AGGREGATE AND DISTRIBUTIONAL IMPACTS OF HOUSING POLICY: CHINA'S EXPERIMENT

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Preliminary and Incomplete

ABSTRACT. What's the role of credit conditions in housing booms and busts and what are the distributional consequences of housing booms and busts across households of different characteristics? In this paper, we take China's recent changes in housing policy as an experiment to address these two key issue. During 2014Q4-2016Q3, China relaxed its housing policies by reducing the minimum down payment ratio of non-primary houses from 60-70 percent to 30 percent. By exploiting two unique micro-level data sets, we find that that this policy change induced a significant increase in mortgage credit demand among high-educated middle-aged households, while crowding out mortgage credit to young households. Moreover, consumption growth by middle-aged high-educated households slowed down following this policy change. To quantify the aggregate and distributional impacts of housing policies, we construct an overlapping-generations economy with household heterogeneity and calibrate it to match various aggregate and cross-sectional moments of China. Our policy experiment suggests that a cut in the minimum down payment ratio for non-primary houses involves a self-enforcing effect on housing demand via equilibrium housing price: a reduction in the down payment ratio for non-primary housing triggers an initial housing price increase. This, in turn, generates capital gains for homeowners before the policy change and allows them to switch to a larger house by overcoming the credit constraint for housing investment. Such a process is self-enforcing via the equilibrium housing prices due to the interaction between stronger housing demand and higher housing price.

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It has been widely acknowledged that booms and busts of a country's housing markets lie at the heart of its macroeconomy. Yet, two important questions surrounding housing booms and busts remain open. First, what's the role of credit conditions in housing booms and busts? Second, what are the distributional consequences of housing booms and busts across households of different characteristics?

In this paper, we take China's recent changes in housing policy as an experiment to address these two key issues. In 2014Q4, China began to relax its housing policies. This relaxation lasted until 2016Q3. The thrust of this relaxation of policy is a reduction in the minimum down payment ratio of non-primary houses from 60-70% to 30%. Accordingly, it experienced a housing market boom during this period: the average annualized growth rate of housing prices for the 35 major cities in China reached 7.30%, in contrast to a 2.32% growth rate during 2011Q1-2014Q3; the average annual newly issued mortgage amount for the same group of cities is 70 percent higher than its counterpart during 2011Q1-2014Q3. The outstanding mortgage debt nationwide increased from 10.6 trillion RMB in 2014 December to 17.9 trillion RMB. On the other hand, the aggregate consumption growth rate has started to decline (Figure 1).

Hence, China's recent policy experiment serves as an ideal identification of changes in credit conditions, and allows us to address their roles in housing booms from both empirical and theoretical perspectives. Our main finding is that a relaxation in credit conditions via loan-to-value ratio (LTV) policies on non-primary houses plays a crucial role in fueling the recent housing boom in China and inolves significant distributional effects on both mortgage and consumption.

Specifically, on the empirical part, we exploit two unique micro-level data sets. Our first data set is a proprietary loan-level mortgage data set covering all new mortgages by one of the largest bank in China to its 70 major cities during 2011-2018. The second data set is China Household Finance Survey, containing four waves conducted every other year from 2011 on. This data set contains household-level information on both consumption, income and various categories of assets and liability. We use these two data sets to explore the changes in the mortgage shares and consumption growth across households of different ages and education levels following the policy changes, and establish the linkage between these two.

Our major empirical findings are as follows: First, during 2014Q4-2016Q3, a period of relaxation of LTV policy, the share of new mortgage in terms of both loan amount and number

of origination for the middle-aged, high-educated households increased significantly, which squeezed out new mortgage for young households. Interestingly, although the relaxation of LTV policy is mostly on the non-primary house, the increase of mortgage by the middle-aged high-educated households came mostly from the mortgage for their primary residence. Second, the slowdown in aggregate consumption growth is mainly driven by consumption growth of the middle-aged high-educated households, who experienced significant increase in mortgage and housing sizes. Finally, controlling for various household characteristics, our regression suggests that households with higher mortgage debt burden tend to have lower consumption growth.

Disciplined by these empirical findings, we construct a dynamic OLG equilibrium model with household heterogeneity. The main goal of our theory is to (1) quantify the effects of a relaxation of LTV policy changes on housing prices, mortgage and non-housing consumption at both aggregate and household levels; (2) analyze experiments of counterfactual policy changes. Three key features consistent with China's institutional background are incorporated into the model: First, primary and non-primary (or so-called secondary) houses are subject to different minimum down payment ratios.[1] As a result, a reduction in the down payment ratio for secondary houses affects households' credit conditions on their primary house only through its indirect effects via equilibrium housing prices. Second, households' utility on housing services contains two stochastic regimes, which capture belief about future housing demand as the likelihood of switching from one regime to the other. Under a strong belief about future housing demand, the middle-aged homeowners, which comprise a non-trivial fractions of housing demand, tends to be credit constrained for investment purposes. Third, rental markets are frictional, which prevent households with secondary houses to rent them out to those without houses. This creates potential misallocation of resources when households with second houses leave them vacant.

We calibrate the stochastic steady state of our model to match various aggregate and cross-sectional moments before the relaxation of LTV policy in 2014Q4, Our calibrated model can replicate well age profile of households' mortgage demand, asset profolios, and leverage, as well as cross-sectional moments on wealth inequality before the policy relaxation. We then use this model to experiment with a temporary cut of the minimum down payment ratio of the second house to mimic China's LTV policy relaxation during 2014Q4-2016Q3. Our

[1]Throughout this paper, we call non-primary houses as secondary houses, although in the data they include a household's second and third (or above) houses.

simulated results can explain about 60% of the increase in housing prices and mortgage loans at the aggregate levels. In addition, as a support for our model mechanism, changes in the cross-sectional moments from our model can match the data on changes in mortgage loan and consumption across different ages and education levels fairly well.

The main mechanism of our model is that a cut in the minimum down payment ratio for non-owner-occupied houses involves a self-enforcing effect on housing demand via equilibrium housing prices. With belief of strong future housing demand, a reduction in the down payment ratio for secondary houses triggers an initial increase in housing prices by encouraging investment in secondary houses. This, in turn, generates capital gains for homeowners before the policy change and allows them to switch to a larger house even if the LTV constraint for the primary house remains the same. Such a process is self-enforcing via the equilibrium housing prices due to the interaction between stronger housing demand and higher housing price.

In terms of consumption, our model predicts that a relaxation of LTV policy reduces non-housing consumption for middle-aged high-education households, who benefited from capital gain due to higher housing prices. This result is in sharp contrast to the theoretical predictions in existing housing literature, in which a positive wealth effects of housing price increases homeowners' non-housing consumption. In our model, the middle-aged high-educated households, despite a capital gain from their housing held before the policy change, choose to switch to a large house for investment purpose in expectation of future capital gain. As a consequence, their non-housing consumption fall for two reasons: first, they substitute current consumption for future consumption via investment in housing; second, a higher mortgage debt burden forces them to reduce their non-housing consumption.

The rest of the paper is organized as follows. Section I provides a literature review. Section II provides the institutional backgrounds regarding China's housing markets and housing policies. Section III describes the two micro-level data sets used in this paper. Section IV discusses the empirical results regarding the changes in mortgage and consumption growth during the period of LTV policy relaxation. In Section V, a dynamic overlapping-generations equilibrium model with household heterogeneity is established and calibrated. Section VI quantifies the impacts of relaxation of LTV policy and other counterfactual policies. Section VII concludes the paper.

I. Related Literature

This paper contributes to an extensive literature on housing booms and busts from both empirical and theoretical perspectives. On the theoretical part, a fast growing literature uses quantitative housing model to explore the role of credit conditions in housing boom and bust.[2] For example, Landvoigt, Piazzesi and Schneider (2015) show that housing prices increased more in lower end of housing markets, which contains a higher fraction of constrained households. Favilukis, Ludvigson and Van Nieuwerburgh (2017) build a general equilibrium model to show that a relaxation of collateral requirements is the main cause of the U.S. housing boom before 2007 via stimulating housing consumption by credit constrained households. By contrast, Kiyotaki, Michaelides and Nikolov (2011) and Kaplan, Mitman and Violante (2017) argue that a relaxation of credit conditions has limited effects on housing demand or housing prices. The key reason is that the potential beneficiaries of the credit relaxation (tenants and constrained owners) in the latter two papers represent a small share of the total housing market, so only a limited amount of conversion between rental and owner-occupied units is need to satisfy additional housing demand. Our theory sheds light on a novel channel for changes in credit conditions to affect housing demand and housing prices. Such a channel relies on two key model ingredients absent from the above studies: (1) middle-aged wealthy households, which represent a non-trivial fraction of the total housing demand, are constrained for housing investment (rather than housing consumption); (2) changes in credit conditions affects existing home owners' housing values via equilibrium housing prices. As a result, the capital gain associated with higher housing prices allows the existing homeowners to overcome the credit constraint and churn up their housing size. In a model with both rental markets and long-term mortgage, we show that this channel can generate quantitatively sizable aggregate impacts of changes in credit conditions on housing prices and housing demand. Also, different from the above papers, a relaxation in credit conditions in our model crowds out the mortgage shares of the young households, arguably the most credit constrained households for housing purchase.

Our paper also contributes to the quantitative studies on the redistributive effects of housing policy and housing booms and busts. The literature has emphasized the redistributive

[2]Apart from changes in credit conditions, the literature has exploited the quantitative housing models with household heterogeneity to understand the role of various other policies on housing prices and consumption, including monetary policy (e.g. Wong (2016) and Beraja et al. (2018)), tax policies (e.g. Sommer and Sullivan (2018)) and changes in payment-to-income requirements (e.g. Corbae and Quintin (2015))

effects of housing (asset) prices on consumption via its income effects. For example, Kiyotaki, Michaelides and Nikolov (2011) argue that net house buyers (such as young worker-tenants) lose and net house sellers (such as retiree-homeowners) gain from the house price spike. Along a similar spirit, Glover, Heathcote, Krueger and Ríos-Rull (2011) show that in the downturn, the young households may benefit from an asset value slump by buying these assets at low prices. While in our model, similar income effects of housing price spikes apply to tenants and young constrained homeowners, the main culprits for changes in housing policy to slow down aggregate consumption are those households with large illiquid assets and heavy debt burden (wealthy hand-to-month). Despite a positive wealth effect of housing capital gain, these households choose to reduce their consumption when investing larger houses for intertemporal substitution of consumption unto future. Another novel feature of our model is that, with rental markets frictions, a relaxation of credit constraints exacerbates misallocation of housing resources between home owners and renters.

On the empirical front, our paper contributes to the extensive literature on the primary drivers of housing booms using micro-level data. The literature takes two drastically different views: credit supply view and the expectation view. According to the former, increase in credit supply unrelated to fundamental improvements in income or productivity was the driver that initiated mortgage boom.[3] According to the latter, inflated housing price expectations led banks to increase the supply of mortgage credit and encouraged borrowers to increase housing demand. By providing new evidence on the reallocation of mortgage debt during housing booms, our evidence suggests the crucial role played by the interaction of both credit supply and expected future housing demand in fueling the housing boom. During China's recent housing boom, changes in credit supply clearly originated from the policy changes, rather than rising anticipated housing appreciation. However, different from the credit supply view, we find that changes in credit conditions increased mostly mortgage and housing demand by high-income homeowners (middle-aged with high education), who are likely constrained for housing investment. Instead, such empirical findings are in line with those in some recent empirical works that are used to support for the expectation view.[4] However, both our evidence and theory suggest that such an reallocation of mortgage credit

[3]Studies along the line of this view, as in the seminal work of Mian and Sufi (2009, 2011), argue that changes in credit supply affected mostly the subprime borrowers, arguably low-income households.

[4]For example, Foote, Loewenstein and Willen (2016) find a uniform increase in mortgage debt across income levels during the boom. Similarly, Albanesi, De Giorgi and Nosal (2017) show that credit growth between 2001-2007 is concentrated in the middle and at the top of credit scores. Adelino, Schoar and Severino

does not necessarily stem from *changes in* housing price expectations, as the expectation view argues.

Apart from the role of credit conditions in housing booms, our evidence also contributes to the recent empirical literature on the effects of housing booms on consumption. The literature so far emphasized the positive wealth effects of housing booms and busts.[5] While our evidence suggests the existence of the wealth effects for some groups of households (e.g. the old high-educated households), it sheds light on an opposite effect of housing booms on household consumption, that is, intertemporal substitution of consumption by households with large illiquid assets and heavy debt burden. Such a channel is potentially important for housing prices to affect aggregate consumption, as consumption by those households represent a non-trivial fraction of aggregate consumption. Moreover, due to the illiquidity of housing, the effects of such a channel may persist even if the housing booms are over.

Finally, our paper contributes to the emerging literature on China's high housing price puzzles. Of particular relevance are the following two studies.[6] Fang, Gu, Xiong and Zhou (2016), using an independent mortgage loan data set that ranges from 2013-2013, find enormous housing price appreciations during the decade and document carefully the financing burden of mortgage borrowers across different income groups and cities. Chen and Wen (2017) develop a general equilibrium model to attribute the faster-than-income growth housing prices during the golden decade to the role of housing as store of values. Both papers focus on the secular growth of housing prices before the recent housing boom starting from 2014. By contrast, our paper focuses on the role of changes in credit conditions or housing policies during housing booms. And both papers use either micro data or equilibrium theory. Our paper exploits both micro data and dynamic equilibrium theory. Accordingly, it fits into the emerging literature that aims to understand the interaction between macroeconomy and microeconomic heterogeneity. The cross-sectional evidence we provide provides an empirical discipline of our quantitative theory, which is crucial to assess the impacts of policy changes. Our theory, in turn, highlights the transmission of housing policy into housing

(2018) find that during the housing boom, mortgage credit was extended to a broad based household of all income/credit scores level.

[5]See, for example, Mian, Rao and Sufi (2013), Berger, Guerrieri, Lorenzoni and Vavra (2017), and Guren, McKay, Nakamura and Steinsson (2018).

[6]Other papers in this literature include, among others, Wei, Zhang and Liu (2017), Chen, Liu, Xiong and Zhou (2017), Gu, He and Qian (2018), which are mostly empirical, and Zhao (2015) and Han, Han and Zhu (2018), with a theoretical focus.

demand and consumption via equilibrium housing prices and is used to study counterfactual policy experiments, both of which can hardly be addressed by a mere empirical exercise.

II. China's Housing Market and Policy

This section discusses the unique features of China's housing markets, financial markets, and housing policies, all of which are pertinent to the subsequent empirical and theoretical analysis in this paper.

II.1. **Financial underdevelopment and housing as store of values.** In China, interest rates are controlled by the central banks. The deposit rate has been subject to a ceiling to subsidize the financing of SOE.[7] Through a system of strict capital controls, where the state directly manages the banking sector and financial intermediation, the government has been able to maintain or suppress interest rates at below market-clearing levels. Accordingly, the mortgage interest rates offered by individual commercial banks follow closely the benchmark lending rate stipulated by the PBoC.

In addition, the availability of financial assets as vehicles of household savings is quite limited in China: stock markets are poorly regulated and dominated by SOE, the national capital account is closed, and the exchange rate is fixed or tightly managed. Under this circumstance, housing has naturally become the most important store of value for most Chinese households, which has led to high concentration of wealth in housing among Chinese households. For example, according to our computation with CHFS data, in 2013, housing comprised of 77.5% of households' wealth in urban China, as compared to about 40% for the U.S. households.[8] The share of financial assets in Chinese households' wealth is only 8.63%, compared with a value of 37.9% in the U.S. The importance of housing in Chinese households' wealth has become even higher in recent years due to the housing boom, reaching 82.62% in 2017.

Land available for home construction in China is strictly controlled by the government. According to a law passed by State Council of China in 2008, the amount of cultivated land in 2010 and 2020 has be maintained at 1.818 billion acres and 1.805 billion acres, respectively, the so-called red-line lower limit for the total amount of arable land, implying a de facto

[7]The ceiling was formally removed in October 2015. However, to prevent competition on the deposit, a market interest rate self-regulation mechanism was established in 2013, which effectively forces commercial banks' deposit rate to peg the benchmark deposit rates.

[8]Within the category of financial wealth, bank deposit takes a share of 65.21%.

fixed supply of land for home and real estate construction. In addition, the local government in China has incentive to limit the supply of land to boost the land price, since the revenues from selling land is important sources of revenues of local governments since 1994.

The use of housing as store of values, together with the limited supply of land, has created speculative investment demand for housing. Around one fifth of urban Chinese households owned a second house (CHFS 2013). As a result, the house-price-to-income ratio is much higher than the developed economies. According to Fang, Gu, Xiong and Zhou (2016), the price-to-income ratio for the bottom-income group has been sustainably above 8 for all three tier cities. For the middle-income group, this ratio has reached to a level of above 6 in 2012. By contrast, the price-to-income ratio for the U.S. was around 3 before during and after the housing bubble that peaked in 2006.

Moreover, the vacancy rate of owner-occupied housing in urban China has been persistently high in recent years. According to our computation with the data from CHFS, among 35 major cities in China, the average housing vacancy rates have been stably around 20% during 2011-2017. The housing vacancy rate for non-primary houses is even higher, reaching 42.06% in 2017. Chen and Wen (2017) show that underlying the faster-housing-price-to-income growth and the high vacancy rates in urban China was the speculative demand for housing.

II.2. **Rental market frictions.** Rental markets in China are under-developed due to various institutional frictions. On the demand side, housing ownership has clear advantages over renting along several dimensions: First, with the scarcity of high-quality education resources in China, it gives the children of a homeowner priority to have access to the schooling where the purchased housing is located. Second, due to the incomplete laws on house lease, tenants cannot safeguard their lawful rights and interests. According to a 2017 survey by Beijing government for 5000 youth about housing status, about one third of them experienced expelling by landlords, 41.3% experienced rent increasing that violated the leasing contract and 43.8% experienced un-creditworthy behavior of rental agencies. By contrast, in Germany, there are a series of laws protecting the lawful rights of tenants.[9] Third, owning a house has increasingly become a prerequisite for male to marry a female under the unbalanced sex ratios in China. According to Wei, Zhang and Liu (2017), the unbalanced sex ratios can well explain the high level of housing prices.

[9]For example, the Amendment Acts on Leasing Rights passed in 2013 requests that the increase of rent cannot exceed 15% in three years.

On the supply side, China does not have credit score systems for individual households such as FICO, Equifax in the U.S. As a result, it is hard for the landlord to identify potentially good tenants and effectively protect themselves against defaults on rental payments. More importantly, due to the fast growth of housing prices, the rent to price ratio has long remained low. The average rent to price ratio for residential housing in first tier cities was around 2.4% in 2013. This is in contrast to a 3% benchmark deposit rate and a 6% benchmark lending rate during the same period. The low rent-to-price ratios discouraged both homeowners to leasing additional housing and the real estate developer to borrow from banks for developing rental housing.

The rental market frictions contributes to high home ownership rates among Chinese households, especially among those below age 30. In 2013, the home ownership rate in China was 87%, compared with 65% in the U.S. Also, China has the highest home ownership rate among young households, reaching 67% in 2013, compared with only about 35% for the U.S. and 31% for UK.

II.3. **Mortgage market and housing policy.** China's mortgage market was developed along the process of housing privatization since 1998. In 1998, the share of outstanding mortgage in GDP was merely about 0.5%, reaching to about 16.5% in 2014. However, during the recent mortgage boom, this ratio increased rapidly, to 26.6% in 2017. The share of mortgage debt in households disposable income grew even faster, from 38.4% in 2014 to 60.5% in 2017. Among various kinds of liability, mortgage loans takes the largest share in consumer loans of Chinese households, especially medium and long-term (MLT) loans. For example, in 2013, the share of residential mortgage loans in total (MLT) consumer loans was 69.4% and 87.4%.

In China, all mortgage loan is for home purchase. Mortgage cannot be used to extract existing home equity. There does not exist home equity line of credit, second mortgage that allow households to refinance. Moreover, the reverse mortgage market did not exist until 2014, when Chinese government started a two-year pilot program to introduce reverse mortgage by some life insurance company.[10]. Moreover, there are no secondary market for mortgage loan via secularization, i.e. Mortgage Back Security. As a result, the maximum LTV ratio that individual banks offer following closely the LTV policy, which we discuss now.

[10]However, the pilot program proved to be unpopular in China. Up to the end of July 2017, only 65 households participated in the program nationwide. See Fang and Feng (2018).

In China, the minimum down payment ratio for primary houses and second houses are different and have often be used by the government to affect housing demand. For example, in 2008, as part of the stimulus package, the minimum down payment ratio for the primary (second houses) dropped from 30% (40%) to 20%. In January 2010, however, to suppress the speculative housing demand, the minimum down payment ratio for the second (first house with area more than 90 square meters) houses increased to 50% (30%). In January 2011, the minimum down payment ratio for the second house was further increased to 60% and no mortgage loan for the third houses and above.

To boost the housing markets, China began to relax its LTV policies in 2014Q4. This relaxation lasted until 2016Q3. The thrust of this relaxation of policy is a reduction in the minimum down payment ratio of non-primary houses from 60-70% to 30%. During this period, the only drop of the down payment requirement for the primary houses happened on August 27, 2015, from 30% to 25%. Since 2016Q4, however, LTV policies have been tightened again. In 2016Q4, twenties cities, most first and second tier, tightened their LTV policy by increasing the minimum down payment ratio for the second (first) houses, to 40% to 70% (30%). By June 2017, 44 cities and counties across China tightened their LTV policy, especially for the second house.

Apart from the above mortgage policies, the montly maximum mortgage payment should be less than 50% of total households' income. The longest mortgage term in China is 30 years. The age of mortgage borrowers should be between 18-65 years of age. [11]

III. Data

III.1. **Data Description.** We use two unique micro-level data sets in our empirical analysis. The first is a proprietary loan-level data for mortgage origination from one of the largest banks in China. The outstanding mortgage loans held by this bank account for around 14% of total outstanding mortgage loans in China, and this share stays roughly constant across years. Our data contains all new mortgage loans advanced by this bank for purchasing new, residential properties during 2011Q1 - 2018Q2. It contains more than 3.3 million mortgage loans, covering the 70 major cities that correspond to the city sample in National Bureau Statistics (NBS) 70-city housing price index. The data records detailed transaction-level

[11] In addition to LTV policies, Chinese government also imposed various restrictions on housing transaction to directly affect the demand or supply of housings. For example, to discourage housing demand, between 2010Q1 and 2014Q1, 46 cities, most of which are first tier or second tier cities, followed the purchase restriction policy. This policy was abandoned in march 2014 except for the first tier cities and Sanya.

information in the following three categories: (i) home buyers' characteristics, including age, gender, occupation, education, (reported) income, number of houses, city, and zip code; (ii) loans' characteristics, including down payment, mortgage loan, maturity, mortgage interest rate, credit score; and (iii) house price and size. Importantly, our data contains information on whether a particular mortgage is for the mortgage borrower's primary or secondary houses. Moreover, it contains information about each homebuyers' characteristics, including age, gender, occupation, education, (reported) income, number of houses, city, zipcode and credit score.

Our second data set is China Household Finance Survey, conducted by Southwest University of Finance and Economics every two years since 2011. This data is the most comprehensive source of household-level data in China on wealth, consumption and income. Relative to traditional household spending data sets in the Unite States and United Kingdom, such as Consumer Expenditure Survey (CEX), Survey of Consumer Finance (SCF) or Living Costs and Food Survey, (LCFS), the clear advantage of this data set is that it contains disaggregate information on *both* (i) wealth and household balance sheet; (ii) a rich array of expenditure at the household levels. This allows us to establish the empirical linkage from household mortgage debt or debt to income ratio to consumption growth, a key for this paper. The survey is large consisting of over 8,000 households in each waves. For example, the 2013 survey sample includes 28,142 households (more than 99,000 individuals). Within each wave, a subset of households were repeatedly interviewed, which allows us to compute the consumption growth rate at the household level.

Each interview records information on the following set of questionnaires: (i) demographic characteristics (age of the household head, education, household size, etc.) and labor market (income); (ii) asset and liabilities, including various categories of both non-financial assets, such as real estates, and financial assets; (iii) expenditures on detailed categories over the past year and non-labor income; (iv) social and commercial insurance. The variables of interest for our purpose are age, education, consumption expenditure, income, mortgage debt, as well as housing tenure status (renter or homeowners).

III.2. **Summary Statistics and Main Variables.** (to be written)

- mortgage data, LTV ratio, average loan amount, mortgage amount by age, numbers of borrowers,
- CHFS data, debt to income ratio for first and second houses, consumption growth (high education, low education), labor earnings, outstanding mortgage debt,

IV. Empirical findings

This section begins with a descriptive analysis on how new mortgage loan and consumption growth changed during the period of relaxing LTV policy at both aggregate and disaggregate levels. After that, we establish the empirical linkage between mortgage debt and consumption growth at the household level.

IV.1. **Mortgage.** Figure 2 shows the age profile of average LTV ratio at origination across years. We pick three years, 2011, 2013 and 2015 to highlight the changes of age profiles that may potentially be attributable to the LTV policy relaxation. The first two years are before the policy changes and the third is during the period of LTV policy relaxation. The life and right panels plot the age profile of LTV ratios at mortgage origination for primary and secondary houses, respectively. As shown in the left panel, the LTV ratio for the primary house for all three years are hump-shaped, peaking at age 30. Relative to the year 2013, when LTV policy was tightened, the LTV ratio in 2015 by the middle-aged (30-50) on their primary house increased somewhat, while the counterpart for the very young household declined. The difference, however, is marginal, which is consistent with the fact that the relaxation of LTV housing during the boom is mostly on the secondary house. The age profile of LTV ratio for the secondary house differs significantly from its counterpart for the primary house in several aspects: first, the profile is essentially flat across ages and close in magnitude to the maximum LTV ratio governed by policy at different years. This is in contrast to the hump-shape age profile of LTV ratio for the primary house. A potential reason for this difference is that the purchase of secondary houses by households of different ages is not for owner-occupation or rent, but for future capital gain. Hence, they would like to maximize their leverage under the current LTV policy. Another notable difference is that the age profile of LTV ratio jumped up from a level below 40% in 2013 to a level above 55% in 2015. Since the maximum down payment ratio for the second house dropped from from 60-70% to 40% in March 2015 (and further to 30% in February 2016). This suggests that the relaxation of LTV policy allowed purchasers of their secondary house to increase their leverage substantially.

Figure 3 displays the dynamics of aggregate mortgage loans and the financing burdens of households. As the top two panels show, the dynamics of mortgage for the primary and all houses, in terms of both loan amount and origination numbers, track each other very closely before the relaxation of LTV policy. The two series started to diverge when the

LTV policy was relaxed in 2014Q4, suggesting an increasing share of mortgage for secondary house under the direct effect of LTV policy relaxation on secondary houses. Nevertheless, the sharp increase in aggregate mortgage during the boom period is mainly attributable to the mortgage of the primary house. Given the marginal change of the minimum down payment ratio for the first house during this period, this suggests that the relaxation of LTV policy for the secondary house has a spillover effect on the mortgage demand for primary houses.

The bottom left panel plots the dynamics of the ratios of mortgage debt at origination to income (DTI). Before the housing boom, the mortgage debt to income ratio was below 4. However, during the mortgage boom, this ratio increases steadily to about 4.5 in 2016Q3. By comparison, during the U.S. housing boom in 2001-2016, even households in the lowest income quintile had a mortgage DTI ratio below 3.50, as shown in Adelino, Schoar and Severino (2016). The right panel plots the house value to income ratio over time. Before the housing boom, the value to income ratio was slightly above 6 on average. During the boom, this ratio increased again steadily to a level of 6.75 in 2016Q3. Both the steadily increase of the DTI and value to income ratios suggest that homeowners have been subject to heavier financing burden since the housing boom.

We now turn to the distribution of mortgage across ages. To this end, we plot the age profiles of mortgage share for 2011, 2013 and 2015, in terms of both loan amount and the number of mortgage origination. As the top panels of Figure 4 shows, mortgage shares in both loan amount and origination numbers are hump-shaped. The age profiles for 2011 and 2013 are very similar, with households aged 25-30 obtaining the highest share of more than 20%. When it comes to 2015, the profile shifted to the right: the mortgage share of households aged 30-40 increased significantly, whereas that for households aged 20-25 declined. Such a change holds for both the mortgage loan amount and origination numbers.

To highlight the role of extensive margins in household indebtedness, we plot the age profile of the ratios of outstanding mortgage debt to income and the share of mortgage holders among all households. The left panel shows that the age profiles between 2011 and 2013 are fairly similar, hump shaped and peaking at age 30. The age of peak is consistent with that in the top two panels regarding the mortgage share. Between 2013 and 2015, however, the DTI ratio for households aged 30-49 increased significantly. Such an increase can be due to an increase in the share of households who newly became the mortgage borrowers (extensive margin) and a higher DTI ratio for those households who were already mortgage borrowers before the housing boom (intensive margin). As the bottom right panel shows,

the age profile of the share of mortgage borrowers has a similar pattern as that for the DTI ratio, suggesting the importance of extensive margin in the age profile of DTI ratio. More importantly, the increase of the share of mortgage borrowers came mostly from households aged 30-50, which suggests the crucial role played by the increasing share of households with positive mortgage in the increase of DTI ratio during the housing boom.

To display numerical values, we classify all households into three age groups. Those aged below 30 as young households, while those aged between 30-and 49 as middle-aged and those aged 50 and above as old households. This classification is consistent with the age profile of mortgage share before the LTV policy relaxation, which peaks in age 30. We also classify all households into two education groups: those with college and above degree and those with high school and below, which, for concision, we call high-education and low-education groups, respectively,

Table 1 reports the mortgage share across age-education groups in 2013. As Panel A shows, in 2013 the mortgage loan amount are more or less equally distributed across middle-aged and young households, especially those with high education. The shares of mortgage loan amount are close to one another for households of middle-aged high-education, middle-aged low-education, and young high-education, all of which are above 25%. Panel B exhibits a similar pattern for mortgage of the primary houses, suggesting that the distribution of mortgage amount across age-education groups are mainly driven by the mortgage amount of the primary house. In terms of origination numbers, panel C and D shows that the the middle-aged low-educated households take the largest share above 33%, followed by young and middle-aged high-educated households.

The relaxation of LTV policy redistributed the mortgage share across age-education groups. As panel A and C of Table 2 shows, the only age-education group that increased mortgage share is the middle-aged high-educated households. Their mortgage shares have increased by 13.45% and 8.12% in terms of loan amount and origination numbers, respectively. By contrast, the mortgage shares of other age-education groups, especially those for the middle-aged low-educated and young high-educated, have declined. Panel B and D suggest that such a redistribution of mortgage share is mainly driven by the redistribution of mortgage share of the primary house, despite the fact that the LTV ratio for the primary house barely changed.

IV.2. **Consumption growth.** We now switched to the impacts of relaxation of policy on consumption growth. Table 3 reports the consumption growth rate for the two episodes:

2013-2015 and 2015–2017. The first episode captures the period before the relaxation of LTV policy and the second during the relaxation of LTV policy.[12] For each panel in this table, we also report the income growth during the two episodes to control its effects on changes of consumption growth during these two episodes. Panel A shows that consistent with Figure 1, consumption growth during the second episode is slower than its counterpart in the period before LTV policy relaxation. This is despite a faster income growth during this period.

The main cause for slowdown in aggregate consumption growth during the housing boom is the slower consumption growth of the middle-aged households. Panel B shows that, despite a faster income growth, middle-age households experienced a decline in consumption growth of 4.16% during the second episode, whereas consumption growth of the other two age groups either increased or hardly changed. Panel C reports the change of consumption or income growth between the two episodes by age and education. The left panel shows that the middle-aged high-educated households experienced a significant consumption growth slowdown by 7.19%, in contrast to an insignificant change in consumption growth of the middle-aged low-educated households. The right panel suggests that consumption growth slowdown of households of middle ages and high education is not due to the slowdown of income growth, as their income growth actually speeded up during 2015-2017.

In summary, during the mortgage boom, middle-aged, high-educated households experienced a significant increase in mortgage share but a decline in consumption growth. The increase of mortgage share by this household group squeezed out mortgage of other age-education groups. This is especially the case for young high-educated households, who have a strong demand for housing, but are likely to be credit constrained. And the decline in consumption growth by the middle-aged high educated household is puzzling in light of their faster income growth during this episode.

We now establish the empirical linkage between consumption growth and mortgage debt burden. We examine the effect of mortgage debt burden along both the extensive and intensive margins on households' consumption growth. Along the extensive margin, we regress consumption growth on a dummy equal to 1 if a household has mortgage debt and 0 otherwise. Along the intensive margin, for a subsample of households who have positive mortgage debt, we regress consumption growth on the outstanding mortgage debt to income

[12]In CHFS, the questionnaire for consumption expenditure is the expenditure during the previous year of each survey.

ratio. Intuitively, households with mortgage debt or a higher debt to income ratio are more burdened by mortgage payment and thus have less cash on hand. Our main control variable is contemporary income growth.[13]

Table 4 reports the regression outcomes. Column (1) suggests that households with mortgage debt on average have consumption growth lower than households without mortgage debt by 5.31%. Column (2) further shows that a higher mortgage debt to income ratio reduces consumption growth. If the household's outstanding mortgage debt increases the amount of its income, the consumption growth will decrease 0.55%. In both regressions, the estimated coefficients are highly significant.[14] Therefore, our regression suggests that the increase in mortgage share of the middle-age high-educated households during the period of LTV policy relaxation might contribute to their consumption growth slowdown by making them more heavily mortgage-debt burdened.

Our empirical findings are puzzling from the perspective of the existing lifecycle models: (1) Why did middle-aged high-educated households, instead of young households, increased mortgage the most in response to the relaxation of LTV policies? (2) Why did the relaxation of LTV policies on secondary houses fueled the mortgage of the middle-aged high-educated households on their primary houses? (3) Why did consumption growth of the middle-aged high-educated households fall while their mortgage loan and housing demand increased?

V. Model

We now develop a dynamic equilibrium model to reconcile with the empirical facts in the previous section. To investigate the aggregate and distributional effects of housing policies, we include the following key model ingredients: (1) Primary and secondary houses are subject to different minimum down payment ratios. (2) Second, households' utility on housing services contains two stochastic regimes, which capture belief about future housing demand as the likelihood of switching from one regime to the other. (3) Rental markets are frictional, which prevent households with secondary houses to rent them out to those without houses.

V.1. **Households.**

[13]Each regression includes age, age-squared, education dummy and growth of household sizes as control variables.

[14]The estimated coefficient for mortgage dummy is significant at 1%, whereas the estimated coefficient for mortgage debt to income ratio is significant at 5%. The less significance of the intensive margin might be due to the fact that income in the survey data might contain higher measurement error, which tends to bias down the estimated coefficients.

V.1.1. *Household environment.* The economy is populated by a continuum of multi-period lived overlapping generations of households whose lifecycle is divided between work and retirement. Age is indexed by $j = 1, 2, , , J$. Households retire at age J^{ret}. All households die with certainty after age J.

Preference are time-separable and the future is discounted by the rate β. Each period, individual households have constant elasticity of substitution (CES) utility over non-housing consumption and housing services.

$$u(c, s; \phi) = \frac{[(1-\phi)c^{1-\gamma} + \phi h s^{1-\gamma}]^{\frac{1-\sigma}{1-\gamma}} - 1}{1-\sigma},$$

where γ and σ determine the elasticity of substitution between non-housing consumption and housing services and the relative risk aversion, respectively. The housing utility weight ϕ determines the share of housing services in total consumption. ϕ is a stochastic variable that is common for all households, capturing the common belief about future aggregate housing demand.[15] In particular, we assume that it follows a two-state Markov process $\phi \in \{\phi^L, \phi^H\}$, with transitional probability matrix Π,

$$\begin{bmatrix} 1 - \Pi_{lh} & \Pi_{lh} \\ 0 & 1 \end{bmatrix}$$

Starting from a low housing preference state, there is probability $1 - \Pi_{ll}$ that the economy will stay in the same state next period and probability Π_{lh} that the economy will move to high preference state. Once the economy moves into the high housing preference state, it will stay there forever. The stochastic belief about future housing demand can be interpreted as anticipated higher future demand for urban housing due to the relaxation of Hukou policy along urbanization.[16] The absorbing high housing preference state can be rationalized by the fact that once the Hukou policy is relaxed, it could not be reversed.[17] To isolate the impacts of policy changes, we assume that households are equipped with ϕ_L in the initial

[15]Our modeling of belief about future housing demand follows Kaplan, Mitman and Violante (2017). Different from their paper, however, the triggers of housing booms in our model are changes in housing policies, rather than exogenous changes in belief on future housing demand.

[16]According to Wu, Gyourko and Deng (2012), since 1996, the urbanization rate has been grown by about 1.4 percentage points since 1996. Even with a slight slowing growth of urbanization since 2015, there are about 15 millions new people entering urban areas each year.

[17]The assumption of absorbing high housing demand state is for computational easiness. We can allow a positive probability for the economy to transit back to the low housing preference state, which would not change our results qualitatively.

steady state and stay in the same regime along the transition following the policy relaxation. In other words, changes in the preferences are not realized, which makes stochastic housing preference capture not a change in the fundamental, but only belief about higher housing demand in future. This modeling approach shares the key features of a rational bubble, but at the same time allows housing to provide housing services even for housing investors.[18]

Upon birth, households are ex-ante heterogeneous in their permanent lifetime labor ability, η_k, where $k \in \{H, L\}$. Moreover, working-age households are subject to uninsurable idiosyncratic shocks to their efficiency units of labor, ϵ, where ϵ follows a first-order Markov process. Total household labor income is given by $y = w\varepsilon_j\eta_k\epsilon$, where w denotes the wage rate per efficiency unit of labor, and ε_j denotes the deterministic age efficiency profile.[19] When a household retires, each period it receives a pension benefit equal to a fraction ξ of the income at the last period of working age, denoted as $y = \xi y^{ret}$.

Housing service can be obtained by either renting a house at a rental rate ρ_h or buying houses at a price p_h. Housing size for both rental and purchased housing are discrete. For purchased houses, housing size belongs to the set $\mathcal{H}$, while for rental housing, housing size belongs to the set $\tilde{\mathcal{H}}$.

To capture rental market friction on the demand side, we assume that renting generates service less than one-for-one with the size of house, i.e. $hs = \omega\tilde{h}'$. $0 < \omega < 1$. Both rental and owned housing depreciates at a rate δ_h. When a household sells its home, it incurs a transaction cost $\kappa_h p_h h$, that is proportional to its housing value. Renter can adjust their housing size without cost.

Households can purchase multiple houses with total housing size h, We assume that there is an upper bound for the size of first house, $\hat{h}$, such that the size of first house is $\min\{h, \hat{h}\}$. The rest of h, with size $\max\{0, h - \hat{h}\}$, is counted as the second house. The second house provides no utility to the homeowner.

Households can finance the purchase of both first and second houses by mortgage if their age is less than J^M (corresponds to age 65 in reality). However, the maximum loan-to-value (LTV) ratio at origination differ between these two, denoted as λ_1 and λ_2 respectively. Specifically, at the time of origination, the borrower is subject to the following maximum

[18]Several papers model China's housing as rational bubbles, such as Zhao (2015) and Chen and Wen (2017).

[19]Since our model abstracts from the government budget, a household's labor income in our model should be interpreted as labor income after tax payment and government transfer.

LTV ratio constraint:

$$m' \leq \lambda_m(h')p_h h'$$

where

$$\lambda_m(h')p_h h' = \begin{cases} \lambda_1 p_h h' & \text{if } h' \leq \hat{h} \text{ and } j \leq J^M \\ \lambda_1 p_h \hat{h} + \lambda_2 p_h (h' - \hat{h}) & \text{if } h' > \hat{h} \text{ and } j \leq J^M \\ 0 & \text{if } j > J^M \end{cases}$$

All mortgage are constant amortization, subject to a fixed origination cost, κ_m, and amortized with a fixed payment each period π_m during the remaining lifetime.

$$\pi_m = \frac{r_m(1+r_m)^{J+1-j}}{(1+r_m)^{J+1-j} - 1} m$$

where j denotes the borrower's age, r_m denotes the mortgage interest rate. The outstanding principle evolves according to

$$m' = (1+r_m)m - \pi_m$$

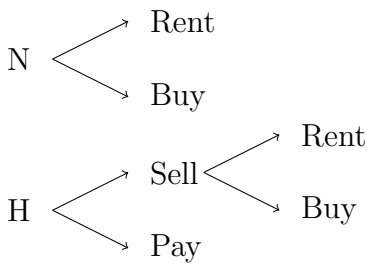
Consistent with China's institutional feature, mortgage, once originated, can not be refinanced. Finally, we assume that all mortgages are non-defaultable for simplicity.

Apart from housing, households can save in a one-period risk-free financial asset b, at an exogenous price q_b. We define the associated interest rate as $r_b = 1/q_b - 1$. Households could not borrow by short selling the financial asset. In other words, homeowners have no access to home equity line of credit in our model, which is consistent with China's institutional feature .

V.1.2. *Household's decision.* For each period, a household starts the period either with or without housing. A household without housing chooses between renting or buying a house. A household starting the period as an owner can choose to sell its house or keep its current house and make the mortgage payments. If it sells the house, it can then choose to either buy a new house or rent a house. Diagram I summarizes the beginning-of-period housing status and the housing tenure choices during the period.

Diagram I: Beginning-of-period Housing Status and Housing tenure choices

Beginning-of-period State		Intermediate/Choice			
w house	w/o house	sell	pay	rent	buy
H	N	s	p	r	b



We now describe a household's problem in recursive forms. Each period, a household's idiosyncratic state vector $\chi = (b, m, h, m_0, y)$, where m_0, denotes the size of mortgage at origination. Denote $\mu(\chi)$ as the measure of households across individual states and the aggregate states vector as $\Omega = (\phi, \mu)$. We solve the problem of a household in two steps. First, the household chooses the intermediate housing status as described above. Conditional on its housing status, it then chooses the size of housing to either rent or purchase, together with the choice of consumption and saving in financial assets.

At the beginning of each period, a household without a house solves the following problem by choosing between renting or buying a house.

$$V_j^N(b, y; \Omega) = \max\{V_j^r(b, y; \Omega), V_j^b(b, y; \Omega)\}$$

where V_j^N, V_j^r, and V_j^b denotes the value functions for a household without a house, value function of the renter and value function of the homebuyer, respectively. Note, by modeling renting versus owning a discrete choice, we rule out the possibility that a household purchases a house (of a smaller size than desired) and at the same time, rent another house for housing consumption. This makes the lumpiness of purchasing owned house matter for housing tenure choices.

The decision on whether to rent or buy a house depends on the costs and benefits of owning a house. The costs are down payments. The advantages of owning a house are as follows: (1) owning a house generates extra utility from housing services. (2) owning a house allows the household to enjoy potential capital gain with expected returns much higher than saving in the risk-free assets.

On the other hand, a household with a house faces the option of keeping or selling the house.[20] Accordingly, it solves the following problem:

$$V_j^H(b, m, h, m_0, y; \Omega) = \max\{V_j^p(b, m, h, m_0, y; \Omega), V_j^s(b, m, h, m_0, y; \Omega)\}$$

[20]For simplicity, we assume that once a household decides to sell it house, it sells all its housing stock.

where V_j^H, V_j^H, and V_j^s, denote the value functions for a household with a house, value function of keeping the house and value function of selling the house, respectively. If a household chooses to sell it house, it needs to pay all the outstanding mortgage debt associated with the sold house. Accordingly, the financial wealth after selling the house is

$$b_n = b + (1 - \delta_h - \kappa_h)p_h h - (1 + r_m)m \tag{1}$$

After the household sells it house, it can then choose whether to rent or buy a new house by solving the following problem:

$$V_j^s(b, m, h, m_0, y; \Omega) = \max\{V_j^{sr}(b_n, y; \Omega), V_j^{sb}(b_n, y; \Omega)\}$$

subject to (1). V_j^{sr} is the value function for a household who sells its house and chooses to rent and V_j^{sb} is the function for a household who sells its house and choose to buy a new house.

Now we switch to the choice of housing size. Since a household dies after age J, we first describe the problem of a household with age $j < J$. For a renter, it solves the following problem.

$$V_j^r(b, y; \Omega) = \max_{\{c, b', \tilde{h}'\}} u(c, \omega\tilde{h}'; \phi) + \beta E_{y', \phi'}[V_{j+1}^n(b', y'; \Omega')|y, \phi]$$

subject to

$$\begin{aligned} s.t. \quad & c + \rho_h \tilde{h}' + q_b b' \leq b + y \\ & b' \geq 0 \\ & hs = \omega\tilde{h}', \tilde{h}' \in \tilde{\mathcal{H}} \\ & \mu' = \Gamma_\mu(\mu; \phi', \phi) \end{aligned}$$

A homebuyer solves the following utility maximization problem

$$V_j^b(b, y; \Omega) = \max_{\{c, b', m', h'\}} u(c, h'; \phi) + \beta E_{y', \phi'}[V_{j+1}^h(b', m', h', y'; \Omega')|y, \phi]$$

subject to

$$\begin{aligned} s.t. \quad & c + p_h h' + q_b b' + \kappa_m \cdot 1_{\{m'>0\}} \leq b + y + m' \\ & b' \geq 0,\ m' \geq 0 \\ & hs = h', h' \in \mathcal{H}^1 \\ & m' \leq \lambda_m(h') p_h h' \\ & \mu' = \Gamma_\mu(\mu; \phi', \phi) \end{aligned}$$

A homeowner who chooses to keep its house and pay mortgage solves the following problem:

$$V_j^p(b, m, h, y; \Omega) = \max_{\{c, b', m'\}} u(c, h'; \phi) + \beta(1-\eta) E_{y', \phi'}[V_{j+1}^h(b', m', h', y'; \Omega') | y, \phi]$$

subject to

$$\begin{aligned} s.t. \quad & c + \delta_h p_h h + \pi_m + q_b b' \leq b + y \\ & b' \geq 0 \\ & hs = \min\{h', \hat{h}\}, h' = h \\ & \pi_m = \frac{r_m (1+r_m)^{J+1-j}}{(1+r_m)^{J+1-j} - 1} m \\ & m' = (1+r_m) m - \pi_m \\ & \mu' = \Gamma_\mu(\mu; \phi', \phi) \end{aligned}$$

Similar to a renter's problem, a household who sells its house and chooses to rent solves

$$V_j^{sr}(b_n, y; \Omega) = \max_{\{c, b', \tilde{h}'\}} u(c, \omega \tilde{h}'; \phi) + \beta E_{y', \phi'}[V_{j+1}^n(b', y'; \Omega') | y, \phi]$$

subject to

$$\begin{aligned} s.t. \quad & c + \rho_h \tilde{h}' + q_b b' \leq b_n + y \\ & b' \geq 0 \\ & hs = \omega \tilde{h}', \tilde{h}' \in \tilde{\mathcal{H}} \\ & \mu' = \Gamma_\mu(\mu; \phi', \phi) \end{aligned}$$

Finally, similar to a home buyer's problem, a household who sells its house and choose to buy a new house solves

$$V_j^{sb}(b_n, y; \Omega) = \max_{\{c,b',m',h'\}} u(c, h'; \phi) + \beta E_{y',\phi'}[V_{j+1}^h(b', m', h', y'; \Omega')|y, \phi]$$

subject to

$$\begin{aligned} s.t. \quad & c + p_h h' + q_b b' + \kappa_m \cdot 1_{\{m'>0\}} \leq b_n + y + m' \\ & b' \geq 0, \ m' \geq 0 \\ & hs = h', h' \in \mathcal{H} \\ & m' \leq \lambda_m(h') p_h h' \\ & \mu' = \Gamma_\mu(\mu; \phi', \phi) \end{aligned}$$

In the last period of life, $j = J$, since there is no bequest motive, a household simply sells its existing house if it starts the period with a house and chooses to rent. Also, a household would choose to not save in financial assets or housing at the end of period and instead consume all its wealth and die.

V.2. **Rental sector.** Each period, a representative rental company purchases housing in the housing market and rents them to renters. The rental company can frictionlessly buy and sell housing units subject to an operating cost ψ for each unit of housing rented out. The problem of the representative rental company is

$$J(\tilde{H}; \Omega) = \max_{\tilde{H}'} [\rho_h(\Omega) - \psi]\tilde{H}' - p_h(\Omega)[\tilde{H}' - (1 - \delta_h)\tilde{H}] + \frac{1}{1 + r_b} E_{\Omega'|\Omega} J(\tilde{H}'; \Omega')$$

The zero profit condition gives the equilibrium rental rate as

$$\rho_h(\Omega) = \psi + p_h(\Omega) - \frac{1 - \delta_h}{1 + r_b} E_{\Omega'}[p_h(\Omega')|\Omega].$$

In other words, the rent is simply the user cost of housing plus the operating cost.

Note that in our model, households with more than one house do not have the option of renting their second house. This may capture various frictions on the supply side of China's rental market, such as the information asymmetry between the landlord and the tenants due to the absence of credit scores on potential tenants. Also, there lack laws to punish default on rental payments. Third, there is no property tax or vacancy taxes. All these frictions would discourage homeowners from renting their secondary houses, if available, and instead leave it vacant.

V.3. **Production sector.** There are two production sectors in the economy: a non-housing consumption good sector and a construction sector, which produces new houses. Labor is perfectly mobile across sectors.

The competitive firms in the non-housing production sector use a constant returns to scale technology in labor

$$Y = \Theta N_c$$

where Θ is aggregate labor productivity and N_c are aggregate units of efficiency labor. The first-order condition for labor pin down the wage rate as $w = \Theta$.

In the construction sector, the government issues new permits equivalent to $\bar{L}$ units of land each period, and these permits are sold in a competitive markets to real estate developers. As a result, all rents from land ownership accrue to the government. After acquiring the land permit, competitive real estate developer combines labor and land to produce new houses according to a Cobb-Douglas technology

$$\max_{N_h} \; p_h I_h - w N_h$$

$$s.t. \; I_h = (\Theta N_h)^{\alpha} (\bar{L})^{1-\alpha}$$

The Cobb-Douglas technology implies that the the developer makes no profit in equilibrium. The first-order condition, together with the equilibrium condition $w = \Theta$, give rise to the investment function

$$I_h = (\alpha p_h)^{\frac{\alpha}{1-\alpha}} \bar{L}$$

V.4. **Equilibrium.** Denote $\chi^H = (b, m, h, m_0, y)$ and $\chi^N = (b, y)$ as the idiosyncratic state vectors for homeowners and non-homeowners, respectively. Also, let μ_j^H and μ_j^N be the measure of these two types of households at age j. A recursive competitive equilibrium consists of household value functions $\{V_j^N\left(\chi^N;\Omega\right), V_j^H\left(\chi^H;\Omega\right), V_j^r\left(\chi^N;\Omega\right), V_j^b\left(\chi^H;\Omega\right), V_j^p\left(\chi^H;\Omega\right), V_j^s\left(\chi^H;\Omega\right)\}$, household decision rules, aggregate functions for construction labor $N_h(\Omega)$, rental units stock $\tilde{H}'(\tilde{H};\Omega)$, homebuyers' housing stock $H'(H;\Omega)$, housing investment $I_h(\Omega)$, rental price $\rho_h(\Omega)$, house price $p_h(\Omega)$, and a law of motion for the aggregate states:

(1) Households optimize with value functions and associated decision rules;
(2) Construction sector firms maximize profits with associated labor demand and housing investment functions $\{N_h, I_h\}$;
(3) The labor market clears at the wage rate $w = \Theta$;
(4) The rental market clears at price ρ_h;

(5) The housing market clears at price p_h;

$$\tilde{H}' + H' = (1 - \delta_h)(\tilde{H} + H) + I_h$$

(6) The aggregate law of motion is induced by the exogenous stochastic processes and all the decision rules, and it is consistent with individual behavior.

V.5. **Calibration.** We calibrate the model to match the key aggregate and cross-sectional moments before the relaxation of LTV policy in 2014Q4. When necessary to choose a specific year, we use 2013, which corresponds to the year before the LTV policy relaxation. The initial steady state of the model, therefore, maps into the Chinese economy before the LTV policy relaxation in 2014Q4. The resulting parameter values are summarized in Table 5 and the targeted moments are in Table 6.

There are two categories of model parameters to calibrate. One category contains parameters assigned without the need to solve for the model equilibrium. The other contains parameters chosen for the model moments to target specific moments from the data.

Demography Each period corresponds to a two-year horizon. Households enter the economy at age 20, retire at age 55 (corresponding to $J^{ret} = 19$), and live until age 76 (corresponding to $J = 29$), which is the average life expectancy in China. In addition, the share of high-ability households is calibrated to match the share of households with college and above degree in CHFS data. Accordingly, high (low) labor-ability households in our model correspond to households with college and above (high school and below) degree in the data. In the results below, we therefore call households with high permanent labor ability in our model as households with high education to compare with the data counterparts.

Preference We set $1/\gamma$, the elasticity of substitution between non-housing consumption and housing services, to be 1.25, following Piazzesi, Schneider and Tuzel (2007). The risk aversion parameter, σ, is set to 2, which is standard in the literature. The utility discount factor β is calibrated to target the average ratio of wealth to labor income of 9.2 in 2012, which is estimated by Xie and Jin (2015) using CFPS data. The utility discount parameter for renting, ω, is set to be 0.70 to target the average home ownership rate of China in 2013, which was 87%. The housing preference parameter at low state, ϕ_L, is chosen so that the average share of housing in total consumption expenditure is 0.2 in the stochastic steady state, consistent with the weight used in the official CPI basket in China. We choose ϕ_H to target the home ownership rate of second houses in 2013, 18.6%. The transition

probability Π_{lh} is set to target the average ratio of outstanding mortgage debt to income among homeowners in 2013, which is 3.38.

Endowment The age profile of labor efficiency units are taken from He, Ning and Zhu (2017), who use the data in China Health and Nutrition Survey (CHNS) to estimate them. The log of idiosyncratic labor income shocks are specified as AR(1) process with the value of ρ_ϵ and σ_ϵ taken from İmrohoroğlu and Zhao (2018). We normalized the permanent lifetime labor ability η_L to be 1 and set $\eta_H = 1.6$ to match the the college premium in 2011, an estimate by Cooper and Zhu (2018) using CHNS data. The social security replacement rate is set to be 0.45, which is the average national replacement rate during 2010-2013.

Housing To discipline the set of owned house size $\mathcal{H}$, we follow the strategy of Kaplan, Mitman and Violante (2017) to choose three parameters: the minimum size of owner-occupied units, the number of house sized in that set, and the gap between house sizes. We target three moments of the distribution of the ratio of housing wealth to net wealth, defined as the sum of housing and net financial wealth, among home owners: the 10th percentile, median and the 90th percentile. This is because the distribution of housing equity at the initial steady state is crucial for the impacts of LTV relaxation at both aggregate and household levels. We then choose the number of housing size for the rental housing and the gaps between rental housing sizes (we restrict the minimum size of rental housing to be the same for owned houses) to target two moments: a ratio of the average earnings of home owners to renters of 2.87 and a ratio of the average size of owner-occupied house to rental house of 2.07 (2013 CHFS). Finally, we choose the threshold value of second house, $\hat{h}$, to target the share of mortgage amount for second houses in total mortgage amount in 2013, which is 5% according to our mortgage data.

The housing depreciation rate, δ_h is set to 2%, the estimated depreciation rate on China's urban owner-occupied housing by OECD. The transaction cost for selling a house, κ_h equals 3% of the value of house. The rental company operating cost is chosen to match the home ownership rate of households under 30. The construction technology parameter α is set to be 0.8, so that price elasticity of new housing supply equals 4, about the average value by Wang, Chan and Xu (2012) for the 35 major cities in China. The value of new land permit $\bar{L}$ is set to target the housing price to income ratio in 2012. According to E-house China, for the 35 major cities in China, the average house price to income ratio is 7.3 in 2012.

Financial Instruments The risk-fee interest rate r_b is set to be 3% per annum, which is the average benchmark deposit rate during 2010-2013. The mortgage interest rate r_m is

set to be 4.94%, which is the average mortgage interest rate for households (CHFS 2013),[21] The origination cost for mortgage κ_m is set to target the share of second house origination numbers in total mortgage.

LTV Policy We calibrate the minimum down payment ratio for the first and second houses, $1-\lambda_1$ and $1-\lambda_2$, respectively to target the LTV policies before 2014Q4. Accordingly, $\lambda_1 = 0.7$ and $\lambda_2 = 0.3$.

V.6. **Household Distributions in Stochastic Steady State.** Before examining the dynamics of the economy following a relaxation of LTV policy, we first present a set of model predictions at the stochastic steady state that were not explicitly targeted in the calibration. We first examine the model predictions along the life cycles, followed by its cross-sectional implications regarding wealth and housing.

Lifecycle Implications Figure 5 plots the lifecycle profiles for home ownership and wealth, both in the model and in the historical data as given by CHFS. The top two panels display the overall home ownership and that for secondary house. As the left panel shows, in both model and data, the lifecycle profile of home ownership rates rises rapidly from around 50% to a level above 80% at age 35. The home ownership rate rises at young ages in the model because it takes time for households to accumulate enough savings to overcome the down payment constraint. In the data, the home ownership rate after age 35 levels off at around 85%. By contrast, in the model home ownership rates continue to increase until age 65, at which it starts to drop abruptly. The abrupt drop in home ownership rates at the later stage of life is because in our model, households do not have bequest motives. As a result, as households get old, they discount future consumption heavily and start to decumulate housing wealth for current consumption. The top right panel plots the home ownership rate for secondary houses. In both model and data, this profile exhibits a hump-shape. In the data, home ownership rate for secondary house peaks around age 45, while in the model, the peak occurs at age 55. After age 55, home ownership rate in the model drops rapidly, which again reflects households' preference for current consumption as they become aged.

The middle two panels shows net wealth, by age, divided by average net wealth across all households for the two income groups. In the data, the lifecycle profile of net wealth for

[21]In China, households with housing provident funds can enjoy a lower mortgage interest rate than the market rate. Since our model abstracts from housing provident funds, mortgage interest rates correspond to the average mortgage interest rate for households with and without housing provident funds, which is what CHFS data contains.

both income groups are hump-shaped, peaking around age 55. Consistent with the data, in our model total wealth for both income groups exhibit a hump shape and peak at age 55. The bottom two panels, which display the lifecycle profile of housing wealth for both income groups, show a similar pattern. In our model, the rapid drop of housing wealth after 55 again is because households discount future consumption more heavily when they become aged.

Cross-sectional Implications Table 7 reports additional cross-sectional moments of interest for both model and data. The top panel reports the distribution of housing wealth to income ratio for homeowners. Our model can match the data fairly well for the bottom quintile. It, however, under-predicts the housing wealth to income ratio for the median and the top quintiles. The middle panel reports the Gini coefficients for net wealth and net housing wealth. We see that the wealth distribution in our model closely reproduces its counterparts in the data, especially for net housing wealth. The Gini coefficients for housing net wealth in the model is 0.464, compared with 0.562 in the data. The bottom panel reports the share of net wealth across households. Our model can replicate reasonably well the share of net wealth for both bottom and top quintiles. In our model, households in the bottom quintile hold 4% of net wealth, while in the data it is 0.8%. For the top quintile, households in the data hold 61.8% of net wealth, while in the model they hold 47.6% of net wealth.

To summarize, our model does a reasonably well job in replicating both the lifecycle profiles of home ownership rates and wealth and the distribution of housing net wealth and total net wealth. Since the initial age-profile of home ownership and the distribution of housing net wealth among homeowners are crucial for transmission of housing policies into housing prices, housing demand and consumption, our model provides a reasonable benchmark for exploring the quantitative impacts of housing policy.

VI. Impacts of Housing Policy

This section provides a quantitative assessment of the aggregate and distributional impacts of various housing policy. We started with the policy experiment of a surprising relaxation of LTV policy for second houses, which mimics the relaxation of LTV policy for non-primary houses during the period of 2014Q4 and 2016Q3. We then explore the impacts of alternative counterfactual policies on housing prices, mortgage and consumption.

VI.1. **Benchmark Results.**

Our benchmark policy experiment is to reduce the minimum down payment ratio for the second house. Specifically, the economy is at the steady state at

period 0. At the beginning of period 1, the maximum LTV ratio for second houses increased from 0.3 to 0.7 unexpectedly. Since one period in our model corresponds to two years, the relaxation in LTV policy lasts only for one period, consistent with the period of LTV policy relaxation 2014Q4-2016Q3. During this period, however, all households expect that the new LTV policy, i.e. $\lambda_2 = 0.7$, will last forever. In period 2, the LTV policy, λ_2, experiences a surprise reversal back to the initial steady state value of 0.3. Despite the transitory nature of the policy changes, since all cohorts alive at period 1 experience such policy changes, the transitional dynamics last at least J periods. We keep the minimum down payment ratio for the first house and other parameters, such as mortgage interest rates, unchanged throughout the experiment.

Panel A of Table 8 reports the aggregate effects of this policy change. Aggregate housing price increases by 6.96%, or 3.42% per annum. In other words, changes in LTV policy for second house alone can explain about 60% of the observed increase in housing price growth between 2011Q1-2014Q3 and 2014Q4-2016Q2 (from 2.32% to 7.3%). The aggregate newly issued mortgage loan amount is 33.94% higher than that in the initial steady state, explaining about fifty percent of the increase in new mortgage amount during this period (in the data it is 70%). About half of the increase in mortgage amount is accounted for by the increase in the mortgage origination numbers, which is 17.11% higher than its counterpart in the steady state. On the other hand, aggregate consumption drops by 1.02%, consistent with the data. Panel B further shows that the relaxation of LTV policy on the second house triggers an increase in the demand for mortgage of primary houses, as can be seen by an increase in mortgage amount (number) of the first house by 13.11% (11.37%)

Table 9 reports the simulated results on changes in mortgage shares and consumption across households of different age and education levels. Consistent with our data, the left two columns of Panel A show that the share of mortgage amount (number) for middle-aged households increases by 8.61% (8.56%), while the mortgage share for young households declines. In terms of consumption, young households' consumption declines, and the consumption of the middle-aged households almost stays the same, which is at odd with the data.

Panel B reports the change in mortgage shares and consumption by age-education groups. The left two columns show that among all age-education groups, the middle-aged high-educated households experience the largest increase in the share of mortgage amounts, by 14.22%. Such an increase in the share of mortgage amount by middle-aged high-educated

households can be explained by the increase in mortgage numbers by the same group (10.85%), as seen in the middle two columns. By contrast, the shares of both mortgage loan amount and origination numbers by young high-educated households drop, by 5.49% and 3.71%, respectively. In terms of consumption, the right two columns show that the middle-aged high-educated households experienced a decline in consumption by 1.55%, which is consistent with the data. On the other hand, our model implies that consumption of both education groups of young households decline, and especially for the low-educated ones. This is mainly because in our model, as housing price increase, housing rental rate also increases. This increase in rental rate imposes a negative income effect on low-educated young households, which are mainly renters.

Our results on the negative responses of consumption of homeowners (middle-aged high-educated households) to higher housing prices is in sharp contrast to the literature, which emphasizes the wealth effects of housing prices. Despite the positive wealth effects of higher housing prices on middle-aged high educated households, most of whom are homeowners before the policy relaxation, these households choose to switch to a large house via mortgage finance in expectation of high capital gain in future. The fall in their consumption on impact reflects an intertemporal substitution of consumption into the future. However, such a fall in consumption will persist since those switch to large houses via higher leverage (against their income) are more heavily mortgage debt burdened in future. Note that consumption of old households with high education in model and data increases in response to the relaxation of the LTV policy. This is because old households discount future consumption heavily. As a result, the positive wealth effects of higher housing prices drive up the non-housing consumption of the old households who were homeowners at the initial steady state.

VI.2. **Counterfactual experiments.** (to be written)

VII. Conclusion

This paper investigates the aggregate and distributional impacts of housing policy, using China's recent relaxation of LTV policy as a policy experiment. With two unique micro-level data sets, we find that a relaxation of LTV policy on non-primary houses stimulated new mortgage loan for middle-aged high-educated households at the sacrifice of young households. Such a policy, moreover, slowed down consumption growth of middle-aged, high-educated households.

We build a dynamic OLG equilibrium model with household heterogeneity to account for the empirical findings. Our theory uncovers a novel channel for changes in credit conditions to affects housing prices and mortgage demand via a self-enforcing mechanism: a reduction in the down payment ratio for non-owned-occupied housing triggers an initial housing price increase by encouraging housing investment. This, in turn, generates capital gains for homeowners before the policy change and encourage them to switch to a large house in expectation of future capital gain. Accordingly, it squeezed out the mortgage origination for young households, especially those would-be-homebuyer, and reduces non-housing consumption. This is because, despite capital gain from higher housing price, middle-aged high educated households chose to reduce consumption persistently, due to both an intertemporal substitution into future consumption and heavier mortgage-debt burden relative to their income.

Our findings bear important normal implications of housing policies in China. We show that, as an unintended consequence of the change in LTV policies, higher housing prices makes housing less affordable to young households who were not homeowners before the policy changes. This policy change, moreover, crowds out consumption for those already or would-be homeowners. Furthermore, with frictional rental markets and the absence of property or vacancy taxes, such a policy exacerbates the resource misallocation between rich households who hold second houses vacant and poor households who would rent a house.

TABLE 1. Mortgage Share in 2013

(A) Mortgage Amount Share in 2013: All Houses

	High School and Below	College and Above
Age < 30	11.77	25.60
$30 \leq$ Age < 50	27.04	29.91
Age ≥ 50	3.63	2.05

(B) Mortgage Amount Share in 2013: 1st House

	High School and Below	College and Above
Age < 30	12.30	26.55
$30 \leq$ Age < 50	27.26	28.29
Age ≥ 50	3.64	1.95

(C) Mortgage Number Share in 2013: All Houses

	High School and Below	College and Above
Age < 30	13.41	22.73
$30 \leq$ Age < 50	33.98	24.15
Age ≥ 50	4.09	1.64

(D) Mortgage Number Share in 2013: 1st House

	High School and Below	College and Above
Age < 30	14.00	23.59
$30 \leq$ Age < 50	34.19	22.59
Age ≥ 50	4.09	1.54

Note: The table reports the mortgage origination share in 2013. The data source is the proprietary loan-level data for mortgage origination from one of the largest banks in China.

TABLE 2. Mortgage Share Change between 2013 and 2015

(A) Mortgage Amount Share Change between 2013 and 2015: All Houses

	High School and Below	College and Above
Age $<$ 30	-4.13	-2.58
30 $\leq$ Age $<$ 50	-6.66	13.45
Age $\geq$ 50	-0.90	0.82

(B) Mortgage Amount Share Change between 2013 and 2015: 1st House

	High School and Below	College and Above
Age $<$ 30	-3.79	-1.17
30 $\leq$ Age $<$ 50	-6.47	11.86
Age $\geq$ 50	-0.98	0.56

(C) Mortgage Number Share Change between 2013 and 2015: All Houses

	High School and Below	College and Above
Age $<$ 30	-2.66	-0.09
30 $\leq$ Age $<$ 50	-5.60	8.12
Age $\geq$ 50	-0.37	0.60

(D) Mortgage Number Share Change between 2013 and 2015: 1st House

	High School and Below	College and Above
Age $<$ 30	-2.46	0.52
30 $\leq$ Age $<$ 50	-5.36	7.30
Age $\geq$ 50	-0.42	0.42

Note: The table reports the mortgage share change between 2013 and 2015. The data source is the proprietary loan-level data for mortgage origination from one of the largest banks in China.

TABLE 3. Household Consumption Growth Rate

(A) Average Household Consumption and Income Growth Rate (Percent)

	2013-2015	2015-2017	Difference
Consumption	8.09	6.32	-1.77*
Income	13.45	21.69	8.24***

(B) Household Consumption and Income Growth Rate by Age (Percent)

	Consumption			Income		
	2013-2015	2015-2017	Difference	2013-2015	2015-2017	Difference
Age $<$ 30	10.02	12.43	2.41	21.49	27.03	5.54
30 $\leq$ Age $<$ 50	9.52	5.36	-4.16***	18.30	23.10	4.80**
Age $\geq$ 50	6.37	6.60	0.23	7.41	20.26	12.85***

(C) Household Consumption and Income Growth Rate Difference by Age and Education

	Consumption		Income	
	Low Edu	High Edu	Low Edu	High Edu
Age $<$ 30	5.66	0.16	12.31	0.97
30 $\leq$ Age $<$ 50	-2.81	-7.19***	2.38	10.30***
Age $\geq$ 50	-0.18	2.70	12.45***	15.52***

Note: The table reports the growth rates of consumption and income. The data source is China Household Finance Survey. The numbers reported in this table are two-year growth rates. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 4. The Effects of Mortgage Debt on Consumption Growth

Consumption Growth Rate	(1)	(2)
Mortgage debt dummy	-5.31***	
Mortgage debt to income ratio		-0.55**
Income growth rate	0.13***	0.18***
Controls	Y	Y
City-Time Fixed Effects	Y	Y
N	28457	2739
R^2	0.07	0.17

Notes: The table reports the regression results of mortgage debt on consumption growth rate. Controls for both regressions include age, age squared, education dummies, and family size growth rate. The data source is China Household Finance Survey. Significance: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

TABLE 5. Parameter Values

Parameter	Interpretation	Value
Demographics		
J^{ret}	Retirement age (years)	36
J	Length of life (years)	57
ν	High labor-ability household share	0.5
Preferences		
$1/\gamma$	Elasticity of substitution	1.25
σ	Risk aversion	2.00
β	Discount factor	0.96
ϕ_L	Housing preference L	0.12
ϕ_H	Housing preference H	0.20
Π_{lh}	Prob: ϕ_L to ϕ_H	0.35
ω	Utility discount from renting	0.70
Endowments		
ε_j	Life-cycle profile	He, Ning and Zhu (2017)
ρ_ϵ	Income correlation	İmrohoroğlu and Zhao (2018)
σ_ϵ	Std of income shocks	İmrohoroğlu and Zhao (2018)
η_H	High labor ability	Cooper and Zhu (2018)
ξ	Replacement rate	0.5
Housing		
$\mathcal{H}$	Owner housing grid	$\{0.5, 1.75, 3.5, 5\}$
$\tilde{\mathcal{H}}$	Renter housing grid	$\{0.5, 1.75\}$
$\hat{h}$	2nd house cutoff	3.50
κ_h	Housing sale transaction cost	0.03
δ_h	Housing depreciation rate	0.02
ψ	Rent company operation cost	0.01
$\alpha/(1-\alpha)$	Housing supply elasticity	4.0
$\bar{L}$	Land endowment	0.19
Financial Instruments		
r_b	Interest rate	0.03
r_m	Mortgage rate	0.049
κ_m	mortgage origination cost	0.015

Note: The table reports parameter values. The model period is two-years. All values for which the time period is relevant are reported here annualized.

TABLE 6. Targeted Moments in the Calibration

Moments	Data	Model
Homeownership rate	0.86	0.84
Homeownership rate under 30	0.67	0.64
housing wealth to net wealth ratio: p10	0.56	0.69
housing wealth to net wealth ratio: p50	0.88	1.00
housing wealth to net wealth ratio: p90	0.98	1.00
Owned over rented house size ratio	2.07	1.82
Onwer over renter income ratio	2.87	2.14
2nd house mortgage amount share	0.05	0.13
2nd house mortgage number share	0.05	0.04
2nd house homeownership rate	0.19	0.03
Aggregage wealth to income ratio	9.20	5.38
Outstanding mortgage to income ratio	3.38	2.59
Purchased house value to income ratio	7.30	6.17

Note: The table reports targeted moments. The empirical moments for 2nd house mortgage amount share, 2nd house mortgage number share, and purchased house value to income ratio are calculated from the bank's loan-level mortgage origination data, and other moments are calculated from China Household Finance Survey.

TABLE 7. Cross-sectional Moments

Moments	Data	Model
Housing wealth to income for owners: p10	2.27	2.12
Housing wealth to income for owners: p50	9.75	5.34
Housing wealth to income for owners: p90	42.05	10.44
Net wealth Gini coefficient	0.594	0.427
Net housing wealth Gini coefficient	0.562	0.464
Net wealth share: bottom quintile	0.008	0.040
Net wealth share: middle quintile	0.108	0.143
Net wealth share: top quintile	0.618	0.476

Note: The table reports cross-sectional moments. The empirical moments are calculated from China Household Finance Survey.

TABLE 8. Aggregate Impacts of Relaxation of LTV Policy

(A) Aggregate Impacts on House Price and Mortgage

	Percentage Changes
House price	6.96%
Mortgage amount	33.94%
Mortgage number	17.11%
Consumption	-1.02%

(B) Mortgage Growth Rate For Primary and Second houses

	Mortgage Amount	Mortgage Number
1st House	13.11%	11.37%
2nd House	114.66%	95.85%

Note: The table reports simulated results for the aggregate impacts of relaxation of LTV policy.

TABLE 9. Distributional Impacts on Mortgage and Consumption

(A) Changes in Mortgage Shares and Consumption by Age

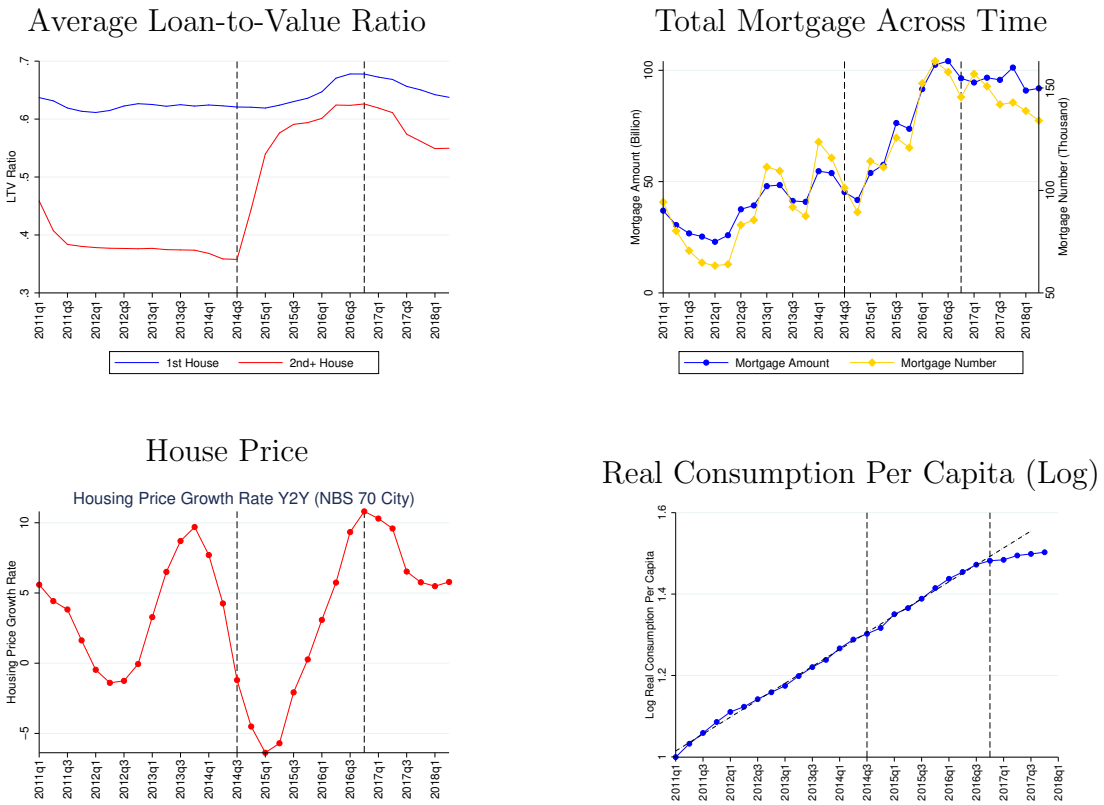
	Share Change		Growth Rate
	Mortgage Amount	Mortgage Number	Consumption
Young	-5.02%	-4.40%	-9.56%
Middle-aged	8.61%	8.56%	0.48%
Old	-3.59%	-4.15%	0.99%

(B) Changes in Mortgage Share and Consumption by Age and Education

	Share Change				Growth Rate	
	Mortgage Amount		Mortgage Number		Consumption	
	L Edu	H Edu	L Edu	H Edu	L Edu	H Edu
Young	0.47%	-5.49%	-0.69%	-3.71%	-15.83%	-3.28%
Middle-aged	-5.60%	14.22%	-2.30%	10.85%	2.52%	-1.55%
Old	-0.93%	-2.66%	-1.02%	-3.13%	-0.70%	2.69%

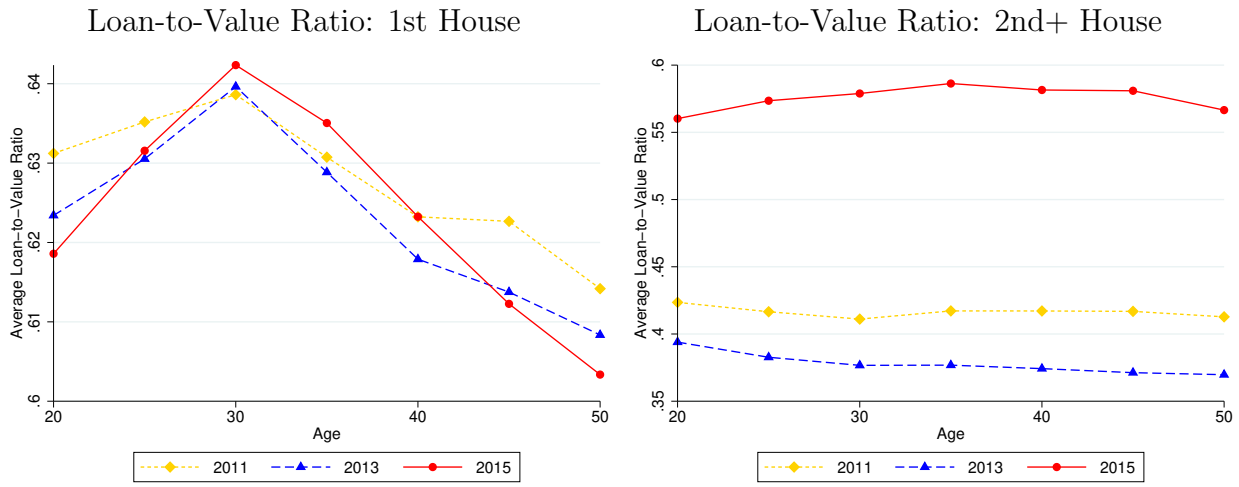
Note: The table reports numerical simulation results for the distributional impacts of relaxation of LTV policy.

FIGURE 1. Time series of Aggregate Variables



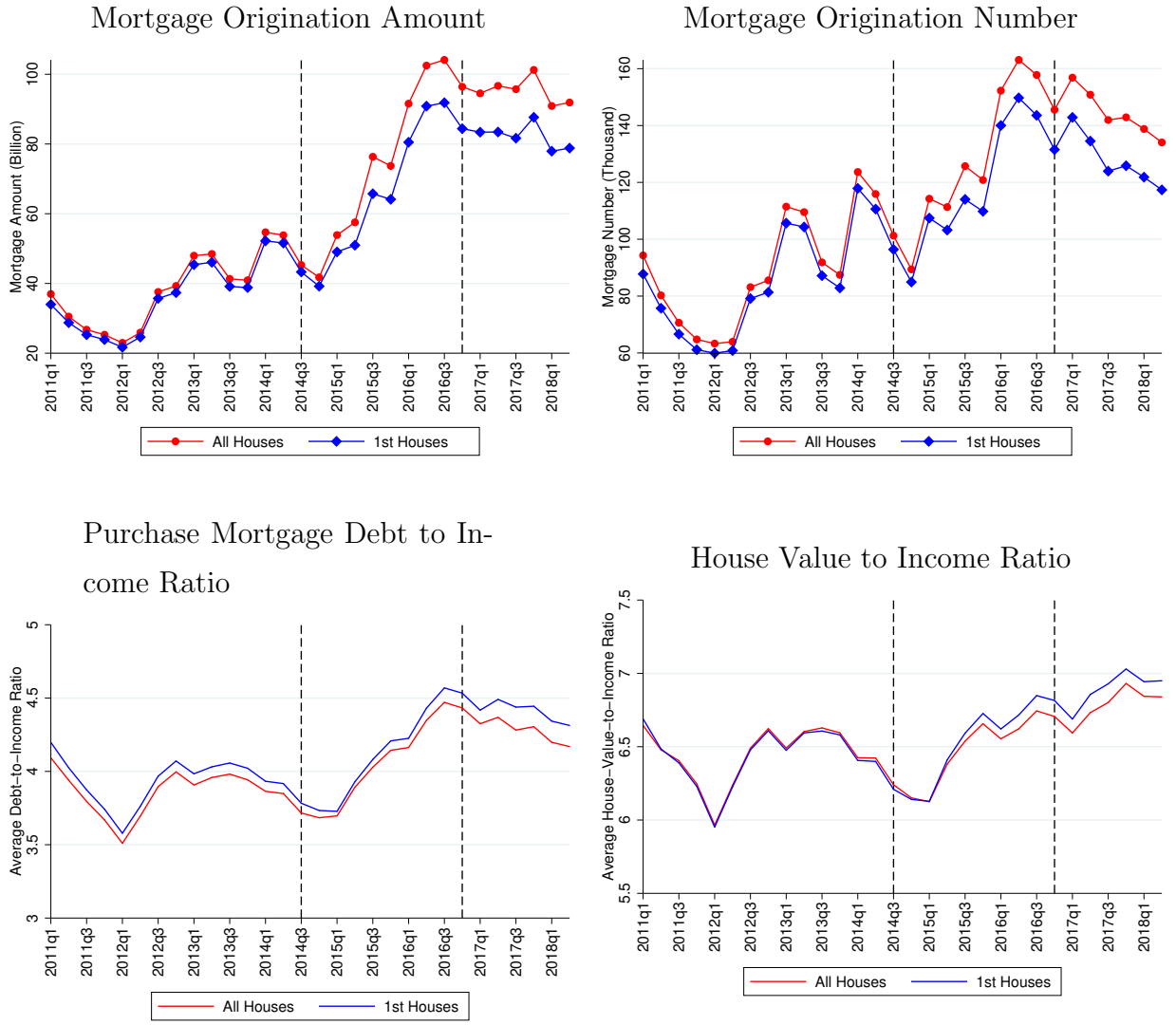
Note: The top left panel plots the LTV ratios for primary and non-primary houses across time. The top right panel plots the mortgage origination amount and number. The bottom left panel plots the house price year-to-year growth rate. The bottom right panel plots the logarithm of real consumption per capita (the value in 2011Q1 normalized to be one). The LTV ratio and mortgage origination are calculated from the bank's mortgage origination loan-level data. The house price is from the National Bureau of Statistics of China. The consumption data is from China's macroeconomy time series data from Center for Quantitative Economic Research in the Federal Reserve Bank of Atlanta.

FIGURE 2. Loan to Value Ratio at origination



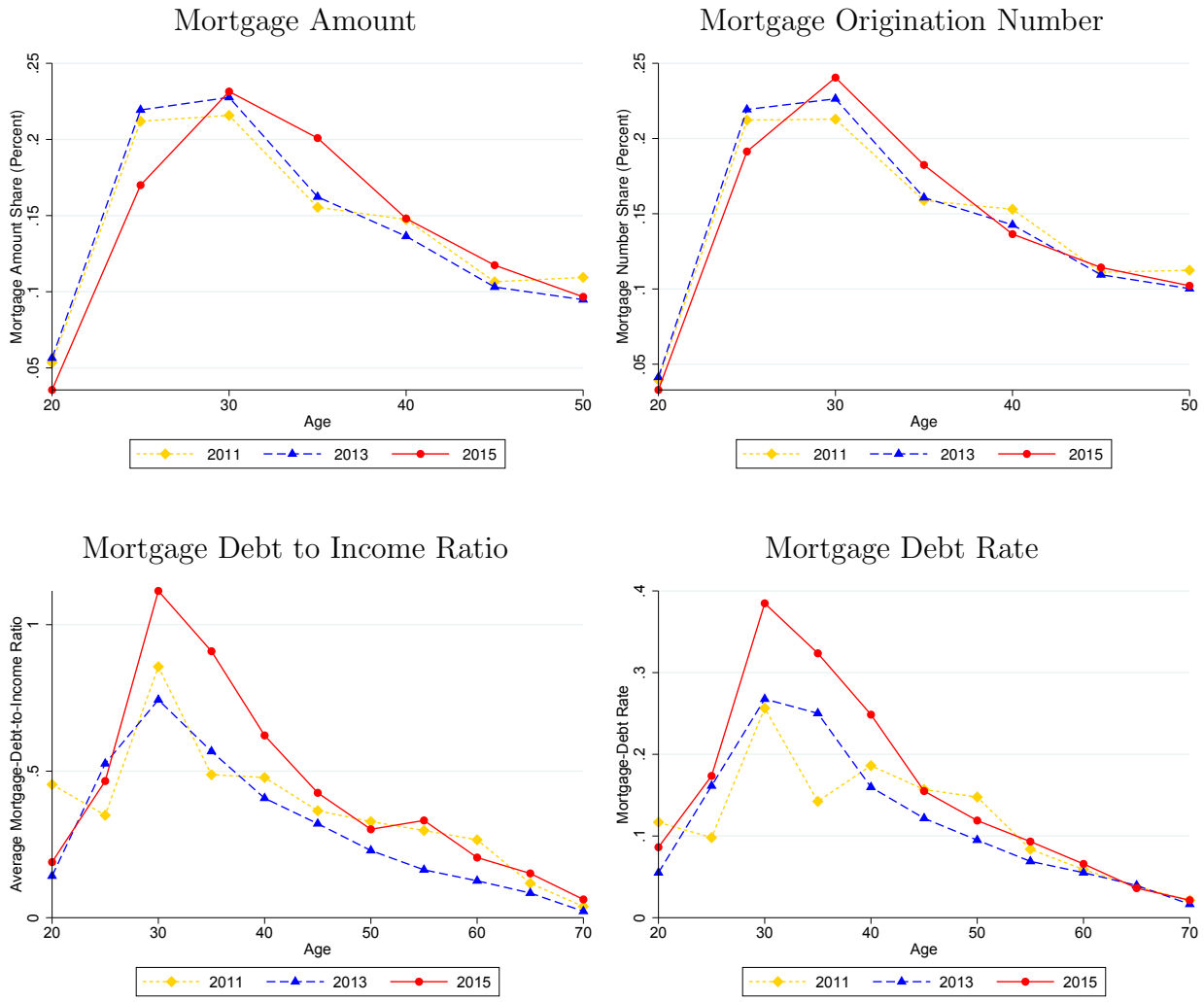
Note: The left panel plots the average LTV ratios for the primary houses in 2011, 2013 and 2015 across ages. The right panel plots the average LTV ratios for the non-primary houses in 2011, 2013 and 2015 across ages. The average LTV ratio is computed for each of a five-year age bin (e.g. 23-27, 28-32). The data is from the bank's mortgage origination loan-level data.

FIGURE 3. Mortgage, Mortgage Debt, and House Value



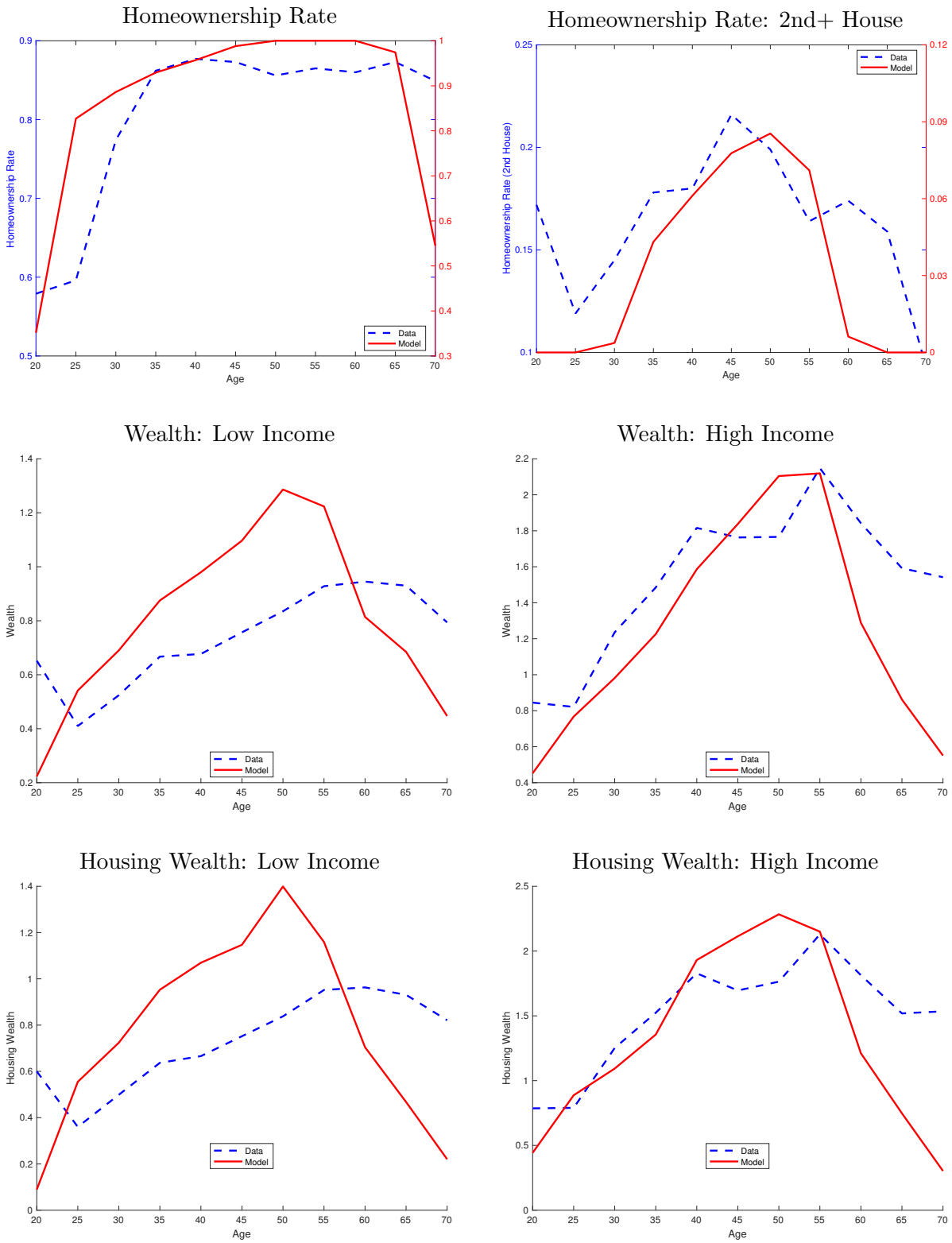
Note: The top left panel plots the mortgage origination amount for all and the first houses across time. The top right panel plots the mortgage origination number for all and the first houses across time. The bottom left panel plots the average mortgage debt at origination to income ratio for all and the first houses across time. The bottom right panel plots the average house value to income ratio for all and the first houses across time. The data is from the bank's mortgage origination loan-level data.

FIGURE 4. Mortgage Shares across Age Groups



Note: The top left panel plots the mortgage origination amount share in 2011, 2013 and 2015 across ages. The top right panel plots the mortgage origination number share in 2011, 2013 and 2015 across ages. The data is calculated from the bank's mortgage origination loan-level data. The bottom left panel plots the average outstanding mortgage debt to income ratio in 2011, 2013 and 2015 across ages. The bottom right panel plots the average rate of household with positive mortgage debt in 2011, 2013 and 2015 across ages. The data is calculated from China Household Finance Survey.

FIGURE 5. Lifecycle Profiles of Homeownership Rate and Wealth



Note: The top panels plot the homeownership rate for all and the second houses across. The middle panels plot the net wealth (normalized by the average net wealth) for low and high income groups. The bottom panels plot the housing wealth (normalized by the average housing wealth) for low and high income groups. Empirical age profiles are calculated from China Household Finance Survey.

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