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Supervision of and Response to China's Real Estate Bubble: The Effects of the Loan-to-Value Ratio Policy[†]

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Abstract

This paper assesses the impact of differentiated housing credit policies on house prices between 2007 and 2016, during which time Chinese government agencies frequently issued loan-to-value requirements for property purchases. The empirical strategy applied employs an exposure measure to quantify policy efforts and uses a difference-in-differences approach to determine the causal effect. The results show that the loan-to-value ratio policy has been effective in dealing with increasing house prices; tightening policy tends to exert a greater impact on house prices. Evidence is found that the elasticity of urban housing supply affects the effectiveness of loan-to-value policy.

Key words: house prices, residential property, loan-to-value ratio, policy effect, difference-in-differences

JEL Classification: G21, G28, R21, R38

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1 Introduction

With the continuous development of the global economy and the acceleration of the urbanisation process, loan-to-value (LTV) policies are increasingly being used to stabilise property markets. While such policies have long been adopted by governments, their impact on house price growth and market activity has been difficult to measure. The biggest challenge is understanding how market indicators would have performed without these policies.

I address this question by applying a standard fixed effects model with variable treatment intensity to investigate China's real estate market and by adopting the difference-in-differences (DD) technique to confirm the findings. I focus on China not only because it is the largest emerging market globally but also because there is a distinction between city- and national-level LTV policies, which enables a causal analysis. Other leading countries such as the U.S. and the U.K. have yet to impose any caps on LTV ratios at a national level.

Although LTV policies announced by the central government apply to the whole country, cities have some degree of freedom in setting stricter requirements. As a result, LTV ratios are not uniform across China. In this context, treatment groups and control groups can be selected depending on whether a city's LTV cap changed after a policy was released. This research design estimates the impact of LTV policy by comparing the outcomes in treatment and control cities.

Why should LTV ratio policy be studied? First, as a form of macroprudential regulation, the policy can achieve better results than monetary or fiscal solutions by acting directly on housing market activities (Crowe et al. 2011). Rubio (2016) incorporates LTV limits in a standard New Keynesian dynamic stochastic general equilibrium model to simulate real estate market activity and explore the policy effect. The results show that LTV ceilings could reduce credit volatility and ensure financial stability; when stricter limits on LTV ratios are established, a stronger policy effect will be produced. Since the 1990s, the use of LTV policy in regulating the real estate market

has increased greatly (Shim et al. 2013, Akinci and Olmstead-Rumsey 2018).

Second, in theory, LTV ratio policy is designed to reduce demand pressure and systemic risk by curbing borrowers' leverage, but its effectiveness also depends on the extent to which credit-constrained households are marginal buyers of homes and the ability of constrained homebuyers to borrow from sources other than banks (Jácome and Mitra 2015, Cizel et al. 2019), which makes this an important empirical question. Therefore, it is necessary to look at the data and evaluate the effectiveness of LTV restrictions in practice. Previous studies have proved that LTV restrictions can effectively reduce systemic risk and credit growth, but the impact on house price inflation is not clear. Ahuja and Nabar (2011), Igan and Kang (2011) and Hwang, Park, and Lee (2013) and argue that limits on the LTV ratio restrain the growth of house prices, whereas Neagu, Tatarici, and Mihai (2015), Vandenbussche, Vogel, and Detragiache (2015) and Cerutti, Claessens, and Laeven (2017) find a very limited influence of LTV caps on house prices. The International Monetary Fund (2014) also notes that as house prices rise, the LTV ratio ceiling is likely to become less binding.

Third, China has implemented a differentiated credit policy, in which different LTV requirements apply to different types of residential transactions. For instance, the LTV caps for first-time buyers[1] are always set higher than or equal to those for buyers who wish to buy an additional property. This provides more financial support to potential homebuyers who have a more urgent demand for houses. It is important to identify the effects linked to different types of loan caps and understand how LTV policies can help the more effective allocation of resources and the steady development of the real estate market. These issues have not been studied in previous research.

I assess the effects of LTV ratio policy on house price growth using a city-level panel data set that includes house price index, LTV caps and some macroeconomic variables. The sample comprises 70 large- and medium-sized cities in China between 2007 and 2016. With this data set, I test whether treated cities, in which LTV caps changed,

[1] The expression ‘first-time buyers’ applies to homebuyers who never bought a home before and also to homebuyers who buy another home after selling their previous home, so they still only own one home. In China, homebuyers are seen as two groups, those buying their only home and those who own other homes when buying a new home.

showed different patterns of price growth compared to control cities.

To examine the impact of differentiated credit policy, I separate the LTV limits for borrowers who do not own properties and for borrowers who already own property. The results show that both types of LTV ceiling have a significant positive influence on price growth rates, which implies that a drop in LTV ceilings would slow down house price growth whereas an increase in the maximum LTV ratio would accelerate the growth of house prices.

The most serious issue in exploring the impact of LTV policy using a fixed effects panel regression model is that the problem of endogeneity may arise. Although real estate policies are used to control high house prices, the high level of house prices may have a reciprocal effect on real estate policy. To confirm that this is the case, I provide independent evidence using a classical DD model at two time points, before and after a release of national LTV policies. Because LTV ratio policies announced by the central government apply all over the country, they are unlikely to be correlated with the local economic environment and the state of the regional property market. I also adopt the propensity score matching technique to artificially construct a control group and a treatment group that meet the parallel trend assumption.

I then examine the asymmetry of the effect of LTV policy. It seems that tightening policies (i.e., reducing maximum LTV levels) tend to have a greater impact on house prices than relaxing such policies, especially in the case of LTV limits applied to borrowers who already own property. I also find that the elasticity of housing supply affects the effectiveness of LTV policy to some extent.

This paper investigates China, an important emerging market; most existing studies on LTV ratios focus on developed countries. Since 2000, many residents and investors have been flocking to the Chinese property market, leading to a surge in housing prices. In 2016, the Central Economic Work Conference proposed that “Houses are for living in, not for speculation”, requiring the function of houses to be residential. Therefore, it is especially important to understand the actual effects of policy so that the government can use the feedback to adjust future policies.

Although there is extensive literature on the impact of LTV policies on other

economies, mainly after the financial crisis, most previous studies have only estimated the relationship between LTV restrictions and housing market indicators. In contrast, I use the fixed effects regression model and the DD technique to determine the causal effects of LTV policy. These methods have recently become popular in real estate research (Berger, Turner, and Zwick 2016, Sá 2016).

In addition, existing literature usually uses dummy variables to represent LTV measures (Ahuja and Nabar 2011, Kuttner and Shim 2012, Akinci and Olmstead-Rumsey 2018) or includes numeric variables to count the number of policy actions taken within a given period as a way to show the intensity of policy intervention (Kuttner and Shim 2016, Jung, Kim, and Yang 2017). However, these methods cannot capture the change of LTV caps over time and may greatly affect the accuracy of the performance evaluation of this consistent time-varying strategy. Therefore, I apply an exposure measure to quantify policy efforts, considering the direction and magnitude of changes in the LTV caps.

The remainder of this paper is organised as follows. In the next section, I introduce the differentiated credit policy adopted by the Chinese government and compare the policy design with other major countries. Section 3 describes the data and the application of the DD method for policy evaluation. In Section 4, I discuss the empirical methodology for estimating the impact of LTV policy on house prices and report the results. Finally, Section 5 summarises the key findings and provides advice for policy formulation.

2 Background

The LTV ratio is used in home mortgages to determine the amount necessary for a down payment. Tightening LTV caps means that borrowers need to provide larger down payments, which would reduce household leverage and the supply of credit, and vice versa. Although higher LTV caps help people gain access to home ownership, they also increase the likelihood of default. Therefore, both of these aspects should be

considered in the policy-making process (Gete and Reher 2016).

Operating in parallel with China's housing reform, the system of commercial bank mortgage loans and housing provident fund (HPF) loans has been gradually established. These two types of home loans serve the same purpose. In general, HPF loans have lower interest rates and down payment requirements due to their assurance and mutual assistance nature. However, in view of provident fund's complicated application process, the long approval time and loan amounts that may be too low in relation to house prices, the vast majority of home buyers still opt for commercial loans to buy properties or to make up shortfalls in insufficient HPF loans.

Also, the Chinese government implements a differentiated credit policy to ensure that eligible residents can obtain the required mortgage loans when buying their first ordinary commercial housing units. Homebuyers who do not own a property or have never taken out a mortgage can apply for loans from commercial banks or the HPF administration centre under preferential government policies. Existing owner-occupiers are often subject to stricter LTV restrictions to reduce the possibility of banks' money being used for speculative purchases. Table 1 shows the example of changes in credit policy terms in Guangzhou. The details of the differentiated credit policy are well presented; it can be seen that caps on LTV ratios relate to many factors including the number of properties owned, the building area per apartment, whether previous housing loans have been paid off, etc. Households with more homes and outstanding loans are restricted to lower LTV caps, and in some cases no loan will be available. Houses larger than 144 m^2, identified as non-ordinary residences, such as villas and high-end apartments, are usually subject to tougher LTV restrictions.

Furthermore, the example of adjustment of HPF policy in Guangzhou also reflects the fact that regional real estate markets are restricted not only by national policies but also by laws and regulations issued by local governments. Beijing has issued the most LTV ratio policies, followed by Shanghai. Other cities with relatively steady price growth have introduced fewer regulations. As shown in Figure 1, the government in Beijing issued 10 LTV ratio policies to control house prices from 2007 to 2016, whereas Yinchuan, a provincial capital, only implemented the LTV ratio policies stipulated by

the state. The caps on LTV ratios implemented in Beijing changed more frequently and were typically lower than those in Yinchuan. Due to the introduction of urban policies, the actual implementation of an LTV ceiling may vary among cities.

In comparison, major developed countries such as the U.K., the U.S. and Australia do not set legal upper limits for LTV ratios at government level. Instead, mortgage sizes are controlled independently by commercial banks according to their risk control preferences and market principles. In addition to mainland China, the two special administrative regions of China and some other countries, mainly in developing economies and a handful of small developed countries in Europe, have included LTV ratios in their regulatory targets and have implemented caps.

For instance, the legal ceilings on LTV ratios imposed by the Singapore government peaked at 90% in July 2005 and were then reduced several times, reaching 60% in January 2011. China's LTV cap level was 80% at its peak in most cities after the 2008 financial crisis and 30% at its lowest in Beijing, Shanghai, Guangzhou and Shenzhen in 2013 for existing owner-occupiers. Because of the high volatility of China's property market, a lower minimum level was required than in other countries. Another example is South Korea. The Korean government divided the country into speculative zones and speculation-prone zones, and imposed differential LTV limits, depending on mortgage loan maturity, the type of financial institution issuing loans and the appraised value of the property. In Hong Kong Special Administrative Region, the government has also adopted a differentiated LTV policy, which sets a maximum LTV ratio based on the assessed value of the property. Sometimes, a lower LTV ceiling may be applied to a luxury property. The most distinctive feature of the Hong Kong market is the Mortgage Insurance Programme, launched in March 1999. Under this programme, the Hong Kong Mortgage Corporation provides insurance to banks to enable homebuyers to secure mortgage loans to a certain level of LTV ratio. This approach has proved to be effective in alleviating the disadvantages of an LTV policy that leads to insufficient liquidity (Wong et al. 2011). Hong Kong's policy also distinguishes between owner-occupied residential properties and non-owner-occupied residential properties in order to encourage home purchases for the purpose of owner-occupation. Policies in

developed countries in Europe such as Norway, Sweden and the Netherlands usually set a uniform and relatively high ceiling on LTV ratio.

3 Data and research design

3.1 Loan-to-value ratio limits

By manually collecting policy releases from local government official websites, I construct a dataset containing LTV ratio limits imposed by central and local authorities for 70 major cities in China from January 2007 to December 2016. Figure 2 gives a visual representation of the changes in national LTV requirements for commercial mortgage loans. Half of these 14 national policy actions are tightening actions and the other half are loosening actions. The Appendix contains more details on the sample of cities and national LTV ratio policies.

Table 2 shows that China's central government typically pays more attention to commercial lending, whereas LTV limits for personal HPF loans are issued more often by local authorities. However, no matter what the sources of loans are, it can be seen that governments at all levels have imposed more and tougher policies on second housing purchases, limiting credit supply while supporting reasonable housing demand. When house prices become too volatile, the management of the demand for second homes becomes a high priority.

In addition to LTV ratio policies announced by the central government, many local authorities have also introduced their own policies, which may be even more stringent than national policies. When municipal governments set lower LTV caps, regional housing markets always implement these more restrictive credit limits, rather than the general LTV ceilings set by central authorities. This mechanism makes it possible to use the DD approach to study policy effects.

In China, analysts usually divide cities into four tiers. Higher-tier cities generally have a higher gross domestic product, larger populations and a higher level of political administration. For the cities featured in this study, I use the tier categories generally

used by analysts. In the 70-city sample, tier one is made up of six cities, of which the four municipalities Beijing, Chongqing, Shanghai and Tianjin are directly controlled by China's Administration Centre; the second category comprises 29 provincial capital cities and sub-provincial capital cities; the third tier consists of 34 prefecture capital cities; and there is one county-level city, Dali, categorised as tier four. Table 3 shows that higher-tier cities tend to issue more LTV ratio policies to constrain housing credit growth, which is postulated to be due to sharp rises in their house prices, indicating a potential endogeneity problem in the application of the fixed effects model.

3.2 House prices and macroeconomic data

House price indices are taken from the National Bureau of Statistics of China. Much of the information contained in the monthly data is likely to be noise, and the house purchasing process can take months to complete. Policy change is unlikely to have an immediate effect on prices. Therefore, I convert monthly data to quarterly price indices for consistency with most of the literature on the effectiveness of LTV ratio policy.

In the regression analysis, I also include population, income and unemployment rate to measure the real housing demand and control for the housing market dynamics in cities. These macroeconomic indicators are commonly used as control variables in research of the real estate market (Cao, Huang, and Lai 2015, Berger, Turner, and Zwick 2016, Sá 2016). Data are collected from the Wind database, Qianzhan database, the annual Statistical Communiqué on the National Economic and Social Development and work reports of municipal governments. Table 4 presents descriptive statistics for the key variables by city tiers.

3.3 Difference-in-differences model

In China, the releases of national policies create additional local variation in LTV caps. When the central government changes LTV limits for housing loans, some cities will comply with the requirements of the national policy, but other cities that have

implemented tighter LTV restrictions than the national limits may not change their LTV requirements. This provides a favourable condition for applying the DD approach to capture the causal effect of LTV ratio policy, by comparing differences between cities and over time.

The DD method allows for different treatment intensity across cities. After an LTV policy is issued, the cities whose LTV limits remain unchanged are regarded as the control group, and cities whose LTV limits change with the new policy requirements are regarded as the treatment group. If, for example, after the release of a tightening policy, the growth rate of house prices decreases in treated cities compared to control cities, this is an indication that the policy has effectively slowed down house price growth.

4 Empirical methods and results

4.1 Specification

The following model is used to estimate the impact of LTV restrictions on housing prices:

$$HP_{c,t} = \alpha + \sum_{i=1}^{4} \beta_i LTV_{c,t-i} + \gamma X_{c,t-1} + \phi_t + \rho_c + \varepsilon_{c,t} \quad (1)$$

where $HP_{c,t}$ denotes the annualised quarterly growth rate in real house prices in city *c* at time *t*. The main explanatory variable is the LTV ratio limit (LTV_c), used to assess the policy's effects in the four quarters following tightening and easing actions. The coefficient β_i can be interpreted as the percentage change in house prices corresponding to a quarterly change of one percentage point in maximum LTV ratios.

X_c is a set of controls, including a one-quarter lag of the dependent variable and lagged resident population, per capita disposable income of urban households and registered urban unemployment rate. The latter three control variables are used to capture local macroeconomic conditions, which may have an impact on housing demand. In order to reduce heteroscedasticity, I take logs for the resident population and disposable income, and all three controls are in first differences. A lagged housing

price is also included in the estimation equation due to the inertia in house price growth (Case and Shiller 1989). A related concern is that the use of the fixed effects estimator in a model with a lagged dependent variable may cause bias. However, Nickell (1981) argues that as the number of time series observations increases, the bias will decrease. Thus, given that the dataset contains observations obtained over 10 years for 70 Chinese cities, the magnitude of such bias will be small. All control variables are lagged to avoid the simultaneity problem (Case and Shiller 2004).

Here I use the growth rate version of the regression equation to avoid the nonstationary problem (Kuttner and Shim 2016). The purpose of using real house price growth rate is to further eliminate the impact of inflation and ensure the stability of the data.

ϕ_t denotes year dummies, incorporating the impact of the influence factors that are only related to different time points and are not related to the differences in characteristics between cities, such as national trends in some time-varying economic variables. Although the regressions are on a quarterly basis, I control for year fixed effects because such effects do not change much from quarter to quarter. Moreover, although time-invariant influence factors specific to a city have been differenced out, I still include the city fixed effect ρ_c to control for different trends in house price growth among cities (Sá 2016). According to Angrist and Pischke (2009), a regression DD model with panel data raises serial correlation. For repeated observations on cities, house price in a quarter is highly related to the prior quarter price, and an equivalent relationship holds for residuals. I therefore use clustered standard errors, which are heteroskedasticity-robust and clustered by cities to account for correlation within groups.

Moreover, the exposure measure has been increasingly used in studies of policy effects, as in Mian and Sufi (2012), who measured the exposure of U.S. cities to the 2009 cash for clunkers programme. This method takes into account the extent to which policies can affect economic variables, and is therefore superior to the use of policy dummies in estimating policy effects. In this case, a policy which changes the ceiling on the LTV ratio by 20% is expected to have a larger effect than another one which

changes the LTV ceiling by 10%. In other words, the effect of each policy release will vary depending on the size of the policy intervention. Using dummy variables to represent policy announcements cannot capture the change in maximum allowable LTV ratios, so it is impossible to accurately estimate the regulatory effect of the policy on house prices. My empirical strategy exploits variation across Chinese cities in exposure to the policy as measured by the actual change in LTV caps. The larger the LTV ratio limit adjustment, the greater the exposure will be.

4.2 Baseline regressions

Table 5 and Table 6 report the implied four-quarter effects of LTV ratio policy applicable to first-time buyers and existing owner-occupiers, respectively, on the real price growth of newly constructed residential buildings made available for sale.[2] The results for second-hand residential buildings are reported in Table A3 and Table A4 in the Appendix.

Because provident fund loans and commercial loans have no essential differences except for the lenders, I use the shares (by total value) of these two kinds of home loans in the individual housing loan market to calculate a weighted average of LTV restrictions and observe the overall policy effect. The results for commercial loans only can be found in the Appendix.

As shown in Table 5, changes in LTV caps for first-time buyers have a large, statistically significant positive effect on prices in the next quarter after a policy is released, which is in line with expectations. A drop in LTV caps slows down the pace of house price growth, whereas an increase in the maximum LTV ratio accelerates the growth of house prices. The overall effect of LTV limits in the four quarters immediately following policy changes is highly statistically significant. According to column (2), on impact, the annualised growth rate in real house prices decreases by about 0.438% in

[2] Since 2011, the National Bureau of Statistics of China has implemented the new Real Estate Price Statistical Reporting System. According to the system, the price indices for newly built and second-hand houses in 70 large and medium-sized cities will be released every month. The overall home sales price index is no longer released. According to the National Housing Provident Fund Annual Report, most of the mortgages used to buy houses are advanced for new houses, and only a small number of them are advanced for second-hand houses.

a year in which the LTV cap is reduced by one percentage point. The regression results are robust. The results are not significantly affected by the inclusion of city-specific trends or the weighing of the equation by population size.

The results for LTV restrictions applied to borrowers who own one property, and who wish to buy a second property are presented in Table 6. Compared with the regression coefficients of the LTV caps for first-time buyers, changes in LTV caps for existing property owners have a much smaller, but statistically significant, impact on house price growth. The overall effect of four lags of LTV caps is also weaker in terms of magnitude. Including city-specific trends, the results show that a 1% drop in maximum LTV ratios leads to the house price growth rate falling by about 0.114% in a year.

For a better understanding of how the response of house prices to LTV ceiling shock changes over time, I refer to Jordà (2005); local projections are used to directly estimate impulse responses at different time points. Unlike a vector autoregression, this approach avoids the need to identify all unknown influencing factors and multivariate dynamic processes. The approach was also applied by Favara and Imbs (2015) and by Sá (2016) to analyse the effect of shocks on house price growth; the former studied the shock to credit supply and the latter studied the shock to foreign investment. Local projections are made by estimating sequential regressions of the endogenous variable shifted forward. I use the dependent variable as a lead factor because LTV restrictions will only affect future housing transactions from the time they are in place:

$$HP_{c,t+h} = \alpha + \beta^h LTV_{c,t} + \gamma X_{c,t-1} + \phi_t + \rho_c + \varepsilon_{c,t} \quad (2)$$

The vector of estimates $\{\beta^h | h = 0,1, \dots\}$ measures the impact of LTV ratio policy on house price growth at horizon *h*, giving a visual representation of how the effect of an LTV policy shock changes over time. Figure 3 presents the impulse responses of real house price growth rate over a period of eight quarters for the LTV ratio.

The impacts of these two kinds of LTV restrictions peak in the first quarter after implementation. The effect on house price growth of an increase in LTV caps for first-time buyers is fairly persistent, and only fades away two years after the shock. When

LTV limits are applied to existing property owners, the regulatory effect on house prices is temporary, fading gradually and becoming insignificant two quarters after the change. Overall, limits on the LTV ratio for borrowers without homes have much bigger and longer-lasting effects on house prices than those applied to people who already own a property.

4.3 Evidence obtained by difference-in-differences method

The evidence already presented shows that LTV ratio policy has a regulating effect on the growth rate of house prices. However, there may be concerns that the results of the standard fixed effects model are affected by endogeneity problems, causing the parameter estimation to be biased, resulting in the coefficients being deemed to be unreliable measures of policy effectiveness. Specifically, local governments tend to introduce more policies to control housing prices in the face of rapidly escalating prices, whereas for cities with slowly rising house prices, local governments will lack the incentive to frequently adjust LTV ratio caps.

It would be possible to use an instrumental variable to replace the endogenous regressors, but it is difficult to identify an exogenous source of variation for the policy variables. Fortunately, this issue will lead to underestimation of policy effectiveness (Kuttner and Shim 2016). The faster house prices rise in cities, the more likely local governments are to implement tougher and more frequent policies intended to control prices. If policymakers are inclined to tighten LTV limits when the housing market is already overextended, this will create a negative correlation between LTV variables and house prices, partially (or entirely) offsetting the desired policy effects. In this sense, the existence of an endogeneity problem does not affect the basic conclusion.

In order to address the potential impact of endogeneity as much as possible, I also use the classical DD model for a robustness check. Here I apply the following equation with a panel dataset at two time points before and after a national LTV policy roll-out:

$$HP_{c,t} = \alpha + \gamma Treat_c + \lambda Post_t + \tau Treat_c * Post_t + \varepsilon_{c,t} \quad (3)$$

where $Treat_c$ represents a dummy variable which is assigned a value of 1 for the treated cities in which mortgage LTV caps have been changed by the policy, otherwise values are 0; $Post_t$ denotes another dummy variable assigned a value of 0 before an LTV policy announcement and 1 after a policy announcement. An interaction term is included to indicate treated cities after the intervention, and coefficient τ is the policy effect of interest.

The model only includes the effect of LTV policies issued by the central government because the country is unlikely to make national-level policies based on the situation of particular regional real estate markets. As a result, there will not be serious endogeneity problems. Table 7 and Table 8 respectively report the results for tightening and loosening LTV policies imposed by the Chinese central government for commercial housing loans.

Table 7 shows the impact on house price growth of two nationwide policies tightening LTV restrictions launched on April 17, 2010, and on January 10, 2010, for first-time homebuyers and for existing property owners, respectively. Within the framework of the DD model, the control group consists of cities, which had already implemented even tougher LTV restrictions than the new nationwide LTV caps mandated by the policy. For these cities, LTV ratio limits did not change after the nationwide policy was introduced. The treated cities were implementing higher LTV ceilings than the reduced level of maximum LTV ratios set by the new policy, so those cities became subject to the new lower LTV limits and decreased their LTV ceilings accordingly. In this case, I expect the estimated policy effect $\hat{\tau}$ to be negative, i.e., tightening LTV ratio policy reduces the real growth rate of house prices. The results of columns (1) and (3) in Table 7 confirm this prediction. The negative coefficients on the interaction term are statistically significant at the 1% level.

One concern with the DD approach is whether rising property prices in Chinese cities violate the DD model's assumption about parallel trends. As a result, I also adopt the propensity score matching (PSM) technique to select the treated cities whose house price growth trend is similar to that of control cities, so that the cities in the control group and the treatment group had parallel average growth trends in the

period before the policy was issued. PSM can help reduce the bias caused by confounding variables that could be observed in an estimate of the treatment effect obtained by simply comparing the results of units receiving treatment with those not receiving treatment. According to the results shown in columns (2) and (4) of Table 7, the effect of LTV policy is still highly significant when the sample is controlled for price growth trends.

Another noteworthy aspect is that the subsample selected by PSM technique is unbalanced. For both tightening LTV policies, only Beijing was used as a control city, and all other cities were affected by these policies. Because the timing of each of the two policy announcements was very close, the past trajectory of house price growth of the control city has been similar. The same set of treated cities is therefore selected for assessing the impact of these two policies based on the graphs presented in Figure 4.

Table 8 shows the DD regression results with dummy variables for national policies loosening LTV ratios introduced on October 22, 2008 and on February 2, 2016. Loosening policies issued by the central government take into account cities' intention to treat. When such a policy is introduced, eligible cities that intend to relax credit restrictions will be able to raise their LTV caps according to the new scheme. For the LTV policy released on October 22, 2008, only Beijing is used as a control city. The Beijing municipal government introduced an LTV limit of 70% for first-time buyers in January 2006 and maintained it until September 2016. This is why Beijing did not change its LTV cap in response to the identified national-level changes. For the policy announced on February 2, 2016, the control group includes four cities, Beijing, Guangzhou, Shenzhen and Shenyang. These cities had maintained 30%–35% LTV caps on commercial loans for existing property owners since 2013, despite the national-level changes.

Columns (1) and (3) in Table 8 report the ordinary results for each of the two national-level changes. It can be seen that the two loosening LTV policies have a positive impact on house price growth, i.e., they effectively encouraged faster price rises in treated cities. The house price trends of the control group and the treatment

group with and without the PSM method before the two loosening policies had been issued by the central government are presented in Figure 5. The effect of the policy announced on October 22, 2008 remains statistically significant at the 1% level when the PSM technique is applied to ensure parallel trends in house price growth between cities as much as possible. For the policy announced on February 2, 2016, although the coefficient of the interaction term in column (3) is not statistically significant, it becomes significant at the 5% level after the PSM technique is used to form a treatment group.

4.4 The asymmetry of the policy effect

Loosening and tightening LTV policies are usually carried out at different stages of the economic cycle, and so the effects can be asymmetric. On the one hand, when caps on LTV ratios are reduced, the availability of credit to potential homebuyers will be more limited, putting real constraints on them. On the other hand, increases in LTV caps tend to occur during economic downturns. During those periods, households may still be reluctant to buy properties, despite the availability of bigger loans, because they find themselves constrained by factors other than the LTV ratio, such as concerns regarding the risk of future decreases in house prices or low wages that prevent them from being able to pay their mortgages. As a result, LTV cap easing might be less effective than tightening. Igan and Kang (2011), McDonald (2015) and Kuttner and Shim (2016) all found that loosening LTV policies has done little to boost the housing market, whereas tightening LTV policies has effectively curbed price growth.

To test this hypothesis, house price growth rate is regressed on the lags of changes in LTV caps in the following model, performed separately for tightening and loosening policies:

$$HP_{c,t} = \alpha + \sum_{i=1}^{4} \beta_i \Delta LTV_{c,t-i} + \gamma X_{c,t-1} + \phi_t + \rho_c + \varepsilon_{c,t} \quad (4)$$

For tightening policies, the policy variable has a negative value in the quarter when LTV caps are reduced, and zero in other periods; for loosening policies, the policy variable is positive in the quarter when LTV caps are raised, otherwise it is zero. The

results for asymmetric effects are presented in Table 9 and Table 10.

By using the actual change of LTV caps, more statistically significant results are obtained than in previous studies that used dummies to represent policy changes. The effects of LTV policies on first-time buyers and on existing property owners are examined separately. Overall, LTV limits for first-time buyers have a greater effect on house price growth rate than those for existing property owners. In terms of the asymmetry in the effect of these two types of LTV restrictions, tightening LTV policies that apply to borrowers who do not own a property have a higher and more statistically significant effect on house prices in the first quarter following policy releases, compared with loosening LTV policies. The difference between the overall magnitude of effects of tightening and loosening policies for first-time buyers is not statistically significant. For LTV requirements applied to borrowers who already own one property, the effect of tightening policy is much greater than that of loosening policy over a period of four quarters; the magnitude of effect is almost twice as great. This difference is found to be statistically significant at the 5% level. Therefore, LTV policies have been more effective in controlling growth rates during real estate booms than in lifting the housing market out of downturns, especially for LTV changes applied to existing property owners.

The results suggest that only potential buyers who already own one property are severely affected by tightening actions, whereas for LTV requirements applied to first-time buyers, there is no significant asymmetric policy effect. By tightening LTV limits, policymakers can sharply reduce home purchases by existing property owners during housing booms; price growth rates will not fully return to their former levels when restrictions are relaxed. However, the asymmetry in the effect of LTV policy changes for homebuyers who do not own a property is less obvious and more short-lived. Tightening actions have not dampened their demand and enthusiasm for buying houses. Once LTV restrictions for first-time buyers are relaxed, house price growth rates can return to their previous levels as demand recovers.

4.5 Supply constraints

There are reasons to suspect that the degree to which house prices respond to changes in LTV limits may be influenced by supply conditions. When there are many regulatory or geographical restrictions on housing supply, house prices rise rapidly due to excessive demand. They cannot be lowered immediately by increasing the supply of property. As a result, in cities where the housing supply is quite inelastic, the implementation of mandatory restrictions on credit availability should reduce the growth rate of house prices to a greater extent.

To test this hypothesis, I use the estimates of housing supply elasticity of 35 first- and second-tier cities in China taken from earlier studies. Using a dataset from 1998 to 2009, Wang, Chan, and Xu (2012) state that the national housing supply elasticity should be somewhere between 2.8 and 5.6, whereas Liu (2014) claims that China's aggregate supply elasticity is 2.65. In either case, their conclusions suggest that China's housing supply elasticity is significantly lower than the estimated supply elasticity of 7.3 in the United States (Green, Malpezzi, and Mayo 2005), which implies that China is more vulnerable to house price fluctuations. The main difference between the two studies is that Wang, Chan, and Xu (2012) include both current and one-year lagged housing price levels as explanatory variables, whereas Liu (2014) only uses the lagged growth rate of house prices rather than the price level. This is done to avoid the impact on the estimation of non-stationarity caused by the time trend in price data, and to avoid the problem of endogeneity. For this reason, the model used by Liu (2014) seems to be more reliable in the estimation of housing supply elasticity.

The regression equation considering the impact of housing supply elasticity is shown in equation (5):

$$HP_{c,t} = \alpha + \beta LTV_{c,t-1} + \delta LTV_{c,t-1} * elasticity_c + \gamma X_{c,t-1} + \phi_t + \rho_c + \varepsilon_{c,t} \quad (5)$$

where the product of LTV limits and the supply elasticity of cities are added. The coefficient on this interaction term is expected to be negative because high housing supply elasticity is postulated to lessen the effect of LTV policy. Table 11 and Table 12 present the regression results obtained by using the estimation of housing supply

elasticity in 35 Chinese first- and second-tier cities by Liu (2014).

For LTV caps applied to first-time buyers, the coefficients on the elasticity term are negative in all four regression models in Table 11. The coefficient on this term in column (2) is statistically significant at the 1% level when including city-specific trends. This suggests that LTV ratio limits have a stronger effect on house prices in cities with a lower elasticity of housing supply. For LTV policies that restrict borrowers who own one property, the coefficients on the elasticity term are negative and statistically significant when controlling for city trends as shown in columns (2) and (4) of Table 12.

The analysis draws on studies such as those of Adelino, Schoar, and Severino (2012), Favara and Imbs (2015) and Sá (2016) using data from the U.S. and the U.K. examining the impact of housing supply elasticity on the transmission of shocks to house prices. All these studies have found that house prices respond more strongly to shocks in areas where housing supply is less elastic, i.e., high elasticity of supply helps reduce house price fluctuations, which is consistent with the results in this paper.

4.6 The potential impact of home purchase restrictions

Grodecka (2019) points out that in the mortgage business, LTV requirements may not be the only constraint on potential homebuyers. Ignoring other potential constraints may lead to an overstatement of LTV's effectiveness as a macroprudential policy tool. She develops a multiconstraint framework where borrowers are constrained by LTV limits and by debt service-to-income limits and finds that if borrowers are subject to both constraints, tightening LTV policy may actually push up house prices without changing the debt ratios. In China, there are no explicit debt service-to-income constraints. Another widely used real estate policy in China is the home purchase restrictions (HPR) policy, which aims to curb speculative demand and rapidly increasing house prices. The HPR policy limits the number of homes each family can buy, regardless of their financial situation. On April 17, 2010, the State Council issued a notice on resolutely curbing soaring housing prices in some cities, pointing out that local governments may take temporary measures to limit the number of houses

people can buy within a certain period. In the same month, Beijing established detailed rules for implementing the restriction, the first city to stipulate that each family can buy only one additional home. Other Chinese cities then also began to introduce purchase restrictions. Among the 70 Chinese cities in the sample, 39 cities adopted HPR policies in late 2010 or early 2011 (Cao, Huang, and Lai 2015). Four first-tier cities (Beijing, Shanghai, Guangzhou and Shenzhen) and other lower-tier cities gradually ended their purchase restrictions in 2014.

Considering the potential impact of the HPR policy, a dummy variable was added to the basic regression equation:

$$HP_{c,t} = \alpha + \sum_{i=1}^{4} \beta_i LTV_{c,t-i} + \sum_{i=1}^{4} \delta_i HPR_{c,t-i} + \gamma X_{c,t-1} + \phi_t + \rho_c + \varepsilon_{c,t} \quad (6)$$

If a city adopts HPR in a certain period, then HPR_c takes the value of 1; otherwise, it is 0. The coefficients on HPR terms are expected to be negative because HPR policy prohibits some potential buyers from buying houses, thereby cooling the real estate market and reducing house price growth; when the policy is lifted, these people can re-join the buying market, pushing up prices. The results are shown in Table 13; regression results obtained with and without the HPR dummy are compared.

The table shows that the estimates of LTV policy effect have hardly changed and remain highly significant after including the dummy variables for HPR policy, which proves that the original results are robust. Compared with the LTV ratio policy, the purchase restriction has a small impact on house prices and does not affect the effectiveness of LTV limits on regulating housing price growth. In columns (6) and (8), where I control for different city trends, significant negative coefficients on the HPR variable are obtained, which implies that the adoption of this policy has reduced the growth rate of housing prices.

5 Conclusion

This paper identifies the causal effect of the LTV ratio policy on house prices in China. It uncovers some interesting results, and the main findings are listed below.

First, I employ a fixed effects model in panel regressions, including the LTV caps for the four quarters immediately following policy releases. Both LTV limits for first-time buyers and for existing property owners are found to have a statistically significant positive impact on house price growth, which suggests that LTV ratio policy plays an important role in regulating house prices. Using the impulse response function, I find that LTV caps applied to first-time buyers have a greater and more prolonged influence on house prices than those applied to people who already own one property. In the former case, the effect lasts for about two years. For these two types of LTV ratio policy, their impacts on house prices peak in the first quarter following policy changes.

Second, I examine the asymmetric effect of LTV policy. It seems that tightening policies tend to have a higher impact on house prices than loosening policies, especially for LTV limits applied to borrowers who own one property. For these people, a tightening LTV policy causes real financial constraints, whereas a loosening policy has a relatively small impact on their purchases because it usually happens during an economic downturn, when existing homeowners are not in a good position to buy another property.

I also show that the elasticity of housing supply affects the effectiveness of LTV ratio policy. The more elastic the housing supply is, the sooner the price fluctuation can be smoothed out. As a result, the impact of LTV policy on house prices is smaller in cities with an elastic housing supply. Typically, there is a statistically significant negative coefficient for the interaction term of LTV caps and supply elasticity when controlling for city-specific trends.

Based on the results obtained, I make the following policy recommendations. The effect of LTV limits on first-time homebuyers can last for almost two years. Therefore, such policies should not be changed often. The impact on house prices of an LTV policy applied to existing property owners begins to wane after two quarters. Therefore, the government could consider introducing such restrictions more frequently or combining them with other real estate policies to limit speculation. Also, given that tightening policies are more effective than loosening policies, once the need to stimulate the property market arises, the government may need to loosen LTV

restrictions by a greater amount in order to achieve the desired effect. Furthermore, as cities with low housing supply elasticity are greatly affected by house price fluctuations, and LTV restrictions in these places have a greater effect, these regions may consider strengthening their use of LTV policy to regulate house prices.

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Figures

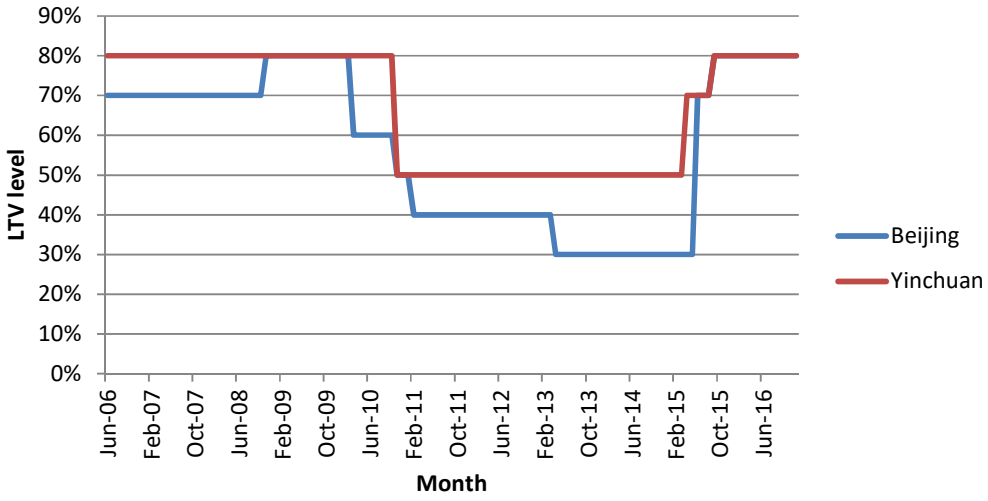

Figure 1. Loan-to-value caps of housing provident fund loans for borrowers who own one property and have cleared the corresponding loans in Beijing and Yinchuan

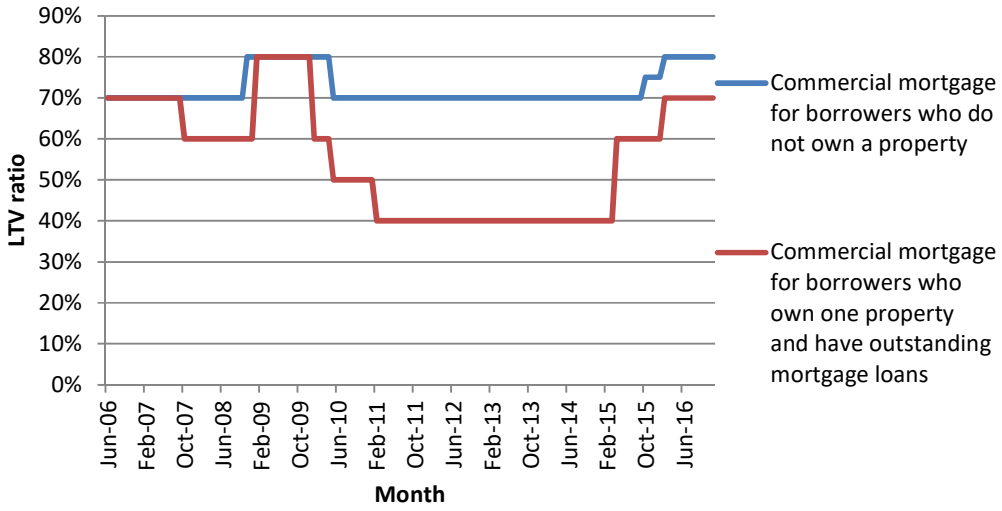

Figure 2. The evolution of loan-to-value caps for commercial loans set by national policies

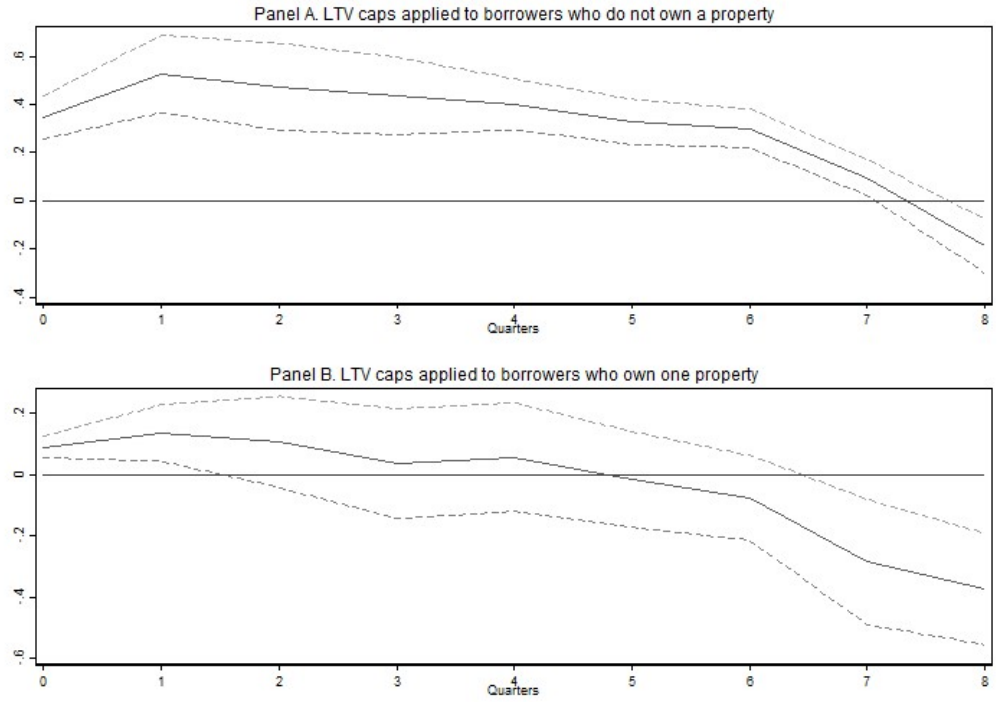

Figure 3. Impulse responses of house price growth rate to shock to loan-to-value caps (dashed lines are 90% confidence bands)

Note: The figure shows estimated coefficients and 90% confidence interval from local projection equations, which investigates the impact of a change in LTV ratio caps on real house price growth for eight quarters after the shock. The sample comprises 70 cities in China for the period 2007–2016. Regressions include city fixed effects, year fixed effects, lagged real house price growth rate, resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables.

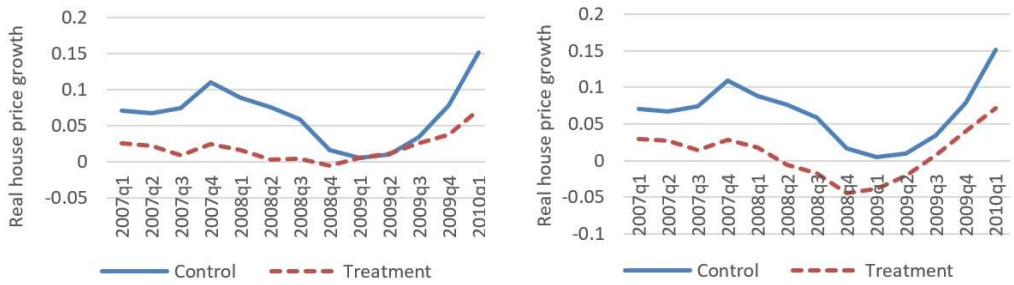

Figure 4. Price trends with and without propensity score matching (tightening policies)

Note: The graph on the left shows the price growth rate of the control city, Beijing, and the average growth rate of treated cities based on the whole sample of 70 cities as of the first quarter of 2010; the graph on the right shows the price growth rate of the control city, Beijing, and the average growth rate of the treated cities selected by propensity score matching technique as of the first quarter of 2010.

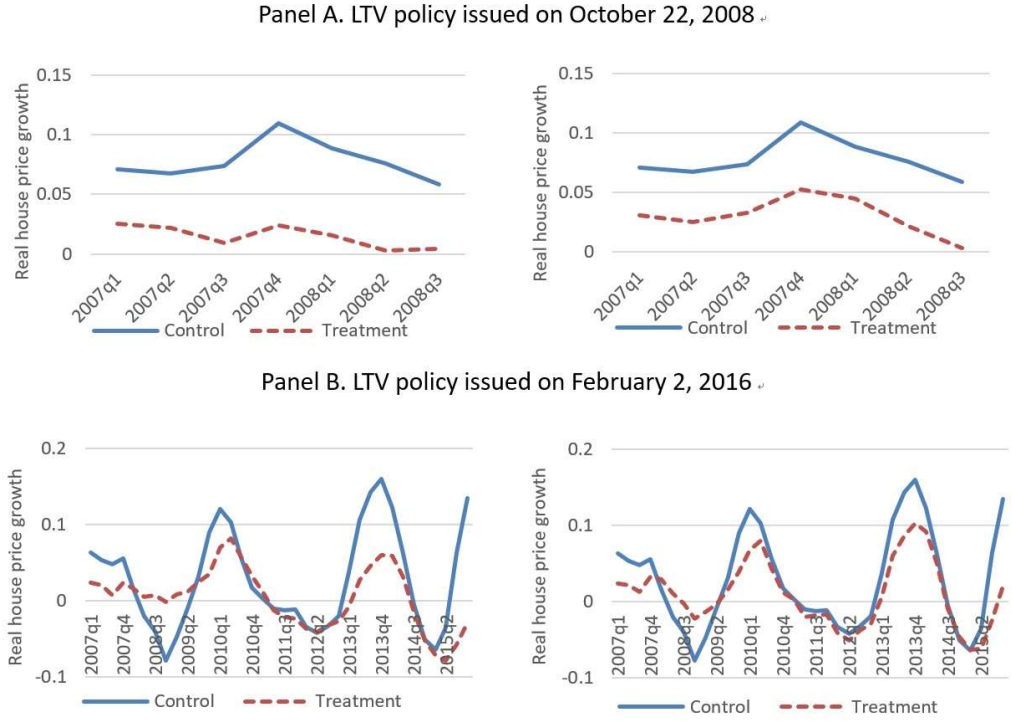

Figure 5. Price trends with and without propensity score matching (loosening policies)

Note: The graph on the left shows the average price growth rate of control cities and the average growth rate of treated cities based on the whole sample of 70 cities; the graph on the right shows the average price growth rate of control cities and the average growth rate of the treated cities selected by propensity score matching technique.

Tables

Table 1. Changes in provident fund loan terms in Guangzhou on March 20th, 2017

Housing situation			Old policy		New policy		Change
Building area per apartment	Number of properties owned	Housing loan records	LTV caps	Interest rate	LTV caps	Interest rate	
Below 144 m^2 (including)	0	None	70%	Base rate	70%	Base rate	
		Paid off	70%	Base rate	60%	Base rate	Lower LTV
		One outstanding loan	30%	By 10% above the base rate	30%	By 10% above the base rate	
		Two or more outstanding loans	No loan granted				
	1	None or paid off	70%	By 10% above the base rate	50%	By 10% above the base rate	Lower LTV
		Unsettled housing loans in this city	30%	By 10% above the base rate	30%	By 10% above the base rate	
		Unsettled housing loans outside this city	No loan granted				
Above 144 m^2	0	None or paid off	70%	Base rate	30%	Base rate	Lower LTV
		One outstanding loan	30%	By 10% above the base rate	30%	By 10% above the base rate	
		Two or more outstanding loans	No loan granted				
	1	None or paid off	70%	By 10% above the base rate	30%	By 10% above the base rate	Lower LTV
		Unsettled housing loans in this city	30%	By 10% above the base rate	30%	By 10% above the base rate	
		Unsettled housing loans outside this city	No loan granted				

Source: Guangzhou Housing Provident Fund Management Centre.

Table 2. The number of national or city-level loan-to-value ratio policies during 2007–2016

Region	LTV caps for a commercial mortgage for households who do not own a property	LTV caps for a commercial mortgage for households who own one property	LTV caps for HPF loans for households who do not own a property	LTV caps for HPF loans for households who own one property
Nationwide	4	7	2	4
Beijing	1	3	1	5
Chongqing	0	0	1	1
Guangzhou	0	1	1	2
Shanghai	1	2	1	3
Shenzhen	0	1	1	1
Tianjin	1	1	4	6
Changchun	0	0	0	1
Chengdu	0	2	2	2
Changsha	0	0	1	0
Dalian	0	0	0	1
Fuzhou	1	0	0	0
Hefei	1	1	1	1
Hohhot	1	1	1	1
Haikou	0	0	1	1
Hangzhou	0	0	3	2
Jinan	1	1	2	2
Ningbo	0	0	0	1
Nanchang	0	1	1	1
Nanjing	0	2	0	0
Shenyang	0	2	1	4
Wuhan	1	2	0	0
Xi’an	0	0	0	1
Xiamen	1	1	1	1
Zhengzhou	0	1	1	2
Wuxi	0	1	1	4
Wenzhou	0	0	1	0
Jinhua	0	0	3	2
Luoyang	0	1	0	0
Pingdingshan	0	1	0	0
Yueyang	0	0	2	1
Nanchong	0	0	1	1

Table 3. The average number of loan-to-value ratio policy releases by city tiers 2007–2016

Tiers	LTV caps for a commercial mortgage for households who do not own a property	LTV caps for a commercial mortgage for households who own one property	LTV caps for HPF loans for households who do not own a property	LTV caps for HPF loans for households who own one property
First-tier	0.50	1.33	1.67	3.17
Second-tier	0.21	0.48	0.52	0.69
Third-tier	0	0.09	0.24	0.24

Note: Statistics of fourth-tier cities are not reported since there is only one fourth-tier city in the sample. This city did not introduce an LTV ratio policy during the sample period.

Table 4. Descriptive statistics (2007–2016)

Tiers	Obs	Mean	Std. Dev.	Min	Max
Panel 1: The real annual growth rate of the new commercial housing sales prices					
First-tier	240	0.043	0.102	0.009	0.077
Second-tier	1160	0.015	0.066	-0.008	0.054
Third-tier	1360	0.000	0.054	-0.017	0.043
Panel 2: The real annual growth rate of the second-hand housing sales prices					
First-tier	240	0.032	0.099	-0.005	0.076
Second-tier	1160	0.001	0.054	-0.014	0.025
Third-tier	1360	-0.011	0.045	-0.036	0.029
Panel 3: Loan-to-value caps applied to first-time home buyers					
First-tier	240	0.720	0.034	0.707	0.728
Second-tier	1160	0.730	0.040	0.712	0.732
Third-tier	1360	0.731	0.040	0.724	0.732
Panel 4: Loan-to-value caps applied to second-time home buyers					
First-tier	240	0.519	0.151	0.473	0.565
Second-tier	1160	0.563	0.141	0.515	0.570
Third-tier	1360	0.568	0.141	0.553	0.572
Panel 5: The annual growth rate of permanent residents					
First-tier	60	0.027	0.020	0.008	0.037
Second-tier	286	0.018	0.039	-0.002	0.052
Third-tier	338	0.005	0.020	-0.020	0.034
Panel 6: The annual growth rate of per capita disposable income of urban residents					
First-tier	60	0.095	0.040	0.077	0.105
Second-tier	290	0.107	0.040	0.092	0.123
Third-tier	319	0.106	0.039	0.079	0.127
Panel 7: The change in registered urban unemployment rate					
First-tier	60	-0.000	0.001	-0.001	0.000
Second-tier	279	-0.001	0.003	-0.002	0.001
Third-tier	332	-0.001	0.004	-0.003	0.000

Notes: 1. ‘Min’ and ‘Max’ report the minimum and maximum values of the urban average of an indicator at a tier level, respectively.

2. Statistics of fourth-tier cities are not reported since there is only one fourth-tier city in the sample. This city did not introduce an LTV ratio policy during the sample period.

Table 5. Effects of loan-to-value limits for borrowers who do not own a property

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.630***	0.652***	0.519***	0.555***
	(0.095)	(0.095)	(0.103)	(0.101)
Two-period lagged LTV caps	-0.202***	-0.189***	-0.169***	-0.158**
	(0.046)	(0.047)	(0.060)	(0.060)
Three-period lagged LTV caps	0.087	0.103*	0.051	0.069
	(0.052)	(0.053)	(0.068)	(0.074)
Four-period lagged LTV caps	-0.138***	-0.128***	-0.111**	-0.105**
	(0.049)	(0.048)	(0.046)	(0.043)
Lagged real house price growth	0.954***	0.901***	0.986***	0.931***
	(0.031)	(0.032)	(0.016)	(0.015)
Four-quarter policy effect	0.377***	0.438***	0.291***	0.360***
	(0.076)	(0.078)	(0.084)	(0.089)
Observations	2616	2616	2612	2612
R^2 within	0.837	0.847	0.871	0.878
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. Column (1) does not control for city trends or add any weights; column (2) controls for city trends based on equation (13); column (3) is weighted by population of each city; column (4) includes both city trends and weights. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 6. Effects of loan-to-value limits for borrowers who own one property

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.115***	0.123***	0.103***	0.117***
	(0.011)	(0.011)	(0.015)	(0.014)
Two-period lagged LTV caps	0.073***	0.075***	0.070***	0.071***
	(0.008)	(0.007)	(0.007)	(0.007)
Three-period lagged LTV caps	-0.072***	-0.056***	-0.058***	-0.040**
	(0.012)	(0.013)	(0.017)	(0.018)
Four-period lagged LTV caps	-0.048**	-0.028	-0.069**	-0.043*
	(0.021)	(0.017)	(0.026)	(0.024)
Lagged real house price growth	0.948***	0.889***	0.973***	0.914***
	(0.032)	(0.033)	(0.013)	(0.013)
Four-quarter policy effect	0.069***	0.114***	0.046*	0.105***
	(0.023)	(0.019)	(0.026)	(0.022)
Observations	2616	2616	2612	2612
R^2 within	0.840	0.850	0.874	0.883
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. Column (1) does not control for city trends or add any weights; column (2) controls for city trends based on equation (13); column (3) is weighted by population of each city; column (4) includes both city trends and weights. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 7. Difference-in-differences regressions with dummy variables for tightening loan-to-value policies

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
Treat	-0.079***	-0.080***	-0.040***	-0.039***
	(0.010)	(0.011)	(0.004)	(0.011)
Post	0.004***	0.004***	0.073***	0.073***
	(0.000)	(0.000)	(0.000)	(0.000)
Treat*Post	-0.020***	-0.042***	-0.038***	-0.041***
	(0.004)	(0.012)	(0.009)	(0.005)
Observations	140	38	140	38
R^2 within	0.022	0.397	0.084	0.212

Notes: 1. Columns (1) and (2) give the response of real house price growth rates to the policy which reduced the LTV cap applied to commercial loans for borrowers who do not own a property from 80% to 70% on April 17, 2010, where column (2) adopts the propensity score matching technique; columns (3) and (4) show the response of real house price growth rates to the policy which reduced the LTV cap applied to commercial loans for borrowers who already own one property from 80% to 60% on January 10, 2010. Column (4) adopts the propensity score matching technique. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 8. Difference-in-differences regressions with dummy variables for loosening loan-to-value policies

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
Treat	-0.054***	-0.055***	-0.163*	-0.115
	(0.004)	(0.012)	(0.089)	(0.096)
Post	-0.054***	-0.054***	0.065	0.065
	(0.000)	(0.000)	(0.046)	(0.050)
Treat*Post	0.055***	0.043***	0.015	0.144**
	(0.004)	(0.007)	(0.047)	(0.061)
Observations	140	40	140	30
R^2 within	0.017	0.056	0.294	0.403

Notes: 1. Columns (1) and (2) give the response of real house price growth rates to the policy which increased the LTV cap applied to commercial loans for borrowers who do not own a property from 70% to 80% on October 22, 2008, where column (2) adopts the propensity score matching technique; columns (3) and (4) show the response of real house price growth rates to the policy which increased the LTV cap applied to commercial loans for borrowers who already own one property from 60% to 70% on February 2, 2016. Column (4) adopts the propensity score matching technique. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 9. Asymmetric effects on house price growth rate of loan-to-value limits for borrowers who do not own a property

	Tightening				Loosening			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
One-period lagged LTV caps	0.831***	0.800***	0.782***	0.766***	0.481**	0.624***	0.317	0.442*
	(0.108)	(0.106)	(0.072)	(0.073)	(0.201)	(0.215)	(0.238)	(0.257)
Two-period lagged LTV caps	0.324***	0.336***	0.326***	0.340***	0.412***	0.506***	0.296**	0.383***
	(0.054)	(0.053)	(0.043)	(0.043)	(0.106)	(0.114)	(0.116)	(0.127)
Three-period lagged LTV caps	-0.077	-0.072	-0.119**	-0.121**	0.443***	0.594***	0.313	0.448**
	(0.062)	(0.063)	(0.056)	(0.056)	(0.166)	(0.183)	(0.189)	(0.213)
Four-period lagged LTV caps	0.374***	0.397***	0.344***	0.361***	0.610***	0.721***	0.508***	0.614***
	(0.049)	(0.051)	(0.051)	(0.054)	(0.136)	(0.151)	(0.122)	(0.139)
Lagged house price growth	0.943***	0.899***	0.961***	0.918***	0.944***	0.893***	0.971***	0.921***
	(0.029)	(0.032)	(0.017)	(0.019)	(0.034)	(0.035)	(0.016)	(0.015)
Four-quarter policy effect	1.453***	1.460***	1.332***	1.345***	1.945***	2.445***	1.433**	1.887***
	(0.160)	(0.155)	(0.133)	(0.133)	(0.584)	(0.641)	(0.644)	(0.716)
Observations	2616	2616	2612	2612	2616	2616	2612	2612
R^2 within	0.838	0.846	0.873	0.879	0.831	0.842	0.867	0.875
City trends	No	Yes	No	Yes	No	Yes	No	Yes
Weights	No	No	Yes	Yes	No	No	Yes	Yes

Notes: 1. The dependent variable is the annualised quarterly growth rate in real house prices. The overall policy effect is the effect in the four quarters following LTV policy releases. The sample comprises 70 cities in China for the period 2007–2016. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 10. Asymmetric effects on house price growth rate of loan-to-value limits for borrowers who own one property

	Tightening				Loosening			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
One-period lagged LTV caps	0.151***	0.143***	0.137***	0.134***	0.076***	0.079***	0.066***	0.072***
	(0.027)	(0.026)	(0.023)	(0.023)	(0.012)	(0.010)	(0.021)	(0.019)
Two-period lagged LTV caps	0.291***	0.286***	0.280***	0.280***	0.140***	0.148***	0.120***	0.132***
	(0.030)	(0.030)	(0.023)	(0.024)	(0.012)	(0.010)	(0.024)	(0.022)
Three-period lagged LTV caps	0.191***	0.195***	0.192***	0.200***	0.052***	0.056***	0.055***	0.062***
	(0.032)	(0.032)	(0.022)	(0.023)	(0.016)	(0.018)	(0.017)	(0.021)
Four-period lagged LTV caps	0.179***	0.177***	0.169***	0.173***	0.152***	0.149***	0.148***	0.147***
	(0.036)	(0.035)	(0.022)	(0.023)	(0.029)	(0.028)	(0.022)	(0.023)
Lagged house price growth	0.956***	0.911***	0.973***	0.931***	0.945***	0.896***	0.970***	0.922***
	(0.029)	(0.032)	(0.018)	(0.021)	(0.031)	(0.034)	(0.013)	(0.015)
Four-quarter policy effect	0.811***	0.800***	0.779***	0.787***	0.420***	0.433***	0.389***	0.412***
	(0.111)	(0.110)	(0.072)	(0.077)	(0.047)	(0.049)	(0.051)	(0.054)
Observations	2616	2616	2612	2612	2616	2616	2612	2612
R^2 within	0.841	0.849	0.877	0.883	0.834	0.843	0.869	0.876
City trends	No	Yes	No	Yes	No	Yes	No	Yes
Weights	No	No	Yes	Yes	No	No	Yes	Yes

Notes: 1. The dependent variable is the annualised quarterly growth rate in real house prices. The overall policy effect is the effect in the four quarters following LTV policy releases. The sample comprises 70 cities in China for the period 2007–2016. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 11. The impact of supply elasticity on the effectiveness of loan-to-value policy for borrowers who do not own a property

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.515***	0.648***	0.399***	0.540***
	(0.108)	(0.115)	(0.100)	(0.097)
Effect of elasticity on LTV caps	-0.016**	-0.021***	-0.010	-0.017*
	(0.007)	(0.008)	(0.008)	(0.009)
Lagged real house price growth	0.980***	0.922***	0.978***	0.918***
	(0.014)	(0.015)	(0.017)	(0.016)
Observations	1340	1340	1336	1336
R^2 within	0.867	0.877	0.881	0.890
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. The sample comprises 35 cities in China for the period 2007–2016. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 12. The impact of supply elasticity on the effectiveness of loan-to-value policy for borrowers who own one property

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.136***	0.221***	0.111***	0.200***
	(0.022)	(0.026)	(0.020)	(0.025)
Effect of elasticity on LTV caps	0.000	-0.009***	0.001	-0.008**
	(0.001)	(0.003)	(0.001)	(0.004)
Lagged real house price growth	0.988***	0.919***	0.980***	0.908***
	(0.013)	(0.015)	(0.014)	(0.016)
Observations	1340	1340	1336	1336
R^2 within	0.869	0.882	0.883	0.895
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. The sample comprises 35 cities in China for the period 2007–2016. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table 13. Potential impact of the home purchase restrictions policy on house price growth rate

	Without HPR				With HPR			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. LTV limits for borrowers who do not own a property								
Overall effect of LTV policy	0.377***	0.438***	0.291***	0.360***	0.373***	0.423***	0.292***	0.339***
	(0.076)	(0.078)	(0.084)	(0.089)	(0.076)	(0.077)	(0.079)	(0.086)
Overall effect of HPR policy					-0.001	-0.012***	0.002	-0.011***
					(0.003)	(0.003)	(0.004)	(0.004)
R^2 within	0.837	0.847	0.871	0.878	0.838	0.849	0.872	0.880
Panel B. LTV limits for borrowers who own one property								
Overall effect of LTV policy	0.069***	0.114***	0.046*	0.105***	0.075***	0.112***	0.059**	0.102***
	(0.023)	(0.019)	(0.026)	(0.022)	(0.021)	(0.020)	(0.022)	(0.023)
Overall effect of HPR policy					0.004	-0.007**	0.006**	-0.005
					(0.003)	(0.003)	(0.003)	(0.004)
R^2 within	0.840	0.850	0.874	0.883	0.840	0.851	0.875	0.883
Observations	2616	2616	2612	2612	2616	2616	2612	2612
City trends	No	Yes	No	Yes	No	Yes	No	Yes
Weights	No	No	Yes	Yes	No	No	Yes	Yes

Notes: 1. The dependent variable is the annualised quarterly growth rate in real house prices. The overall effect of LTV policy or HPR policy is the effect in the four quarters following policy releases. The sample comprises 70 cities in China for the period 2007–2016. Regressions include city fixed effects, year fixed effects, lagged real house price growth rate, resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Appendix

Table A1. Chinese cities in the sample

City	Tier	Region	City	Tier	Region
Beijing	First-tier	North	Anqing	Third-tier	East
Chongqing	First-tier	Southwest	Bengbu	Third-tier	East
Guangzhou	First-tier	Centre	Beihai	Third-tier	Centre
Shanghai	First-tier	East	Baotou	Third-tier	North
Shenzhen	First-tier	Centre	Changde	Third-tier	Centre
Tianjin	First-tier	North	Dandong	Third-tier	North
Changchun	Second-tier	North	Ganzhou	Third-tier	East
Chengdu	Second-tier	Southwest	Guilin	Third-tier	Centre
Changsha	Second-tier	Centre	Huizhou	Third-tier	Centre
Dalian	Second-tier	North	Jinhua	Third-tier	East
Fuzhou	Second-tier	East	Jining	Third-tier	East
Guiyang	Second-tier	Southwest	Jiujiang	Third-tier	East
Harbin	Second-tier	North	Jilin	Third-tier	North
Hefei	Second-tier	East	Jinzhou	Third-tier	North
Hohhot	Second-tier	North	Luzhou	Third-tier	Southwest
Haikou	Second-tier	Centre	Luoyang	Third-tier	Centre
Hangzhou	Second-tier	East	Mudanjiang	Third-tier	North
Jinan	Second-tier	East	Nanchong	Third-tier	Southwest
Kunming	Second-tier	Southwest	Pingdingshan	Third-tier	Centre
Lanzhou	Second-tier	North	Qinhuangdao	Third-tier	North
Ningbo	Second-tier	East	Quanzhou	Third-tier	East
Nanchang	Second-tier	East	Sanya	Third-tier	Centre
Nanjing	Second-tier	East	Shaoguan	Third-tier	Centre
Nanning	Second-tier	Centre	Tangshan	Third-tier	North
Qingdao	Second-tier	East	Wuxi	Third-tier	East
Shijiazhuang	Second-tier	North	Wenzhou	Third-tier	East
Shenyang	Second-tier	North	Xiangyang	Third-tier	Centre
Taiyuan	Second-tier	North	Xuzhou	Third-tier	East
Wuhan	Second-tier	Centre	Yichang	Third-tier	Centre
Urumchi	Second-tier	North	Yantai	Third-tier	East
Xi’an	Second-tier	North	Yueyang	Third-tier	Centre
Xiamen	Second-tier	East	Yangzhou	Third-tier	East
Yinchuan	Second-tier	North	Zhanjiang	Third-tier	Centre
Zhengzhou	Second-tier	Centre	Zunyi	Third-tier	Southwest
Xining	Second-tier	North	Dali	Fourth-tier	Southwest

Table A2. Introduction to national loan-to-value policy from 2007 to 2016

Policy release date	Release agency	Main content	Policy descriptions
27-09-2007	People's Bank of China (PBOC) and China Banking Regulatory Commission (CBRC)	Commercial banks should still require no less than 20% of the transaction price as a down payment for those purchasing their first house (less than 90 m^2), and if the floor area is equal to or above 90 m^2, the down payment shall not be less than 30%. For those using commercial loans to purchase houses, the minimum down payment ratio of the loans for the second or above house shall not be lower than 40%, and the loan interest rate shall not be lower than 1.1 times the benchmark interest rate.	Increasing the down payment ratio and the interest rate for commercial housing loans.
22-10-2008	Ministry of Finance and State Administration of Taxation	The minimum down payment ratio for all commercial personal housing loans for first homes has been reduced to 20%. The lower limit of commercial personal housing loan interest rate can be expanded to 0.7 times the benchmark lending rate. The interest rates on all types of individual housing provident fund (HPF) loans are reduced by 0.27 percentage points respectively.	The down payment for first homes being lowered for the first time in several years.
21-12-2008	General Office of the State Council	For residents who have raised loans to buy houses whose per capita housing area is lower than the local average level and who need to buy a second dwelling for their own use and to improve their living conditions, then the preferential policy for first-time buyers can be applied. For the purchase of a second or above house, the loan interest rate shall be reasonably determined by commercial banks on the basis of the benchmark interest rate.	Increasing credit support for self-occupied housing consumption and to improve living conditions, comprehensively stimulating the housing market.
10-01-2010	General Office of the State Council	For those families who have used loans to buy houses and apply again to buy a second or above house (including borrowers, spouses and minor children), the proportion of the down payment shall not be less than 40%, and the loan interest rate shall be strictly determined according to the risk pricing.	Reiterating the minimum down payment of 40% for commercial mortgages for second homes.
17-04-2010	The State Council	For the first self-occupied housing (more than 90 m^2), the down payment ratio shall not be less than 30%; the ratio for second houses shall not be less than 50%. The lending rate shall not be less than 1.1 times the benchmark interest rate. For those who purchase a third or above house with mortgage loans, the proportion of the down payment and the corresponding interest rate shall be greatly increased, as determined by the commercial banks independently according to the risk management principle.	Increasing the down payment ratio for commercial loans.
29-09-2010	People's Bank of China and China Banking Regulatory Commission	Commercial banks shall suspend loans for buying a third or above home. Non-local residents who cannot provide proof of local tax payment or social insurance payment for more than one year shall be suspended from being granted house purchase loans. For the purchase of commercial housing, the down payment ratio will be adjusted to 30% or more; for buying second homes, the rule of no less than 50% down payment and no less than 1.1 times the benchmark interest rate is strictly enforced.	Further increasing the down payment ratio for commercial loans.
04-11-2010	PBOC, CBRC, Ministry of Finance and Ministry of Housing and Urban-Rural Development (MOHURD)	The down payment of HPF loans for the purchase of first common self-housing (less than or equal to 90 m^2) shall not be less than 20%; for the rest (above 90 m^2), the down payment shall not be less than 30%. The second HPF loan is only for the families whose existing per capita housing construction area is lower than the local average level, and the use of the loan is limited to the purchase of ordinary self-housing to improve living conditions. The down payment ratio of HPF loans for second houses shall not be lower than 50%, and the loan interest rate shall not be lower than 1.1 times that for first housing in the same period.	Increasing the down payment ratio for HPF loans.

Table A2. Introduction to national loan-to-value policy from 2007 to 2016 (cont.)

Policy release date	Release agency	Main content	Policy descriptions
26-01-2011	General Office of the State Council	For families buying second homes, the down payment ratio is not less than 60%, and the loan interest rate is not less than 1.1 times the benchmark interest rate. Branches of the People's Bank of China may, based on national uniform credit policies, increase the down payment and interest rate of second housing loans based on local price control targets and policy requirements. Banking supervision departments should strengthen supervision and inspection of commercial banks' implementation of differentiated housing credit policies.	Strengthening differentiated housing credit policies and raising the down payment ratio for second homes.
01-03-2013	General Office of the State Council	In cities where housing prices are rising too quickly, local branches of the People's Bank of China can further increase the down payment ratio and loan interest rate on second home loans according to the price control target and policy requirements of the People's Government of the city.	Continuing to strictly manage housing consumption loans.
30-09-2014	People's Bank of China and China Banking Regulatory Commission	For households who purchase their first ordinary self-owned house, the minimum down payment ratio is 30%; the lower limit of loan interest rate is 0.7 times the benchmark interest rate, as determined independently by banking financial institutions. For those who own a house and have cleared previous loans, buying a second common commercial housing unit to improve living conditions, the same policy as for first-time buyers is implemented. Except for Beijing, Shanghai, Guangzhou, Shenzhen and Sanya where restrictions on purchases remain in place, the lending restrictions on the third or above house are lifted.	Easing lending restrictions.
30-03-2015	PBOC, CBRC, MOHURD	In order to improve living conditions, when families who own one house and whose corresponding purchase loans have not been cleared apply for commercial personal housing loans to purchase ordinary self-owned houses, the minimum down payment ratio shall be adjusted to no less than 40%. The minimum down payment for an HPF loan to purchase the first ordinary self-housing is 20%. When those who own a house and have already paid off their loan apply for an HPF loan, a minimum down payment of 30% applies.	Credit limit policy gradually being relaxed and the down payment for second home loans being reduced.
31-08-2015	PBOC, MOHURD, and Ministry of Housing	For households that own one house and have already cleared the corresponding housing purchase loans, if they apply for HPF loans to buy another house to improve living conditions, the minimum down payment proportion will be reduced from 30% to 20%. Beijing, Shanghai, Guangzhou and Shenzhen can independently decide on the minimum down payment ratio for the application of HPF for the purchase of second housing on the basis of national unified policies and in combination with local conditions.	Further decreasing the down payment ratio for HPF loans for second homes.
30-09-2015	People's Bank of China and China Banking Regulatory Commission	In cities that do not implement house purchasing restrictions, the minimum down payment ratio will be adjusted to no less than 25% for commercial loans for buying the first ordinary house. In cities where house purchasing restrictions are in place, the minimum down payment ratio is 30% for households purchasing houses for the first time or who currently do not own a house. The minimum payment for commercial personal housing loans for second homes is 40%.	Down payment ratios for first homes being reduced.
02-02-2016	People's Bank of China and China Banking Regulatory Commission	In the cities that do not implement house purchasing restrictions, in principle, the minimum down payment proportion of commercial loans for first houses is 25%, and cities can lower this by 5%. For households that own a house and have not cleared the corresponding purchase loan, if they apply for a commercial personal housing loan again to purchase ordinary housing to improve living conditions, the minimum down payment proportion will be adjusted to no less than 30%.	Further decreasing down payment ratio for commercial mortgages.

Table A3. Effects of loan-to-value limits for borrowers who do not own a property

	Real growth in prices of second-hand houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.443***	0.457***	0.389***	0.405***
	(0.078)	(0.079)	(0.084)	(0.082)
Two-period lagged LTV caps	-0.186***	-0.167***	-0.188***	-0.165***
	(0.043)	(0.044)	(0.051)	(0.049)
Three-period lagged LTV caps	-0.018	-0.009	-0.018	-0.010
	(0.055)	(0.055)	(0.060)	(0.061)
Four-period lagged LTV caps	-0.039	-0.043	-0.048	-0.056
	(0.045)	(0.044)	(0.039)	(0.038)
Lagged real house price growth	0.935***	0.869***	0.979***	0.914***
	(0.029)	(0.029)	(0.021)	(0.020)
Four-quarter effects	0.200***	0.238***	0.135	0.173**
	(0.065)	(0.069)	(0.085)	(0.086)
Observations	2616	2616	2612	2612
R^2 within	0.817	0.829	0.865	0.874
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. Column (1) does not control for city trends or add any weights; column (2) controls for city trends based on equation (13); column (3) is weighted by population of each city; column (4) includes both city trends and weights. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table A4. Effects of loan-to-value limits for borrowers who own one property

	Real growth in prices of second-hand houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.081***	0.090***	0.072***	0.086***
	(0.011)	(0.011)	(0.012)	(0.011)
Two-period lagged LTV caps	0.057***	0.060***	0.052***	0.055***
	(0.009)	(0.009)	(0.010)	(0.009)
Three-period lagged LTV caps	-0.085***	-0.071***	-0.082***	-0.068***
	(0.011)	(0.011)	(0.012)	(0.012)
Four-period lagged LTV caps	-0.044***	-0.032**	-0.056**	-0.041*
	(0.016)	(0.014)	(0.022)	(0.021)
Lagged real house price growth	0.926***	0.857***	0.962***	0.895***
	(0.029)	(0.029)	(0.021)	(0.018)
Four-quarter effects	0.010	0.047***	-0.013	0.031
	(0.022)	(0.018)	(0.026)	(0.024)
Observations	2616	2616	2612	2612
R^2 within	0.820	0.833	0.867	0.877
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. Column (1) does not control for city trends or add any weights; column (2) controls for city trends based on equation (13); column (3) is weighted by population of each city; column (4) includes both city trends and weights. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table A5. Effects of loan-to-value limits on commercial loans
for borrowers who do not own a property

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.491***	0.519***	0.396***	0.420***
	(0.087)	(0.087)	(0.097)	(0.100)
Two-period lagged LTV caps	-0.232***	-0.222***	-0.182***	-0.172***
	(0.041)	(0.041)	(0.052)	(0.050)
Three-period lagged LTV caps	0.148***	0.162***	0.111**	0.124**
	(0.040)	(0.042)	(0.051)	(0.056)
Four-period lagged LTV caps	-0.113***	-0.101***	-0.089***	-0.086***
	(0.038)	(0.036)	(0.033)	(0.028)
Lagged real house price growth	0.947***	0.893***	0.976***	0.924***
	(0.031)	(0.032)	(0.016)	(0.015)
Four-quarter effects	0.295***	0.359***	0.236***	0.286***
	(0.069)	(0.070)	(0.078)	(0.093)
Observations	2616	2616	2612	2612
R^2 within	0.834	0.844	0.868	0.876
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. Column (1) does not control for city trends or add any weights; column (2) controls for city trends based on equation (13); column (3) is weighted by population of each city; column (4) includes both city trends and weights. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.

Table A6. Effects of loan-to-value limits on commercial loans
for borrowers who own one property

	Real growth in prices of newly built houses			
	(1)	(2)	(3)	(4)
One-period lagged LTV caps	0.089***	0.097***	0.072***	0.086***
	(0.011)	(0.011)	(0.014)	(0.012)
Two-period lagged LTV caps	0.063***	0.066***	0.062***	0.065***
	(0.008)	(0.008)	(0.007)	(0.007)
Three-period lagged LTV caps	-0.057***	-0.045***	-0.049***	-0.037***
	(0.010)	(0.011)	(0.013)	(0.014)
Four-period lagged LTV caps	-0.048**	-0.028	-0.065**	-0.046*
	(0.022)	(0.020)	(0.025)	(0.027)
Lagged real house price growth	0.943***	0.887***	0.965***	0.910***
	(0.031)	(0.032)	(0.015)	(0.014)
Four-quarter effects	0.047*	0.090***	0.020	0.067**
	(0.025)	(0.023)	(0.029)	(0.031)
Observations	2616	2616	2612	2612
R^2 within	0.837	0.848	0.871	0.880
City trends	No	Yes	No	Yes
Weights	No	No	Yes	Yes

Notes: 1. Column (1) does not control for city trends or add any weights; column (2) controls for city trends based on equation (13); column (3) is weighted by population of each city; column (4) includes both city trends and weights. Regressions include city fixed effects, year fixed effects, lagged resident population, per capita disposable income of urban households and registered urban unemployment rate as control variables. For simplicity, the regression coefficients of control variables are not reported. Robust standard errors clustered by cities are in parentheses.

2. *** indicates significance at the 1 per cent level; ** indicates significance at the 5 per cent level; * indicates significance at the 10 per cent level.