=3. The order that has the strongest rejection to the corresponding null hypothesis should be selected. If the rejection of H02 is the strongest, we should select m=2; otherwise, we should select m=1, namely the model has only one location parameter.

Table B4: Misspecification Tests

Parameter Constancy H0: the model has constant parameters Ha: the model is a TV-PSTR										
	LM		**LM_F**		**HAC**		**HAC_F**		**WB**	**WCB**
	Statistic	**p-Value**	**Statistic**	**p-Value**	**Statistic**	**p-Value**	**Statistic**	**p-Value**	**p-Value**	**p-Value**
Specification 1:										
Full Balanced Panel	13.39	0.2027	1.00	0.4374	9.72	0.4652	0.73	0.6982	1	1
Urban Subsample	14.98	0.1330	1.12	0.3415	10.29	0.4158	0.77	0.6581	0.70	1
Rural Subsample	43.28	0.0554	1.08	0.3487	31.03	0.4139	0.77	0.8052	1	1
Specification 2:										
Full Balanced Panel	50.54	0.0001	2.10	0.0041	31.94	0.0223	1.33	0.1576	1	0.97
Urban Subsample	28.37	0.0567	1.18	0.2695	18.58	0.4181	0.77	0.7363	1	1
Rural Subsample	11.18	0.3440	0.84	0.5928	7.95	0.6339	0.60	0.8192	0.95	1
No remaining heterogeneity H0: r=1 Ha: r=2										
	LM		**LM_F**		**HAC**		**HAC_F**		**WB**	**WCB**
	Statistic	**p-Value**	**Statistic**	**p-Value**	**p-Value**	**p-Value**	**Statistic**	**p-Value**	**p-Value**	**p-Value**
Specification 1:										
Full Balanced Panel	39.09	0.0000	2.93	0.0011	26.99	0.0026	2.02	0.0272	1	1
Urban Subsample	46.89	0.0000	3.51	0.0001	28.72	0.0014	2.15	0.0180	0.89	1
Rural Subsample	48.62	0.0000	3.64	0.0001	32.83	0.0003	2.46	0.0062	0.96	0.91
Specification 2:										
Full Balanced Panel	67.47	0.0000	2.81	0.0001	58.94	0.0000	2.45	0.0006	0.42	0.75
Urban Subsample	58.30	0.0000	2.42	0.0007	36.86	0.0055	1.53	0.0694	0.56	0.60
Rural Subsample	48.62	0.0000	3.64	0.0001	32.83	0.0003	2.46	0.0062	0.64	0.75

Note: (1) The wild bootstrap (WB) evaluation tests are heteroscedasticity-robust; (2) the wild cluster bootstrap (WCB) evaluation tests are both cluster-dependency- and heteroscedasticity-robust. Cluster-dependency implies that there can be dependency (autocorrelation) within individual, but no correlation across individuals; (3) the number of repetitions in the bootstrap procedure is set to be 100.

Given the simulation evidence presented in González, Andrés; Teräsvirta, Timo; Dijk, Dick van (2005, 2017), the small p-values of the standard tests are likely caused by neglecting cross-sectional heteroscedasticity, which renders the tests unreliable. Results from the WB and WCB tests that take both heteroscedasticity and possible with-in cluster dependence into consideration suggest that the estimated two-regime model with one transition is adequate to capture the non-linearity relationship.