Demystifying the Chinese Housing Boom*

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Abstract

We construct housing price indices for 120 major cities in China in 2003-2013 based on sequential sales of new homes within the same housing developments. By using these indices and detailed information on mortgage borrowers across these cities, we find enormous housing price appreciation during the decade, which was accompanied by equally impressive growth in household income, except in a few first-tier cities. Housing market participation by households from the low-income fraction of the urban population remained steady. Nevertheless, bottom-income mortgage borrowers endured severe financial burdens by using price-to-income ratios over eight to buy homes, which reflected their expectations of persistently high income growth into the future. Such future income expectations could contract substantially in the event of a sudden stop in the Chinese economy and present an important source of risk to the housing market.

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There have been growing concerns across the global economic and policy communities regarding the decade-long housing market boom in China, which has the second largest economy in the world and has been the major engine for global economic growth during the past decade. News in recent months seems to suggest that the housing boom might be slowing down. A main concern is that a housing market meltdown might severely damage the Chinese economy, which in turn might generate contagious effects across the world and slow down the fragile global economy that has just emerged from a series of crises that originated in the U.S. and Europe. In particular, critics are concerned that soaring housing prices and the enormous construction boom throughout the country might cause China to follow in the footsteps of Japan, which had an economic lost decade after its housing bubble burst in the early 1990s.

How much have housing prices in China appreciated during the last decade? How did the price appreciation vary across different Chinese cities? Did the soaring prices exclude low-income households from participating in the housing markets? How much financial burden did households face in buying homes? Addressing these questions is crucial for systematically assessing the risk to the Chinese economy presented by its housing market. We address these questions by taking advantage of a comprehensive data set of mortgage loans issued by a major Chinese commercial bank from 2003-2013. Specifically, we construct a set of housing price indices for 120 major cities in China, which allows us to evaluate housing price fluctuations across these cities, in conjunction with the growth of households' purchasing power and stock price fluctuations. The detailed mortgage data also allow us to analyze the participation of low-income households in housing markets and the financial burdens faced by low-income home buyers.

Due to the nascent nature of the Chinese housing market, there are relatively few repeat home sales available for building Case-Shiller type repeated sales housing indices. Instead, we take advantage of the large number of new housing developments in each city and build a housing price index for the city based on sales over time of new homes within the same developments, which share similar characteristics and amenities. Consistent with casual observations made by many commentators, our price indices confirm enormous housing price

appreciation across China in 2003-2013. In first-tier cities, which include the four most populated and most economically important metropolitan areas in China-- Beijing, Shanghai, Guangzhou, and Shenzhen-- housing prices had an average annual real growth rate of 13.1 percent during this decade. Our sample also covers 31 second-tier cities, which are autonomous municipalities, provincial capitals, or vital industrial/commercial centers, and 85 other third-tier cities, which are important cities in their respective regions. Housing prices in second-tier cities had an average annual real growth rate of 10.5 percent; third-tier cities had an average annual real growth rate of 7.9 percent. These growth rates easily surpass the housing price appreciation during the U.S. housing bubble in the 2000s and are comparable to that during the Japanese housing bubble in the 1980s.

Despite the enormous price appreciation, the Chinese housing boom is different in nature from the housing bubbles in the U.S. and Japan. Our analysis offers several important observations that are useful for understanding the Chinese housing boom. First, as banks in China imposed down payments of over 30 percent on all mortgage loans, banks are protected from mortgage borrowers' default risk even in the event of a sizable housing market meltdown of 30 percent. This makes a U.S. style subprime credit crisis less likely in China.

Second, while the rapid housing price appreciation has been often highlighted as a concern for the Chinese housing market, the price appreciation was accompanied by equally spectacular growth in households' disposable income---an average annual real growth rate of about 9.0 percent throughout the country during the decade, with the exception of a lower average growth rate of 6.6 percent in the first-tier cities. This joint presence of enormous housing price appreciation and income growth contrasts the experiences during the U.S. and Japanese housing bubble. Even during the Japanese housing bubble in late 1980s, the Japanese economy was growing at a more modest rate than that of China. The enormous income growth rate across Chinese cities thus provides some assurance to the housing boom.

Third, despite the enormous housing price appreciation over the decade, the participation of low-income households in the housing market remained stable. Specifically, we analyze the financial status of mortgage borrowers with incomes in the bottom 10 percent of all mortgage

borrowers in each city for each year. By mapping the incomes of these marginal home buyers into the income distribution of the urban population in the city, we find that they came from the low-income fraction of the population, roughly around the 25th percentile of the distribution in the first-tier cities and around the 30th percentile in the second-tier cities.

Fourth, while these low-income home buyers were not excluded from the housing market, they did endure enormous financial burdens in buying homes at price-to-income ratios of around eight in second- and third-tier cities and, in some years, even over ten in first-tier cities. In concrete terms, this means that a household paid eight times its annual disposable income to buy a home. In order to obtain a mortgage loan, it had to make a down payment of at least 30 percent, and more typically 40 percent, of the home price, which was equivalent to 2.4 times to 3.2 times the household's annual income. Suppose that the household made a down payment of 40 percent and took a mortgage loan for the other 60 percent of the home price, which would be 4.8 times its annual income. A modest mortgage rate of 6 percent, which is low relative to the actual rate observed during the decade, would require the household to use nearly 30 percent of its annual income to pay for the interest on the mortgage loan. Furthermore, paying the mortgage would consume another 16 percent of its annual income used a linear amortization even if the mortgage had a maximum maturity of 30 years. Together, buying the home entailed saving 3.2 times the annual household income to make the down payment and another 45 percent of its annual income to service the mortgage loan.

To explain the willingness of households to endure such severe financial burdens for a home, it is important to take into account the households' expectations. To the extent that urban household income in China has been rising steadily during the studied period, as well as in the previous two decades, many households may expect their income to continue growing at this rate. At a 10 percent nominal income growth rate, a household's income in five years would grow to 1.6 times of its initial income and the ratio of current housing price to its future income in five years would drop to five. Thus, a high expected income growth rate renders the aforementioned financial burdens temporary.

Such high income growth expectations might have resulted from extrapolative behavior as emphasized by Barberis, Shleifer, and Vishny (1998) and Shiller (2000), or from contagious social dynamics between households as modeled by Burnside, Eichenbaum, and Rebelo (2013). Recently, Pritchett and Summers (2014) examine historical data on growth rates and demonstrate that regression to the mean is the single most robust and empirically relevant fact about cross-country growth rates. Thus, they argue that while China might continue to grow for another two decades at a 9, or even a 7 or 6 percent rate, such continued rapid growth rate would be an extraordinary event, given the powerful force of regression to the mean, which had averaged 2 percent in the cross-country data with a standard deviation of 2 percent. If so, the high expectation of future income growth, which might have been a key driver of the observed enormous price-to-income ratios, may not be sustainable and thus presents an important source of risk to the housing market. When China's growth rate eventually regresses to the mean, and especially when China experiences a sudden stop, households' expectations may crash. In such a case, the large price-to-income ratios have substantial room to contract, which in turn could act as an amplifier of the initial shock that triggers the economic slowdown.

Frictions in the Chinese financial system might also have contributed to the high housing prices across Chinese cities, as reflected by the large price-to-income ratios endured by households. It is well-known that the spectacular economic growth in China since the 1980s has been accompanied by a high savings rate, e.g., Yang, Zhang, and Zhou (2013). Due to stringent capital controls, savers cannot invest their savings in international capital markets and, instead, have only a few domestic investment vehicles. Bank deposit accounts have remained the predominant investment vehicle, with assets totaling near 100 trillion RMB in 2013, despite the fact that the real one-year deposit rate averaged only 0.01 percent in 2003-2013. While the Chinese stock market experienced dramatic growth during this decade, it was still relatively small, with a capitalization of slightly less than 20 trillion RMB in 2013. The size of bond markets was even smaller. Facing this largely constrained investment set, it has been common for households to treat housing as an alternative investment vehicle, which also helps explain their willingness to pay dearly for housing.

From an investment perspective, it is interesting to note a tale of two markets at the time of the world economic crisis in 2008-2009. During this period, the Chinese economy faced tremendous pressure. Nevertheless, the housing market in China remained strong. Housing prices in first-tier cities suffered a modest drop of about 10 percent, and recovered more than the loss shortly after the crisis. Housing prices in second- and third-tier cities continued to rise throughout the period after 2008. This experience was in sharp contrast to the dramatic decline of over 60 percent in the Chinese stock market in 2008--which has not been recovered even to date. To understand this puzzling contrast, we argue that the frequent policy interventions by the central government and the heavy reliance of local governments on land sales revenue for their fiscal budget might have emboldened many households to believe that the housing market is too important to fall and that the central government would institute policies to support the housing market if necessary.

There are divergent views about the Chinese housing boom. Chow and Niu (2014) use a simultaneous equations framework to analyze the demand and supply of residential housing in urban China in 1987-2012 and find that the rapid housing price growth can be well explained by the force of demand and supply, with income determining demand and construction costs affecting supply. Deng, Gyourko, and Wu (2014b) are far more concerned by the risk in the Chinese housing market. In particular, they present evidence of a rapid increase in housing supply and housing inventory held by developers in various major cities in recent years. Different from these studies, we provide an informed account of the demand side by thoroughly analyzing characteristics of mortgage borrowers. Our analysis leads us to take a more balanced stand between these two contrasting views regarding risk in the Chinese housing market. On the comforting side, the rapid income growth, which accompanied the enormous housing price appreciation, helped support the steady participation by low-income households in the housing market. On the concerning side, high expectations about future income growth might have motivated low-income households to buy homes by undertaking substantial financial burdens, causing them to be particularly vulnerable to future sudden stops in the Chinese economy.

This paper is organized as follows. Section 1 briefly describes the institutional background of the housing markets in China. We introduce the housing price indices in Section 2 and then discuss the housing price boom across three tiers of Chinese cities in Section 3. Section 4 summarizes characteristics of mortgage borrowers, and Section 5 provides some conceptual discussions. We summarize the role of government in the Chinese housing markets in Section 6 and discuss several sources of risk in the housing markets in Section 7.

1. Institutional Background

The development of housing markets in mainland China is a relatively new phenomenon. From the 1949 founding of the People's Republic of China to 1978, all land was publicly owned and the Chinese constitution prohibited any organization or individual from buying, selling, leasing, or transferring land. Housing was allocated through a working unit-employee linkage as a form of in-kind compensation, with the size and location of homes depending on the length of employment and the size of the household, among other factors. In 1978, per capita residential area in urban areas was 3.6 square meters, which was even lower than that in 1949.

To reform (and to a large extent privatize) the state-owned enterprises in the mid-1980s, it was considered necessary to introduce an alternative housing system that would delink home allocation from employment. An important milestone occurred in 1988 when the Chinese constitution was amended to allow for land transactions, which set the legal stage for the privatization of housing in China.[1]

Comprehensive housing reform was initiated in 1994 when employees in the state sector were allowed to purchase full or partial property rights to their current apartment units at subsidized prices. Nascent markets for homes, known as "commodity houses," emerged in some large cities in early 1990s; but they grew rapidly only after 1998 when the central government completely abolished the traditional model of housing allocation as an in-kind

[1] Under current law, land used to build residential properties is leased for a term of 70 years; after the expiration of the lease period, the right to use the land and the property will no longer belong to the current owner. It is commonly presumed that the law will eventually be amended so that property owners will be allowed to renew the leases.

benefit and privatized housing properties of all urban residents.

Also in 1998, partly as a response to the adverse effects of the 1997 Asian Financial Crisis, the Chinese government established the real estate sector as a new engine of economic growth. As an important impetus to the development of private housing markets, China's central bank, the People's Bank of China (PBC), outlined the procedures for home buyers to obtain residential mortgages at subsidized interest rates in 1998.[2] Moreover, between 1998 and 2002, the PBC lowered the mortgage interest rate five times to encourage home purchases. By 2005, China had become the largest residential mortgage market in Asia. According to a PBC report published in 2013, financial institutions made a total of 8.1 trillion RMB in mortgage loans in 2012, accounting for 16 percent of all bank loans in that year. At the same time, the PBC also developed policies to encourage housing development, including broadening the scope of development loans and allowing pre-sales by developers.

[Figure 1 about Here]

These policies were effective in stimulating both the demand and supply of residential housing. During this period, home sales maintained about 15 percent of annual growth on average, and areas of residential housing under construction grew even faster, reaching about 18 percent of annual growth. Figure 1 provides a rough estimate of the supply of newly completed residential housing from 2002-2013 by city tier, measured by completed areas in each city and each year divided by the city's urban population in 2012.

It is common in China to separate cities into three tiers: The first tier includes the four cities with the largest population and economic importance in China-- Beijing, Shanghai, Guangzhou, and Shenzhen. Our data cover all of these first tier cities. The second tier includes 35 cities listed in Appendix A. This list is comprised of Tianjing and Chongqing (the two autonomous municipalities other than Beijing and Shanghai) and the capital cities of the 24 provinces[3] and 9 other cities, which are typically vital industrial or commercial centers. Our data cover 31 of these 35 second-tier cities. There is not a commonly used list for third-tier cities. Instead, we list

[2] See Appendix A for detailed information about mortgage loans in China.
[3] Lasha, the capital of Tibet, is typically excluded from the list due to its special economic status.

85 other cities in our sample as the third tier. Appendix B lists the cities in each of the three tiers.

The construction boom of residential housing in first-tier cities started in the late 1990s, followed by that of second- and third-tier cities in the early 2000s. In Figure 1, new construction of residential housing showed a similar growth rate across the three tiers of cities in 2002-2005. From 2005, the new construction in first-tier cities had slowed down substantially due to the shortage of land supply in these cities, while the supply in second- and third-tier cities continued to grow at similar rate as before. The growth rate in third-tier cities was especially strong. Some estimates suggest that investment to residential housing accounted for 25 percent of total fixed asset investment and contributed to roughly one-sixth of China's GDP growth (Barth et al., 2012).

[Figure 2 about Here]

The development of the housing market was also accompanied by an urbanization process throughout China with rural migrants moving into cities, especially into first- and second-tier cities. As shown by Figure 2, the total population of the four first-tier cities, the vast majority of which lived inside the city proper, grew from 48 million in 2004 to almost 70 million in 2012. The total population of the second-tier cities, which is distributed roughly half inside the city proper and half outside, grew from 220 million in 2004 to about 260 million in 2012. The total population of third-tier cities remained stable in this period at around 370 million, among which only 100 million lived inside the city proper.

2. Constructing a Chinese Housing Price Index

To systematically examine the housing market boom, it is important to construct an accurate housing price index for major cities in China. The difficulty in constructing a housing price index arises because a good price index requires that we compare the prices of the same (or at least comparable) houses over time. To the extent that the set of homes involved in the transactions in different periods of time is likely to be different, a price index constructed by

simply comparing the mean or median sale prices per square meter likely measures not only the changes in the prices of similar homes, but also the changes in the composition of transacted homes. This problem is likely to be more severe in emerging housing markets than in mature ones because in emerging housing markets, homes in more central locations are likely to be built and transacted earlier than homes in city outer-rings.

A. Standard Methodologies

There are two standard methodologies that are widely used to construct housing price indices. These methods, which we review briefly below, are aimed at finding a suitable way to compare the prices of similar homes.

One prominent approach for constructing housing price is to use hedonic price regressions, which goes back to Kain and Quigley (1970). In this approach, the sales price is regressed on a set of variables that characterize the housing unit --number of rooms, square feet of interior space, lot size, quality of construction, condition, and so forth. The regression coefficients can be interpreted as prices for implicit attributes. This hedonic approach can then be used to construct a price index in two ways (Case and Shiller, 1987). The first way to construct a price index is to run separate regressions on data from each time period. The estimated equations are then used to predict the value of a standard unit in each period, which is in turn used to construct the housing price index for the standard unit. A second way is to run a single regression on the pooled data from sales in all time periods. Inclusion of a time dummy for the period of the sale allows the constant term to shift over time, reflecting movement in prices, again controlling for characteristics.

Whether hedonic price regressions can accurately capture price movements crucially depends on how well the data capture the actual characteristics and quality of the unit. Unobserved and time varying characteristics that are valued by the market but not captured in the data can lead to biased estimates of the housing price index. This is a particular issue in China. Due to the rapid expansion of Chinese cities, new housing units have been constructed mostly on land near the urban fringes. According to the *China Urban Statistical Yearbook* (published by Ministry of Housing and Urban-Rural Development), the total size of developed

urban area at the national level increased from 19,844 square kilometers in 2003 (Form 3-9 on page 107) to 34,867 square kilometers in 2013 (Form 2-12 on page 90). Such a dramatic expansion of urban residential land parcels implies that unobserved time varying characteristics as transacted homes move from locations closer to city center to locations in city fringe is likely to lead to biased housing price indices.

Case and Shiller (1987) popularized another method using repeated sales. This approach originated with Baily, Muth, and Nourse (1963), who initially proposed a method involving a regression where the i-th observation of the dependent variable is the log of the price of the i-th house at its second sale date minus the log of its price on its first sale date. The independent variables consist of only dummy variables, one for each time period in the sample except for the first (the base period for the index).[4] The estimated coefficients are then taken as the log price index. This initial method builds on a strong assumption that the variance of the error term is constant across houses. As this variance is likely to depend on the time interval between sales, Case and Shiller (1987) proposed a weighted-repeated-sales method with a two-step procedure to relax this assumption.[5]

The repeat sales approach does not require the measurement of quality; it only requires that the quality of individual units in the sample remains constant over time. However, it is well recognized that this repeated sales method wastes a large fraction of transactions data because repeated sales may contribute to only a small fraction of all housing transactions. More important, the set of homes that are sold repeatedly may not be representative of the general population of homes (see Mark and Goldberg, 1984).

B. A Hybrid Approach for Chinese Housing Markets

We propose a hybrid approach of constructing housing price indices for a large number of

[4] Specifically, for each house, the dummy variables are zero except for the dummy corresponding to the second sale (where it is +1) and for the dummy corresponding to the first sale (where it is -1). If the first sale was in the first period, there is no dummy variable corresponding to the first sale.

[5] In the first stage, they implement the Baily, Muth, and Nourse (1963) procedure and calculate the vector of regression residuals, which is then used to construct the weights to be used in the stage two regression. In the second step, a generalized least squares regression (with weights constructed from the regression residuals in the first stage) is run.

Chinese cities. Our approach takes into account several features of the Chinese housing markets. As a result of the nascent nature of the Chinese housing markets, there are relatively few repeat sales. Many of the observed repeated sales are old-style housing units, which are not representative of the newly developed housing markets. This feature prevents us from directly using the Case-Shiller repeated sales method. On the other hand, there are a large number of new home sales in each city. These new homes are in the form of apartments, and typically, apartments in development projects.[6] As a developer sells apartments in a project over a period of time, and sometimes even completes the development over several phases, we observe sequential sales of apartments in the same development. Within the same development project, the unobserved apartment amenities are similar. This feature allows us to build a hybrid index based on sequential new home sales within housing developments after accounting for hedonic characteristics of individual homes.

We implement the housing price indices from January 2003 to March 2013 by running the following regression *for each city*:

$$\ln P_{i,j,c,t} = \beta_{c,0} + \sum_{s=1}^{T} \beta_{c,s} \cdot 1\{s = t\} + \theta_c \mathbf{X}_i + DP_j + \varepsilon_{it},$$

where $P_{i,j,c,t}$ is the price of a new home i sold in month t in city c, $\beta_{c,t}$ is the time dummy for month t, the vector of characteristics $\mathbf{X}_i$ includes area, area squared, floor dummies, and dummies for the number of rooms, and DP_j is a set of *development project* fixed effects. The base month ($t = 0$) is January 2003 and the last month is March 2013. The price index $PI_{c,t}$ for month t in city c is simply given by:[7]

[6] *Statistical Yearbook of China*, published by the Chinese National Bureau of Statistics, estimates that the percentage of apartment units in the newly-built housing markets was around 94-96% during the past decade at the national level.

[7] For several cities in our sample, the mortgage data start later than January 2003. For such cities, $\hat{\beta}_{c,t}$ only reflects the changes in price beyond the first month in record (which is not January 2003). However, as long as a city has some records in the first quarter of 2003, we still use the above method to construct the price index, assuming that the change in prices from January to March 2003 is likely to be small. If a city has no record in any month in the first quarter of 2003, we do not construct a price index.

$$PI_{c,t} = \begin{cases} 1 & \text{if } t = 0 \\ \exp(\beta_{c,t}) & \text{for } t = 1, 2, \ldots \end{cases}$$

[Figure 3 about Here]

Figure 3 graphically illustrates our method of constructing the price index. In every month, say month 1, there are many development projects with new apartments for sale in a given city. In Figure 3, three units in development project A are sold in month 1 and two units are sold in month 2. We take the sales in our data from development projects that have sales in both month 1 and month 2. In our proposed regression above, we control for the development project and other observable differences in the characteristics of the apartment units (such as area, floor number, etc.), thus the time dummy β_1 precisely captures the price difference among otherwise identical units sold between month 1 and month 2. Of course, the *key assumption*, which we believe to be empirically realistic, is that within a development project, differences in the units are fully described by the additional controls we include in the regression. Similarly, as illustrated in Figure 3, the price change from month 2 to month 3 is estimated by the price differences of similar units in development project B sold in month 2 versus those sold in month 3; the price change from month 3 to month 4 is estimated by the price differences of similar units in development projects B and C that are sold in month 3 versus month 4.[8]

The regression specification we use to construct price indices in a city via time dummies also makes two additional assumptions. First, we assume that the price changes between any two months are *uniform* across development projects that may be located in different parts of

[8] Our method of constructing housing price indices is related to the pseudo-repeated sales price index recently proposed by Guo, Zheng, Geltner, and Liu (2014). They also recognize that multiple apartments sold by a development project over a period of time can be used to construct matching pairs that are simply pairs of units within a matching space (say, building or a development project) sold at different points in time. They implement their price index using data of new residential transactions in Chengdu. The main difference between their method and ours lies in the regression specifications. In their specification, each unit may appear multiple times in the regression depending on the number of times it is included in matching pairs. This may create a complicated variance-covariance structure for regression noise. In contrast, in our specification, each unit appears exactly once. See also McMillen (2008) and Deng, McMillen, and Sing (2012) for related ideas that similar units, instead of repeated sales of the same unit, may be matched in order to apply the repeated sales approach.

the city.[9] To see this, note from Figure 3 when we estimate the price change from month 3 to month 4, we pool the units sold in development projects C and D in the two months in the regression; since we restrict the time dummy not to interact with the development projects, we implicitly assume that the price changes in development projects C and D from month 3 to month 4 are the same. Second, we also implicitly assume that the only source of price changes between any two months in a development project is the overall change in the housing market in the city. In particular, we assume that developers do not change their pricing strategies as new units go on the market.[10] One may also be concerned that over time, the amenities and infrastructure around the development projects may improve and thus part of the price differences for units in the same development project sold in different months may reflect such differences, not the housing market conditions. We believe that this is less likely an issue in China, as buyers of earlier units are almost certainly aware of upcoming improvements in the infrastructure (e.g. subway stations, shopping malls, etc.) close to the development projects, as such projects are public information and developers surely advertise them to earlier buyers.

3. The Chinese Housing Market Boom

We use the method outlined in the previous section and a detailed mortgage data set to construct housing price indices for 120 major cities in China. The list of these cities is given in Appendix B. Our mortgage data is compiled from mortgage contracts provided by a large commercial bank, which accounts for about 15 percent of the mortgage loan market in China. We restrict the sample to mortgages for new, residential properties and as a result have over one million mortgage loan contracts dating from the first quarter of 2003 to the first quarter of

[9] This assumption in principle can be relaxed. If each month we have a sufficiently large number of sales located in each district of a city, we can implement our regression at the district level and construct district-specific price indices. As a robustness check, we have divided Beijing into inner region that is close to the town center and suburban area and constructed separate indices for the two areas. The monthly changes of these two indices are highly correlated with a correlation of 0.93, although the index for the inner region grew slightly faster than that for the suburban area during our sample period.

[10] It is not clear how developers would change their pricing strategies during the course of sales of units in a project. Wu, Deng, and Liu (2014) provide some evidence from hedonic regressions that the unit prices tend to lower when the percentage of units in the projects already sold is higher. However, as they admitted, this does not necessarily imply that developers are using different pricing policies for units that go on the market in different months.

2013. A typical mortgage contract contains detailed information on the personal characteristics of home buyers (e.g., age, gender, marital status, income, work unit, education, occupation, and region and address of residence), housing price and size, apartment-level characteristics (e.g., complex location, floor level, and room number), as well as loan-level characteristics (e.g., maturity and down-payment).

[Figure 4 about Here]

Based on the transacted home prices and characteristics, we build housing price indices for 120 cities in China from 2003-2013. As our price indices are nominal, it is useful to keep in mind that inflation was modest during that decade. Figure 4 depicts the national inflation together with bank deposit rate. The national inflation fluctuated substantially from low levels around 2 percent in 2003-2007 to a peak level of 8 percent in early 2008, only to quickly drop to below -1.5 percent in the first half of 2009, rising to around 5 percent in 2011 and eventually returning to a level around 2 percent in 2013. Inflation had a modest average rate of 2.68 percent during our sample period. Figure 4 also shows that the bank deposit rate stayed in a narrow range between 2 and 4 percent during this period.

Our housing price indices allow us to precisely characterize the housing market boom in the last decade throughout China. We describe the housing market boom below by tiers of cities.

A. First-Tier Cities

[Figure 5 about Here]

Figure 5 depicts the monthly housing price indices for the four first-tier cities in four separate panels, together with measures of households' purchasing power. In Panel A, the housing price index of Beijing experienced an enormous rise from an index level of 1 in January 2003 to 7.6 in March 2013. That is, the housing price level has increased 660% in a short period of ten years!

During this period, Beijing's housing prices have actually experienced at least two episodes of downward movement. The first episode started in May 2008, when the price index was at

3.50 (relative to January 2003), and continued until March 2009, when the price index slid to 3.05. This represented a 13% price drop and coincided with the global financial crisis. The second episode is more recent. It began in May 2011 and ended in June 2012 when the housing price index fluctuated between the interval of 5.99 and 6.67.

As benchmarks for the housing price appreciation, Panel A also plots two measures of the households' purchasing power in Beijing: per capita Gross Regional Product (GRP) and disposable income (urban) during the same period. The per capita GRP measures the per capita value of output in the whole city and the per capita disposable income (urban) measures the per capita income received by urban residents of the city. Both of these measures have experienced similar growth from 1 in 2003 to a level around 3 in 2013. While this growth is remarkable by any standard, it is nevertheless substantially smaller than the housing price appreciation in the city.

Panel B plots the monthly housing price index for Shanghai. The index increased from 1 in January 2003 to about 4.43 in March 2013. The overall housing price appreciation in Shanghai was more modest than that in Beijing, even though Shanghai's housing price appreciation actually started faster than Beijing. Shanghai's housing prices doubled by April 2005 relative to that in January 2003, while Beijing's housing prices did not double until August 2006. However, Shanghai experienced three episodes of price adjustment in the last decade. The first adjustment started in May 2005 when the index was at 2.05, and ended in March 2007 when the index went down to as low as 1.79. This represented a 13% price correction. However, the housing prices picked up again from March 2007 to reach an index level of 2.72 in August 2008. The second episode was a swift and small adjustment with the index dropping from 2.72 in August 2008 to 2.41 in December 2008. The third episode started in June 2011 with the price index dropping from 4.27 to as low as 3.20 in March 2012. This represented a 25% price correction. However, housing prices picked up again from March 2012. By March 2013, the price index reached its peak at 4.43.

The growth of households' disposable income in Shanghai during this period was about the same as that in Beijing, with disposable income of urban residents roughly tripling from January

2003 to March 2013. Thus, the housing price appreciation in Shanghai, while quite substantial, is nonetheless much more closely aligned with the growth of disposable income. The other measure of purchasing power, GRP per capita, exhibits more modest growth in Shanghai, but it still more than doubled in this period.

Panels C and D respectively plot the housing price indices for Guangzhou and Shenzhen. The overall picture of these two cities in Guangdong Province (near Hong Kong) is similar. Guangzhou's price index increased from 1 in January 2003 to 5.1 in March 2013, while it rose from 1 to 3.65 in Shenzhen during the same period. Both cities experienced multiple episodes of price adjustment. The most severe price adjustment occurred in Shenzhen, starting in October 2007 when its price index was at 2.97 and reaching a trough in January 2009 when the index was at 1.82. This represented a 39% price correction. At almost the same time, from November 2007, Guangzhou's housing prices also started dropping from an index level of 3.08, and reached a trough of 2.38 in February 2009. This represented a 23% price correction. Both Guangzhou and Shenzhen are located in the Pearl River delta, the world's largest manufacturing export center. The housing price drops in these two cities were clearly related to the global economic crisis. The fact that our housing price indices for the two cities are able to capture these crisis-induced price-adjustment episodes lends credence to them.

Panels C and D also reveal that the per capita disposable income in Guangzhou nearly tripled during the same period, while in Shenzhen grew by only 68 percent. Shenzhen's per capita disposable income growth was much smaller than the growth of the per capita GRP, perhaps because Shenzhen had millions of migrant workers, whose outputs were included in the calculation of the GRP, but not the per capita disposable income for urban residents with *Hukou* (i.e., the official city residence registration).

[Table I about Here]

Table 1 reports, by tiers of city, the summary statistics of the housing return, per capita GRP and per capita Disposable Income (DI). We report these statistics for the whole period from January 2003 through March 2013, as well as for sub-periods from January 2003 through

December 2007 and from January 2009 through March 2013. We exclude 2008 between the two sub-periods to isolate the potential crisis effects. Panel A reports these statistics in nominal values, and Panel B reports them in real values, after adjusting for the national inflation rate.

To aggregate the price indices for the four first-tier cities, we construct a price index for the tier by setting the initial index level of each city to be one at the beginning of a given period and then taking an equal weighted average of the index levels of these cities for each subsequent month. The resulting index level represents the value of a housing portfolio constructed from investing one RMB into the housing index of each city in the first month and keeping the portfolio composition throughout the subsequent months. We also use the same method to construct indices for second- and third-tier cities.

Among first-tier cities, Panel A shows that the nominal housing price index had an average annual return of 21% from January 2003 to December 2007. Housing prices dropped in 2008. After January 2009, the housing price index continued to rise, and on average had another staggering average annual return of 17.7% from January 2009 to March 2013. Over the whole 10-year period from January 2003 to March 2013, the housing price index for the first-tier cities had an average return of 15.9%!

Panel A also reports the nominal growth of two measures of "purchasing power": per capita GRP and disposable income. Both measures have increased significantly in the decade, on average by 9.4% and 9.3% from January 2003 to March 2013. But the housing price appreciation in first-tier cities was nearly twice the magnitudes of the increases in the two measures of purchasing power.

In real values, Panel B shows that the housing return for first-tier cities averaged 13.1% per annum, and the two measures of purchasing power grew on average by 6.7% and 6.6% per year.

B. Second- and Third-Tier Cities

[Figure 6 about Here]

Due to the large number of cities in second and third tiers, we cannot separately plot the housing price index for each city. Instead, we depict the price index for each of the tiers, together with measures of purchasing power in Figure 6.

In panel A of Figure 6, the housing price appreciation in second-tier cities is substantial, though not as breathtaking as that in the first tier cities. Overall, the price index rose from the base of 1 in January 2003 to 3.92 in March 2013. The price fluctuations are also more modest compared to those experienced in the individual first-tier cities, though part of the moderation in price fluctuation is the result of averaging over 31 second-tier cities.

A housing price appreciation of 292% in ten years is remarkable by any standard. It is larger than the magnitude of housing price appreciation during the U.S. housing bubble in 2000s and is comparable to the price appreciation during the Japanese housing bubble in 1980s. However, what is more surprising in Panel A is that the housing price appreciation in second tier cities is very much in accordance to the growth in measures of purchasing power. To the extent we believe that income growth, or growth in GRP, represents fundamental demand of households for housing, the housing price appreciation in the second-tier cities, though enormous, nonetheless does not appear to have significantly deviated from the increases in households' purchasing power.

Table 1 reports summary statistics for the 31 second-tier cities in our sample. During the decade from 2003 to 2013, the second-tier cities on average witnessed an average annual housing return of 13.2% in nominal values and 10.5% in real values. In the same decade, per capita GRP had an average annual growth rate of 13.4% in nominal values, fully comparable to the housing return. The average annual growth rate of per capita disposable income for urban residents was 11.7% in nominal values, which was only slightly smaller than the housing return.

In nominal values, housing prices in the second-tier cities grew on average by 16.8% per year from January 2003 to December 2007, while the increase was 11.6% from January 2009 to March 2013. The increases in housing prices in these two sub-periods are again commensurate with the corresponding increases in purchasing power, measured by either per capita GRP or

disposable income.

[Figure 7 about Here]

There are substantial variations among the cities. Figure 7 depicts the logarithmic nominal housing price appreciation for each city in our sample from January 2003 to March 2013, i.e. $\ln(\frac{P_{2013}}{P_{2003}})$. Panel A collects all cities in first and second tiers and Panel B collects cities in the third tier. We choose logarithmic price appreciation so that we can further break down the price appreciation of each city into two parts, one in 2003-2007 and the other in 2008-2013. Among the first- and second-tier cities, Beijing had the largest price appreciation in 2003-2013, followed by Wenzhou (a coastal city of Zhejiang Province known for its vibrant manufacturing sector) and Nanjing (the capital city of Jiangsu Province). Yinchuan (the capital city of Ningxia Province in Northwestern China) had the lowest price appreciation that nevertheless amounted to over 120% during this period, which came mostly from the second half of the period.

We now examine the price appreciation in third-tier cities. Panel B of Figure 6 depicts the aggregate price index and measures of purchasing power for the 85 third tier cities in our sample. A remarkable feature of the plot is that despite the enormous housing price appreciation in third-tier cities during the decade, the housing price increase actually lagged the growth of disposable income. The housing price index slightly more than tripled, increasing from the base of 1 in January 2003 to 3.13 in March 2013. According to Table 1, the housing price index had an average return of 10.6% per year in nominal values or 7.9% in real values. Again there is substantial heterogeneity across third-tier cities, as shown in Panel B of Figure 7, with the price appreciation ranging from 0.1 to 1.8 in log scale (or 10% to 500% in percentage returns) in 2003-2013. While the price appreciation is positive across all cities in the full period, several of them, such as Lianyungang and Huangshan, had substantial price drops in 2003-2007 and recovered the drops in 2008-2013.

The tripling of the housing index of the third-tier cities is actually below the growth of the two measures of purchasing power in these cities in the same period. According to Table 1, per capita GRP grew on average by 15.0% per year in nominal values during this decade, while per

capita disposable income for urban residents grew on average by 11.7% per year. This pattern, namely, enormous housing price appreciation but nonetheless below the increases in measures of purchasing power, also holds in the two sub-periods.

Overall, housing prices across Chinese cities experienced tremendous growth between 2003 and 2013. The housing price appreciation was particularly dramatic in first-tier cities, rising over five fold in 2003-2013 and substantially outpacing the growth of household purchasing power. The price appreciation in second- and third-tier cities, while remarkable, was matched by equally impressive growth in household purchasing power during the same period.

C. Other Housing Indices for Chinese Cities

Micro-based, constant quality housing price indices for Chinese cities are not yet widely available. The National Bureau of Statistics (NBS) of China reports two widely used official housing price series. These two series are commonly known as the "NBS 70-city index" and the "NBS Average Price Index."[11]

NBS 70-City Index. The NBS started to construct quarterly housing price indices for 35 large- and medium-size cities in 1997. Then, it expanded the list to 70 cities and replaced quarterly indices to monthly ones beginning in July 2005. In the construction of the "NBS 70-City Index," technicians from local statistics authorities are sent in each month to sample housing complexes and collect raw information on housing transaction prices. For each housing complex sampled by the local statistics authorities, the average transaction price is calculated in each month and compared with that of the same complex in the previous month. The monthly house price change at city level is then calculated as the average, weighted by transaction volume, of all complexes' price changes in the corresponding months.[12]

[11] The full names of the two series are: "Price Indices for Real Estate in 35/70 Large and Medium Sized Cities" and "Average Selling Price of Newly Built Residential Buildings", respectively.

[12] The details of the statistical procedure used in the "NBS 70-city Index" can be found at http://finance.sina.com.cn/china/hgjj/20110216/14149383333.shtml (in Chinese). To the best of our understanding, the published procedure for constructing the "NBS 70-City Index" is conceptually similar to our method, though there are some differences in detail: we include all development projects for sale, while the NBS includes only those sampled housing complexes; we control for a list of unit level characteristics, while the NBS

NBS Average Price Index. NBS also publishes the total floor area and revenue of houses sold in 35 major cities, from which average prices can be calculated by simply dividing the total price paid by total floor area of the transacted units in a given month and given city.

As pointed out in Deng, Gyourko, and Wu (2014b), both official series have well-known issues and have been widely criticized: the NBS 70-City Index is remarkably smooth and shows very little real housing price growth in 70 Chinese cities in the last decade, while the NBS Average Price Index fails to control for quality, as it does not account for the fact that the newly transacted units in a given city are gradually moving to the outer-rings of the city, an important feature in rapidly expanding Chinese cities.

[Figure 8 about Here]

Figure 8 depicts our housing price index against the two official series for the four first-tier cities. Indeed, the NBS 70-City Index shows little variation in housing prices during the decade and is thus in sharp contrast to common experiences in these cities. Interestingly, the NBS Average Price Index exhibits highly synchronized co-movements with our index across all four cities. Such co-movements are re-assuring as they indicate that our index is capturing similar fluctuations as the straightforward calculation of average transaction prices. It is also useful to note that the NBS Average Price Index shows smaller price appreciation than our index across three of the four cities, which is consistent with the argument that the average price index does not account for the gradual shift in the location of the transacted housing units.

Wu, Deng, and Liu (2014) have made a notable attempt to construct micro-based, constant quality housing price indices for 35 Chinese cities by using data from the so-called “Real Estate Market Information System" (REMIS) maintained by municipal housing authorities. This data set contains major attributes of transacted newly built housing units after 2006. They estimated a hedonic model where, for each city, housing transaction prices (log) are regressed on observable characteristics of the unit and its apartment complex, and transaction time dummies, which they use to construct housing price indices. Whether Wu, Deng, and Liu’s

obtains the complex level monthly price by dividing total sales revenue in the complex over the total areas.

(2014) housing price indices represent the constant-quality price indices crucially depends on the extent to which the observed characteristics included in the hedonic price regressions are exhaustive. Nonetheless, the housing price indices of Wu, Deng, and Liu (2014) find that for the 35 major cities there was a dramatic housing price surge from 2006 to 2010, with an average appreciation rate substantially higher than the two official housing price indices.[13]

D. Experiences in Japan and Singapore

[Figure 9 about Here]

Does the experience of the Chinese housing market differ from that of other Asian countries during the years of their economic miracle? Figure 9 illustrates the experiences in Japan and Singapore.

We cannot find a suitable housing price index for Japan going back to the 1960s and 1970s, which was the period of Japan's rapid economic growth. Instead, Panel A of Figure 9 depicts an index of urban land price provided by the Japan Real Estate Institute, from 1955 to 2014, together with the per capita GDP of Japan. Both series are in nominal values and are normalized to 1 in 1955. From 1955 to 1990, the per capita GDP grew from a level of 1 to about 40, representing an average growth rate of 10.5% per year. In contrast, the urban land price index grew from 1 to over 80 during the same period, substantially outpacing the per capita GDP. The Japanese economy has staggered since 1990, with the per capita GDP staying flat for the past 25 years. During this period, the urban land price index continued to fall by half and eventually converged back to the same level of the per capita GDP in 2014. The dramatic divergence of the land price index from the per capita GDP before 1990 and the subsequent convergence vividly illustrates the widely recognized Japanese housing bubble. Based on our earlier discussion, the housing price appreciation across Chinese cities during 2003-2013 was

[13] Furthermore, Deng, Gyourko, and Wu (2014a) have constructed a constant-quality, residential land price index, which they refer to as the "Chinese Residential Land Price Index," based on similar hedonic regressions, using sales prices of leasehold estates to private developers for 35 major Chinese cities. Their land price index showed extremely high real land price growth across these cities, much more so and with much more cross-city variations than the "China Urban Land Price Dynamic Monitor" system provided by the Ministry of Land and Resources of China for the same cities.

rather different from the experience of the Japanese housing bubble. Except the few first-tier cities, the housing price appreciation in the large number of second- and third-tier cities was largely in line with the growth of household purchasing power.

Panel B of Figure 9 depicts the private property resale price index for Singapore, which is provided by the Urban Redevelopment Authority of Singapore, together with the per capita GDP of Singapore, from 1975 to 2010. Both series are in nominal values and are normalized to 1 in 1975. During this period, the per capita GDP grew from a level of 1 to slightly over 10, representing an average growth rate of 6.6% per year. Interestingly, the housing price index also grew from 1 to about 11, roughly in line with the GDP growth. While the housing price appreciation was well matched with the GDP growth for the full period from 1975 to 2010, the housing price index did diverge substantially from the GDP in two episodes, one in the early 1980s and the other in 1995-1997, right before the Asian financial crisis. Both episodes happened after a long period of steady economic growth, during which the housing price index rapidly appreciated in a few years, significantly outpacing GDP growth. When the GDP growth slowed, the housing price index collapsed and returned to the level in line with the GDP in a few years. These price corrections appear very relevant for thinking about potential risk in the Chinese housing market, especially in the first-tier cities.

4. Mortgage Borrowers

It is possible to explain the dramatic housing price appreciation in first-tier cities by the limited housing supplies in these over-crowded metropolitan areas. As discussed in Section 1, the total area of newly completed residential housing in first-tier cities has substantially slowed since 2005, while that of second- and third-tier cities has been steadily growing. However, supply is not the only factor that matters to housing markets. As the rising housing prices directly impact every household in the cities, it is important to fully understand the financial burdens faced by home buyers, especially low-income home buyers.

Our detailed mortgage data allow us to provide a comprehensive picture of mortgage borrowers in different cities, who take loans to buy homes. In this section, we summarize a set

of characteristics of these mortgage borrowers, including household income, down payment, price-to-income ratio, home size, age, and marital status. In particular, we focus on discussing the financial burdens faced by these mortgage borrowers.

Note that households in the most wealthy fraction of the population may purchase homes using cash and thus do not appear in our mortgage data. For this reason, our mortgage data is particularly useful for analyzing the characteristics of relatively low-income home buyers as opposed to that of high-income buyers. We focus on analyzing two sets of borrowers in each tier of cities: The first set has household income in the bottom 10% among all mortgage borrowers in a given city and a given year. We refer to this set as the bottom-income borrower group. We also denote borrowers with income exactly at the 10 percentile of all borrowers by p10. The second set has household income in the middle range, specifically within the 45^{th} and 55^{th} percentile of all mortgage borrowers in a given city and a given year. We refer to this set the middle-income group and denote borrowers with exactly the median income of all borrowers by p50.

A. Household Income

[Figure 10 about Here]

Figure 10 depicts the time-series of the household income of p10 and p50 for first-, second- and third-tier cities in Panels A, B, and C, respectively. In panels A and B, the left plot shows the annual income of p10 and p50 (which is averaged across all cities in the tier) in RMB from 2003-2012, and the right plot shows the position of p10 and p50 in the income distribution of the city population based on the income distribution constructed from the Urban Household Survey (UHS). As income distribution is not available for third-tier cities, Panel C shows only the annual income of p10 and p50.

Figure 10 shows steady growth in the household income of both p10 and p50 across the three tiers of cities. In first-tier cities, the annual household income of p10 grew from 39,000 RMB in 2003 to 92,000 in 2012 while the income of p50 grew from 87,000 in 2003 to 184,000 in 2012. In second-tier cities, the annual income of p10 grew from 19,000 RMB in 2003 to 58,000

in 2012, while that of p50 from 40,000 in 2003 to 99,000 in 2012. In third-tier cities, the income of p10 grew from 15,000 to 51,000, while that of p50 grew from 28,000 to 83,000. This tremendous income growth of mortgage borrowers is largely consistent with the income growth of the overall urban population we discussed above.

For most of the first- and second-tier cities, the UHS provides income distribution of urban households. To specifically compare the income growth of mortgage borrowers with that of the urban population, we mark the position of p10 and p50 in the population income distribution reported by the UHS. As our data from the UHS cover only 2003-2009, we extrapolate the income distribution in 2009 into the subsequent years based on the city's average income growth.

The median-income borrower p50 came from the relatively wealthy fraction of the population. In first-tier cities, p50 declined from the 85th percentile of the population in 2003 to the 59th percentile in 2009 and then climbed back to the 75th percentile. In second-tier cities, p50 declined from the 81.5th percentile in 2003 to the 62th percentile in 2010 and then climbed back to the 68th percentile in 2012.

The position of the low-income mortgage borrower p10 is particularly interesting. It indicates the extent to which low-income households in the population were participating in the housing markets. Overall, p10 was located at a position around the 25th percentile of the population in first-tier cities and around the 30th percentile in second-tier cities. These positions indicate that mortgage borrowers were not just coming from the top-income households and instead were reasonably well represented in the low-income fraction of the population.

Interestingly, despite the rapid housing price appreciation in first-tier cities, p10 steadily declined from a position around the 35th percentile in 2003 to the 17.5th percentile in 2010 before it climbed back to the 26th percentile in 2012. This suggests that the rapidly growing prices in recent years have not prevented households from the low-income fraction of the population from buying homes. In second-tier cities, p10 stayed in a range between the 28th

and 40th percentile---it declined from a peak of the 40th percentile in 2005 to the 28.5th percentile in 2010 and then climbed back to the 35th percentile in 2012.

Taken together, Figure 10 shows steady increases in the household income of bottom- and middle-income mortgage borrowers across the three tiers of cities. Furthermore, despite the tremendous housing price appreciation in these cities, mortgage borrowers were well represented in the population and the housing market participation of households from the low-income fraction of the population remained stable.

B. Down Payment

Mortgage down payment is a key variable that determines the leverage used by mortgage borrowers and serves as an equity buffer to prevent borrowers from defaulting on the loans in the event of a future housing price meltdown. Figure 11 depicts the fraction of down payment in the home value at the time of purchase, separately for the bottom- and middle-income groups.

[Figure 11 about Here]

The right panel shows that for mortgage borrowers in the middle-income group, down payment on average contributed to at least 35% of home value across the three tiers of cities. Interestingly, the left panel shows that for borrowers in the bottom-income group, the fraction of down payment was even higher---it was consistently above 38% across the three tiers of cities.

These high levels of down payment are consistent with the strict mortgage policies imposed by the Chinese government on banks. Specifically, the policies restrict one housing unit from being used as collateral for more than one mortgage loan. The policies also require a minimum down payment of 30% on first mortgages. As detailed in Appendix A, this minimum down payment requirement had changed over time between two levels: 30% or 40%. Banks have requested even higher down payments on second mortgages that are used to finance purchases of second homes.

The high levels of mortgage down payment used by Chinese borrowers were in sharp contrast to the popular use of zero down payment loans and negative amortization loans during the U.S. housing bubble of 2000s. According to Mayer, Pence, and Sherlund (2009), during the U.S. housing bubble period of 2003-2006, households with poor credit (the so-called subprime and Alt-A households) had commonly used mortgages with a 5% or zero down payments to finance their home purchases. Some mortgages even allowed the borrowers to have negative amortization over time. When the U.S. housing prices started to decline after 2006, these borrowers were more likely to default on their mortgage loans, exacerbating the housing market decline. The high levels of down payments used by households throughout China mitigated the risk of household default in the event of a future housing market meltdown. Unless the housing prices decline by over 30%, the mortgage borrowers are unlikely to default on their loans. [14] Furthermore, mortgage loans in China are all recourse loans, which allow lenders to collect borrowers' other assets in the event of mortgage defaults. These reasons make a U.S. style subprime credit crisis less of a concern for China.

C. Price-to-Income Ratio

[Figure 12 about Here]

Price-to-income ratio provides a convenient measure of the financial burdens endured by a household in acquiring a home. Figure 12 depicts the price-to-income ratio of mortgage borrowers in the full sample (top panel) and in the subsample of married borrowers (bottom panel). In each panel, there are two plots, the left plot covers the borrowers in the bottom-income group with a separate line for each of the three tiers of cities, while the right plot covers the borrowers in the middle-income group.

The financial burdens faced by the bottom-income group are particularly interesting. In this group, the price-to-income ratio started at a level slightly above 8 across the three tiers of cities in 2003. In first-tier cities, this ratio remained at around 8 before 2008 and then climbed to a

[14] According to annual reports of the China Banking Regulatory Commission (CBRC), the ratio of non-performing loans in residential mortgages has remained below 0.6% since 2009. Even in Shenzhen, which, as we discussed earlier, experienced a large housing price drop of 39% in 2008, the ratio of non-performing loans in our sample remained lower than 1.5% in 2008.

peak of 10.7 in 2011 before dropping back to 9.2 in 2012. In second- and third-tier cities, this ratio was very similar and remained in a tight range around 8. It had a modest decline from a level slightly above 8 in 2003 to 7.2 in 2007 and then climbed back to a peak slightly below 9 in 2011 before dropping back to around 8 again.

The price-to-income ratio for the middle-income group was consistently lower than that for the bottom-income group. It was highest in the first-tier cities and lowest in the third-tier cities. Across the three tiers of cities, it had a similar pattern over time. In first-tier cities, it had an expansion from 5.6 in 2003 to 8.3 in 2011 before dropping back to 7.5 in 2012. In second-tier cities, it expanded from 5.7 in 2003 to 7.4 in 2010 before dropping back to 6.2 in 2012. In third-tier cities, it expanded from 5.0 in 2003 to 6.4 in 2010 before dropping back to 6.2 in 2012.

It is useful to compare the price-to-income ratios observed in Chinese cities with that in other countries. Cheng, Raina, and Xiong (2014, Table 9) examined home purchases by Wall Street employees and lawyers in the U.S. during 2000s and found that they had consistently used price-to-income ratios around three before, during, and after the U.S. housing bubble that peaked in 2006. While the households they examined were from the relatively high-income fraction of the U.S. population, it is common for financial advisors in the U.S. to advise households to purchase homes with price-to-income ratios of around three.[15] There are few studies of financial burdens faced by mortgage borrowers during the Japanese housing bubble. Indirectly, Noguchi (1991, Table 1.3) reported that the average ratio of condominium price (the price of a certain benchmark condominium) to annual income, i.e., the income of an average household which may or may not be a home buyer, in Tokyo rose to 8.6 in 1989, which is consistent with the price-to-income ratios used by the bottom-income borrowers in China.

A price-to-income ratio of 8 or higher, which had been commonly used by mortgage borrowers in the bottom-income group throughout the Chinese cities, implies substantial financial burdens on the borrowers. The financial burdens are reflected in several dimensions. First, in order to qualify for a mortgage loan, a borrower needs to make a down payment of

[15] The lack of property taxes in China has contributed to the high price-to-income ratio observed in China relative to that in the U.S. It is common for homeowners in the U.S. to pay annual property taxes in the range of 1-2% of home values to local townships, while home owners in China typically do not pay any property tax.

about 38% of the home value (Figure 12), which is equivalent to about three times of the borrower's household annual income. This large down payment would require many years of saving. In practice, many home buyers, who are typically in their early 30s (as we will show below), rely on savings of their parents or other close family members to make the down payment.[16]

Second, monthly mortgage payments also consume a substantial fraction of the household income. To illustrate this burden, consider a household, which bought a home at a price that was eight times of its annual disposable income. Suppose that it used its saving to make the down payment at three times its annual income and took a mortgage loan that was five times its annual income. As we describe in Appendix A, all mortgage loans in China carry floating rate interest payments, with the rate determined by a benchmark lending rate set by the People's Bank of China. If the annual mortgage rate was 6%, a rather low rate relative to the rate observed in recent years, then the annual interest payment would consume $6\% \times 5 = 30\%$ of the household's annual income. Furthermore, the household also needed to pay back a fraction of the mortgage each year. Suppose that the loan had a maturity of 30 years (maximum maturity allowed in China) and linear amortization. Then, the household had to set aside another $\frac{5}{30} = 16.7\%$ of its annual income to pay the mortgage. Together, servicing the mortgage loan would consume 46.7% of its annual income.

As we will discuss later, a significant fraction of home buyers in the bottom-income group were unmarried. As they would eventually get married and as it is common in China for a married couple to both work, the household income of a single buyer may soon double upon his/her marriage. Then, the price-to-income ratio of single buyers may not accurately reflect their financial burdens. To isolate this issue, we also compute the price-to-income ratio of married couples in the bottom-income and middle-income groups in each tier of cities. The bottom panel of Figure 12 shows that the price-to-income ratio of married borrowers was very

[16] Due to the high savings rates by Chinese households and the Chinese tradition of children supporting parents in their old age, parents are usually able and willing to provide some financial support to their children's home purchases. For this reason, there is typically not another hidden loan (i.e., a loan taken through the shadow banking system) to pay for the down payment.

similar to that of the full sample with both married and unmarried borrowers across both income groups and different tiers of cities. This lack of difference may reflect the fact that Chinese banks follow a rigid system of using current household income to determine the amount of mortgage loans available to borrowers, regardless of their marital status.

The remarkable income growth of Chinese households during this decade also implies that the large financial burdens endured by mortgage borrowers might be temporary and would subside over time as their income grew. Again consider the household, which purchased a home at an initial price-to-income ratio of eight. Suppose that the household expected its income to grow at an annual rate of 10%, which was roughly the growth rate during this period. Then, it expected its income would rise to 1.6 times of its initial level in five years; the ratio of the current home price to its future income in five years would be five. Of course, this calculation depends on a crucial assumption that the 10% income growth rate would persist into the future. This assumption is ex ante strong despite that ex post the household income in China has been growing at this impressive rate for three decades.

Nevertheless, this simple calculation shows that the household's expected income growth rate is crucial for determining how much it is willing to pay for a home relative its current income. If the household expected its income to persistently grow at a high rate, it would expect the large financial burdens brought by buying a home at eight times of its current annual income to be temporary. Furthermore, this expectation might also motivate an expectation about high income growth of other households, which may in turn lead to an expectation that housing prices will continue to rise. Such an expectation further motivates the household to take on enormous short-term financial burdens to buy the home. In this sense, the households' expectations about their income growth and future housing price appreciation are central for understanding the Chinese housing market boom. We will return to this issue in our later discussion.

D. Home Size

[Figure 13 about Here]

Home size is an important dimension for determining the consumption value of a home. Figure 13 depicts the size of the homes purchased by bottom-income and middle-income mortgage borrowers across the three tiers of cities. Despite the large financial burdens endured by the mortgage borrowers, their homes were rather spacious. The bottom-income borrowers in first-tier cities, which are the most expensive cities in China, bought the smallest homes in our sample. Even for these borrowers, the average size of their home was in a range between 72 and 80 square meters throughout the decade. For a typical family of three (a couple with one child based on China's birth control policy), this home size implies about 25 square meters per person, which is quite spacious by the standards of most large metropolitan areas in the world such as Hong Kong, New York, Singapore, and Tokyo.

It is also useful to note the evident declining trend in the home size purchased by all groups in the three tiers of cities. The homes purchased by bottom-income borrowers in second-tier cities on average declined from 90 square meters in 2003 to 80 in 2012, while the homes purchased by bottom-income borrowers in third-tier cities declined from 109 square meters in 2004 to slightly above 90 in 2012. The homes purchased by middle-income borrowers tended to be bigger but also had a similar decline across all three tiers of cities.

E. Age and Marital Status

[Figure 14 about Here]

Figure 14 shows the age of mortgage borrowers in our sample. Across the three tiers of cities, the mortgage borrowers in our sample were on average in their early 30s. The borrowers in the bottom-income group tended to be slightly younger than those in the middle-income group.

[Figure 15 about Here]

A significant fraction of the borrowers are unmarried. Figure 15 summarizes the fractions of single men and single women among the mortgage borrowers in each income group and each tier of cities. Single men and single women contributed to at least 40% of the bottom-income

mortgage borrowers across the three tiers of cities in each of the years from 2003-2012. This fraction was lower among the middle-income borrowers but nevertheless substantial.

Wei, Zhang, and Liu (2014) argue that home ownership is a status good for single men to strengthen their competitiveness in the marriage market due to the widespread sex imbalance in China. This argument implies that single men should be more eager to buy homes than single women. Consistent with this argument, the fraction of single men among mortgage borrowers was consistently higher than the fraction of single women in second- and third-tier cities across all years and across the bottom-income and middle-income borrower groups. However, in first-tier cities, the fraction of single men was roughly the same as the fraction of single women among the middle-income borrowers, and the fraction of single men was even lower than the fraction of single women among the bottom-income borrowers throughout the sample period.[17] This suggests that while marriage market competition might be a determinant of home ownership in second- and third-tier cities, it is not as relevant for understanding the particularly high housing prices in first-tier cities.

F. Second Mortgages

An often discussed concern regarding the Chinese housing markets is that many urban households hold multiple homes and leave a significant fraction of homes vacant for prolonged periods of time. Our mortgage data allow us to separate second mortgages (i.e., mortgage loans taken by households to purchase second homes) from first mortgages (i.e., single mortgages taken by households) after 2010.[18]

[Table 2 about Here]

Table 2 summarizes the fraction of second mortgages among all mortgage loans issued in each tier of cities in each year between 2011 and 2013. This fraction offers a measure of the

[17] This pattern is consistent with casual observations that sex imbalance is less severe in first-tier cities as people in these cities have been more open-minded about having girls and thus less prone to selecting the sex of their children.

[18] As we explain in Section 6, in early 2010 the Chinese government raised the down-payment ratio and the interest rate on second mortgages, making them higher than those for first mortgages. Since then, banks need to collect information about whether each mortgage is a first or second.

extent that households took loans to buy investment homes. As wealthy households may simply use cash to buy investment homes, such investment purchases by wealthy households do not appear in our mortgage data. Thus, the fraction of second mortgages underestimates the home purchases driven by investment demands.

In first-tier cities, the fraction of second mortgages was 5.3% and 5.2% in 2011 and 2012, respectively, and this fraction had a dramatic increase to 11.8% in 2013. In second- and third-tier cities, the fraction of second mortgages also had an increasing trend during this period, although the levels were much lower. In second-tier cities, this fraction grew from 2.0% in 2011 to 2.4% in 2012 and 3.3% in 2013. In third-tier cities, it grew from 1.0% in 2011 to 1.3% in 2012 and 1.8% in 2013. Taken together, mortgage-financed investment home purchases were much more pervasive in first-tier cities than in second- and third-tier cities.[19]

In summary, our analysis of the mortgage data shows that despite the enormous housing price appreciation during the last decade, the participation of low-income households in the housing markets remained steady. Nevertheless, the relatively low-income home buyers endured severe financial burdens in order to buy homes at prices commonly over eight times their current income. This behavior reflected expectations of persistently high income growth and further high housing price appreciation.

5. Housing as an Investment Vehicle

The spectacular economic growth of China since the 1980s has been accompanied by a high savings rate. According to Yang, Zhang, and Zhou (2013), the gross national savings as a percentage of GDP averaged 35% during the 1980s, 41% during the 1990s, and surged to over 50% in the 2000s. This high saving rate surpassed the rates of all major countries during the same period and was also higher than the prevailing rates in Japan, South Korea, and other East

[19] The fraction of second mortgages in our mortgage data may appear substantially lower than the fraction of households owning multiple homes reported by Chinese Household Finance Survey (2012). According to this survey conducted in 2012, the fraction of urban households owning at least two apartments in China is 15.44%. Note that a significant fraction of the multiple homes owned by the surveyed households was probably old-style housing units that were assigned to the households by their employers as in-kind compensation before the housing reform in late 1990s. These units tended to have undesirable qualities and were different from the newly built homes--the typical homes bought by households in recent years.

Asian economies during the years of their miracle growth. Households, firms, and the government have all contributed to the remarkably high savings rate in China. Roughly speaking, savings by households and firms had each reached about 20% of the GDP during the 2000s.

Despite the high savings rate, households and firms in China have limited vehicles in which to invest their massive savings. Bank deposit accounts are the predominant investment vehicle in China. Due to China's restrictive capital controls, households and firms cannot freely invest their savings in capital markets outside of China, and although they can invest in the stock market inside China, it is still small by size relative to the pool of savings and has not offered attractive returns in the last two decades.[20] Bond markets in China are even smaller. Given these limited investment choices, Chinese households often use housing as an alternative investment vehicle. In this section, we discuss the performance of housing as an investment vehicle, in comparison to bank deposits and stock market.

A. Bank Deposits

[Figure 16 about Here]

Figure 16 shows that total bank deposits in China rose from slightly above 20 trillion RMB in 2003 to over 100 trillion in 2013. The deposit rate is regulated by the central bank. As shown in Figure 4, the nominal bank deposit rate remained in a narrow range, between 2 and 4 percent in 2003-2013, while the national inflation rate frequently surpassed the nominal deposit rate in 2004, 2008-2009, and 2011-2012, making the real deposit rate negative. The average real deposit rate in 2003-2013 was 0.01 percent. This low deposit rate makes the huge pool of bank deposits rather striking. Nevertheless, the low deposit rate has motivated Chinese households to search for alternative vehicles to invest their massive savings.

B. Stocks

[20] There is a debate regarding the performance of the Chinese stock market. On one hand, Allen, et al (2014) argue that despite China's spectacular economic growth, the Chinese stock market has performed rather poorly. On the other hand, Carpenter, Lu and Whitelaw (2014) argue that the Chinese stock market has become as informative about future corporate profits as the U.S. stock market.

China established two stock exchanges in the early 1990s, one in Shanghai and the other in Shenzhen. Figure 16 shows that the market capitalization of all floating shares in the Chinese stock market grew from less than 2 trillion RMB in 2003 to near 20 trillion in 2013. Despite this rapid expansion, the size of the stock market was still substantially smaller than the total bank deposits.

[Figure 17 about Here]

Figure 17 depicts the Shanghai Stock Market Index, a widely followed index for the Chinese stock market, for 2003-2013. This period witnessed a dramatic stock market boom and bust in 2006-2008, when the index rose from 1200 at the beginning of 2006 to a peak of 6092 in October 2007 and then plunged to just below 2000 in October 2008. This boom and bust cycle mostly coincided with the rise and fall of stock markets all over the world in conjunction with the financial crisis in 2008. Since 2008, the Shanghai Stock Market Index recovered in 2009 to a level slightly above 3000, but declined again after 2010 to a level around 2000.

[Table 3 about Here]

Table 3 summarizes the risk and return from investing in the Shanghai Stock Market Index in 2003-2013. During this period, its annual return was an average of 7.3% and it had volatility of 51.5%. This high volatility is not surprising given the dramatic stock market boom and bust in 2006-2008. To isolate this boom and bust period, Table 3 also splits the sample into two sub-periods. In the first half (2003-2008), despite the market crash in 2008, the index return had an average of 8.98% and a staggering volatility of 66.1%. In the second half (2009-2013), the index return had an average of 5.3% and a volatility of 33.9%.

C. Housing

[Table 4 about Here]

Table 4 summarizes the annual returns of the housing indices of first-, second-, and third-tier cities. During our full sample in 2003-2013, first-tier cities offered the highest average annual return at a staggering level of 15.7% and return volatility of 15.4%, second-tier cities

offered an average return of 13.4% and volatility of 9.9%, while third tier cities offered the lowest average return of 11.0% among the three tiers and also the lowest volatility of 7.5%. Relative to the stock index return in the same period, the housing indices across the three tiers all offered higher average returns and, more impressively, much lower volatility. Despite the economic turmoil after 2008, the volatility of housing returns had been remarkably low.

During the first half of the sample, 2003-2008, the housing returns were particularly high for first- and second-tier cities, with the first-tier housing index offering an average return of 20.4% and the second-tier 17.3%. During the second half of the sample, 2009-2013, average returns of both the first-and second-tier were lower at 10.9% and 9.7%, which are nevertheless attractive relative to the average stock index return during the same period. The index return of third-tier cities was stable across the two sub-samples at 11.7% and 10.3%, respectively.

Overall, the housing returns from all three tiers of Chinese cities were surprisingly resilient across the economic crisis period of 2008-2009 and offered returns substantially more attractive than bank deposits and the Chinese stock market.

6. Discussion

Our analysis provides some basic facts to allow us to understand and interpret the Chinese housing boom. In this section, we offer discussion based on these facts.

Housing booms are often associated with credit expansions, with the recent housing bubble in the U.S. being a vivid example. As a result, commentators have often been concerned by the potential risk of excessive leverage in driving the Chinese housing boom. As we have described earlier, Chinese banks have required down payments of over 30 percent for all mortgage loans. Such high down payment ratios substantially alleviate the household default risk faced by banks and make reckless credit expansions to households an unlikely cause of the Chinese housing boom.

A particular concern about the Chinese housing boom is that the enormous housing price appreciation across Chinese cities might constitute a housing bubble that is about to burst. As is

well known by economists, it is difficult to reliably identify an asset bubble. There may or may not be a housing bubble in the Chinese housing market. To forcefully determine the presence of a housing bubble, one needs to develop a systematic framework of supply and demand of housing that fully accounts for the growth of the Chinese economy and the frictions in the Chinese financial system. This entails a task substantially more ambitious than the goal of this paper. Nevertheless, our analysis offers some useful observations about the nature of this nationwide housing boom.

On one hand, the enormous price appreciation does not necessarily indicate the presence of a bubble, as the price appreciation has been mostly accompanied by equally impressive household income growth, except in a few first-tier cities. On the other hand, housing prices are indeed expensive relative to the income of many households, in particular, of the low-income mortgage borrowers. While one can justify their willingness, despite the severe financial burdens, to buy homes based on expectations of persistently high income growth, the high price-to-income ratios observed across Chinese cities expose the housing market to substantial risks when households' expectations are subdued in the future, especially in the event of a sudden stop in the Chinese economy.

Our analysis also highlights a few key ingredients for future efforts to develop a systematic framework for analyzing the Chinese housing market:

1. The housing market across first-, second-, and third-tier cities offered high returns, substantially more attractive than bank deposits and the Chinese stock market.

2. Housing price levels were also high across the three tiers of cities with low-income households buying homes at prices that were over eight times their annual income.

3. Concurrent with the housing boom, Chinese households also accumulated a large pool of cash in bank deposits that paid a minimal deposit rate.

It is important to fully account for the distortions brought to the housing market by the imperfections in the Chinese financial system. The low bank deposit rate that had persisted throughout the studied decade is a key factor. To the extent that near 100 trillion RMB has

been sitting in bank deposits earning an almost zero real rate, households' investment demand for housing is an important driver of housing prices in China.[21]

Beside the well-known illiquidity of housing, risk is an important dimension in evaluating housing as an investment asset. It is difficult to measure the crash risk of the housing market based on month-to-month price fluctuations. The housing market was rather resilient across the crisis period of 2008-2009. In this regard, the housing market has been more robust to crash risk, relative to the stock market, even though the low risk experienced by the housing market in the past does not necessarily imply low risk going forward. As discussed by Pritchett and Summers (2014), the spectacular growth rate of the Chinese economy during the last three decades is clearly a rare event and the powerful force of regression to the mean would make a continued high growth rate of 9 or even 7 or 6 percent an even more unlikely event. This argument implies a substantial risk of an eventual economic slowdown. To the extent that low-income households were buying homes by enduring substantial financial burdens, the risk perceived by them was unlikely to be large. Thus, a systematic framework needs to account for the expectations of households, in particular, their optimistic expectations about persistently high growth rates into the future.[22]

It is also useful to note that housing demand may also be driven by reasons beyond consumption and investment needs. Wei, Zhang, and Liu (2014) emphasize the role of housing as a status good, which strengthens the competitiveness of unmarried men in an unbalanced marriage market where men substantially outnumber women. Indeed, our analysis also confirms relatively larger fractions of unmarried men to unmarried women among mortgage borrowers in second- and third-tier cities, albeit not in first-tier cities.

While our analysis has been largely focused on the demand side of the housing market, the supply side is equally important. There is still a lack of systematic understanding of housing

[21] Chen and Wen (2014) derive a theory to explain the persistently faster-than-GDP housing price growth during the Chinese housing boom based on an idea that a self-fulfilling housing bubble can induce productive entrepreneurs to divert capital from profitable investment projects in order to speculate in housing.
[22] Zheng, Sun, and Kahn (2014) build a measure of real estate confidence level for 35 Chinese cities by using Internet search data. They show that this index predicts subsequent housing price appreciation and new housing construction.

supply in Chinese cities. To the extent that housing prices have been rising at a pace comparable to or even higher than the households' income growth rate during the decade, the housing market equilibrium implies that the growth of housing supply was likely to have stayed either below or comparable to the growth of housing demand, even though Deng, Gyourko, and Wu (2014b) document some evidence of a large housing inventory held by developers in several major cities in recent years. Different from U.S. cities where housing supply is often determined by landscape and local zoning restrictions, e.g., Saiz (2010), housing supply in Chinese cities is determined by land sold by local governments for housing development, as land is legally owned by the state and controlled by local governments. As we will discuss in the next section, land sale revenues have contributed to a substantial fraction of local governments' fiscal budget. As a local monopoly of land supply, local governments' land sales strategy is a key factor in determining housing prices in Chinese cities.

7. Roles of Government in the Housing Market

In China, the governments at the central and local levels have been actively engaged in the housing market. The powerful forces induced by government policies not only directly affect physical aspects of the housing market such as supply of land and availability of funds to buyers, but also delicately influence expectations and confidence of households about the housing market. This is an important channel for understanding the drastically divergent performance of the housing and stock markets after 2008. In this section, we briefly discuss the role of government in the housing market, first on the policy interventions of the central government and then on the dependence of local governments on land sales for their fiscal revenues.

A. Interventions by the Central Government

By 2007, housing prices in most Chinese cities had grown substantially, as discussed in Section 3. In response, the central government implemented a series of monetary and fiscal policies to curb soaring prices and curtail speculative activities in the housing market. For example, in September 2007, the central government raised the minimum down payment ratio from 30 percent to 40 percent, raised the interest rate on second mortgages to 10 percent

higher than the benchmark rate, and capped the monthly mortgage payment-to-income ratio at 50%. In April 2008, it imposed tax on capital gains from housing sales. The government also started to increase the construction of government-subsidized housing, such as affordable housing, low-cost housing, and public rental housing, to help relieve the pressure on the housing market.

These policies might have had some effects on housing prices, especially in cities in Guangzhou and Shenzhen during this period, though it is hard to distinguish the effects of the policies from that of the emerging global economic crisis. In any event, in October 2008 the central government abruptly reversed these policies, and installed a series of measures to support housing market recovery. It reduced the minimum mortgage rates to 70 percent of the benchmark rate and the down-payment ratio to 30 percent. As part of its 4 trillion RMB stimulus package, it also designated the real estate sector as one of the primary industries for investment. As a result, the housing market regained momentum in mid-2009 and started a new round of rapid price appreciation.

In early 2010, the government introduced a series of measures, some traditional and some less standard, to cool off what were widely considered a once again overheating housing market. It again raised the down-payment ratio to 40% and the interest rate on second mortgages. More important, starting in April 2010, following the guidelines of the central government, 39 of the 70 major cities in China introduced the *housing purchase restriction policies.*[23] Under these policies, only those with local *Hukou* (household registration), or those who could show proof of employment in the city for certain consecutive years, were eligible for purchasing one or two new homes. Though not covered in our sample period, the slowdown in the Chinese economy has led to a slowdown of the residential housing market since the end of

[23] The housing purchase restriction policy was initiated by the central government under the so-called "New National Ten Articles" and "New National Eight Articles" issued in April 2010 and January 2011 respectively, which provided guidelines saying that housing purchase restrictions should be implemented in first-tier cities and could be extended to second- and even third-tier cities on an as-needed basis. In Beijing, for example, the policy requires that only a household with household registration in Beijing can buy a new apartment. Migrants living in Beijing are not allowed to buy any apartment unless they can provide documentation to prove payment of taxes and social security contributions for the previous five consecutive years. Shanghai's policy is similar.

2013. Many cities loosened the purchase restrictions in mid- 2014. Currently, the housing purchase restriction policies are in force only in the four first-tier cities.

The frequent interventions by the central government have created a sense among the households that the housing market is too important to fall, as whenever the market started to fall, the central government would provide supports to sustain it.

B. Land Sales and Fiscal Revenue of Local Governments

Land sale revenues have contributed to a substantial fraction of local governments' budgets. This feature was a result of the fiscal reforms enacted in 1994. In the reforms, the central government consolidated provisions for tax revenue collection and sharing in order to redistribute tax revenues to less developed areas. As is well known, local officials in China were evaluated for promotion based to a large extent on regional economic growth (Li and Zhou, 2005), which provided strong incentives for investment in infrastructure and capital projects. However, unlike local governments in western countries, local Chinese governments do not have many sources of revenue. In particular, local governments in China are not authorized to levy sales taxes, property taxes, or local income taxes, which are important sources of revenue for local governments in western countries. Moreover, local governments in China are prevented from directly issuing debt to fund capital projects.

[Figure 18 about Here]

As a result of this central/local fiscal arrangement and the restrictions placed on local governments, China has developed a unique source for local governments to obtain capital necessary to fund required large-scale infrastructure investments---they increasingly rely on selling public land. Figure 18 shows the share of land revenues in city fiscal budgets from 2003-2011 averaged across all cities, as well as among the first-tier, second-tier, and all other cities. At the national level, this share started at 68% in 2003 and decreased to 42% in 2008, only to bounce back to even higher than 70% in 2010 and 2011. Across these tiers, the share is relatively low for first-tier cities as their municipal governments have more sources of revenues, but high for second-tier and other cities. For the cities outside the first- and second-tiers,

revenue from land sales was particularly high, contributing over 90% of their fiscal budgets in some years, such as 2003 and 2010.

The central government has also allowed the local governments to create a unique funding mechanism known as Local Government-Backed Investment Units, through which future land-sales revenue can be pledged as collateral.[24] Local governments have used such investment units to access capital markets and issue bonds that would allow more large-scale infrastructure/capital investment, as well as other economic development and social insurance initiatives. This unique mixing of local governmental fiscal policies with local housing markets implies that a substantial drop in housing or land prices might lead to financial distress of local governments or even trigger defaults by Local Government-Backed Investment Units, which would be equivalent to defaults by the local governments. As a result, many households in China have been emboldened to believe that the housing market is "too important to fall," and that the central government will be forced to institute policies to pump up the housing market if it was to deteriorate, just as it had done in the past.

Taken together, the heavy reliance of local governments on land sales revenue for their fiscal budgets also helped to create a belief among many households that the housing market was too important to fall. This belief might have contributed to the resilient housing prices throughout the last decade.

8. Risks for the Chinese Housing Market

In this section, we discuss the key risk factors facing the Chinese housing market. The most important risk factor is no doubt related to the income growth rate. As the Chinese economy enters a new phase of growth, the annual GDP growth rate will inevitably drop from its nearly 10 percent growth of the last three decades. In 2014, the Chinese economy grew at a rate of 7.4%. As economic growth slows, the growth of disposable household income will slow as well.

[24] According to the latest available statistics published by the National Audit Office, by the end of June 2013, the total volume of outstanding balances on local government debts reached 10.89 trillion RMB, equivalent to 19.15% of China's GDP in 2013, surpassing the 9.81 trillion total volume of central government debt during the same period. Future land sales revenue was used as collateral in 37.23% of the local government debt.

As we argued in Section 3C, the high price-to-income ratio among home buyers was likely sustained by the expectation of sustained high income growth; as such, a significant decrease in the expectation of income growth will lead to a commensurate decrease of sustainable price-to-income multiples for home buyers. As we have shown in Section 3, housing price growth in the last decade substantially outpaced that of income growth in first-tier cities, but not in second- and third-tier cities; thus a potential income growth slowdown is likely to have a more dramatic impact on housing prices in first-tier cities.

Housing supply, however, is much more elastic in second- and third-tier cities than in first-tier cities. The continued increase in new construction in second- and third-tier cities, as shown in Figure 1, has kept the housing price growth in these cities in line with their income growth, but also poses an important source risk to the housing market in these cities. Note that new construction is constrained by land sold for housing development and local governments control land sales. Thus, risks from the glut of new supplies in second- and third-tier cities can be managed by local governments if they have alternative sources of fiscal revenue.

Another near-term risk factor for the housing market is demographic trends. As is well known, 25 years after the initiation of the family planning policy, the Chinese population is rapidly ageing and is expected to decline beginning in 2030. However, the prime age group for home buyers, those between 30 and 49, started to decline for China as a whole in 2005.[25] Using the 2000 Chinese Census micro data, we find that in 2030, the prime age population of homebuyers in China will decline to about 62% of the corresponding level in 2000. Of course, the ongoing urbanization in China is likely to draw a significant share of the rural population to cities (see Figure 2), and thus for the urban housing market, the overall demographic trend may not be as relevant. Ongoing policy discussions in China regarding the relaxation of the one-child policy, as well as a relaxation or even abolishment of the strict *Hukou* policy, could significantly increase the demand for housing in the cities. Policies that relax the *Hukou* system may become necessary to prevent the meltdown of the housing market if, for example, the economy and income growth slow sharply.

[25] In Section 4E, we showed the average age of mortgage borrowers is the early thirties.

We would also like to discuss the likely effects of some of the pending policy reforms in China that may have more subtle implications on the housing market.

First, we consider the possible imposition of property taxes and new fiscal reform. Property taxes are not presently assessed on homeowners in China, with the exceptions of Shanghai and Chongqing, where a small property tax on a certain class of homes was assessed beginning in January 2011. In Shanghai, the property tax is currently at 0.6% of the purchase price of second homes, while in Chongqing, the property tax is 0.5% of the purchase price of second homes, mansions, and luxury apartments. The introduction of property tax in all cities is now on policymakers' agendas. Part of the reason is a desire to increase the cost of speculative purchases of houses, and another part is the desire to have a different source of revenue for local government budgets that have, as we have shown, become increasing reliant on land sales revenue.

An introduction of property taxes will have several effects on the housing market. First, it will make housing speculation less profitable. Speculation would remain profitable only if the expected housing price growth exceeds the opportunity cost of funds used for purchasing the house, plus the property tax assessment. If the property tax rate is chosen properly, it is possible that it could not only deter new speculative demand for housing, but also potentially drive current speculative holdings of homes to the market for sale. Second, the introduction of property taxes, in conjunction with fiscal reform that provides local governments with new revenue sources that are not tied to selling land, is likely to affect households' expectations that the housing market is "too important to fall." Absent such a conviction, the perceived risk associated with housing investment would rise, reducing housing demand. Third, property taxes and other fiscal reform will also put downward pressure on the price that developers are willing to pay for land, which in turn would further lower the cost of housing. All three effects of imposing property taxes are likely to put downward pressure on the housing market.

Another pending reform that may impact the housing market is the unification of the administrative structure of the social insurance system. The current social insurance system in China, particularly the health care and health insurance segments, is poorly designed to

facilitate a transition of housing stock from the older generation to the younger generation. Specifically, most of the best hospitals in China are located either in Beijing and Shanghai, or in a few of the provincial capitals, such as Guangzhou and Chengdu. More important, the current health insurance system is mostly based on employment or pre-retirement employment, and it is implemented under a prefecture- or county-level planning framework, where the planning units have discretion over policy details and are responsible for balancing their own budgets (see Fang, 2014, for an overview of the social insurance arrangement in China). Health insurance is not accepted nationwide. This means that if retirees in first-tier cities were to relocate to third-tier cities, they would not only experience more difficulty in accessing the best hospitals, but would also have difficulty in having their medical expenditures covered by their health insurance. This creates strong disincentive for the elderly to relocate as they retire, leading to unnecessary competition between the young and the old for the limited housing resources in the first-tier and some second tier cities. As China attempts to unify the administrative structure of the social insurance system and equalize medical resources across different areas, it is possible that retirees in first-tier cities will relocate to retirement communities located in cities that have good medical facilities, leaving limited housing resources for the young, creating a healthy life-cycle for first-tier city residents. This is likely to be a stabilizing force for the Chinese housing market.

Appendix

Appendix A: Residential Mortgages in China

A.1 Borrowing Requirements

The borrower of a mortgage loan should have a stable source of income and a good credit record, and be between 18 to 65 years of age. Generally, loan to value ratio should be lower than 70%, and the loan term should be less than 30 years. According to the requirements announced by the China Banking Regulatory Commission (CBRC) in "Guidelines for the risk management of real estate loans of commercial banks" in 2004, a borrower's ratio of monthly mortgage payment to income should be lower than 50%, and the ratio of monthly debt payment to income should be lower than 55%.

In China, only houses can act as collateral for mortgage loans. This includes villas, with the down payment ratio of a villa being higher than that of other types of houses. House age (from its completion date) should be no more than 20 to 30 years, and house age plus the loan term should be no more than 30 to 40 years. Different from other countries, such as the U.S., collateral of a mortgage loan has to belong to the borrower.

A.2 Loan Application Procedure and Payments

A mortgage applicant should first submit all required documents to a bank. After receiving the application, the bank carries out an eligibility investigation. The most important factor for the investigation is the applicant's income and credit record. The bank can check an individual's credit record through the credit rating system of the People's Bank of China, which started its trial operation in December 2004 and official operation in January 2006. Upon approval, the borrower signs a mortgage contract with the bank, and then opens a mortgage account with the bank for making mortgage payments. If the loan term is one year or shorter, both principal and interest must be repaid as a lump sum at maturity; if the loan term is longer than one year, the loan may be repaid in equal installments of the principal plus interest, or in equal installments of the principal.

A.3 Mortgage Interest Rate

Interest rates for all bank loans, including mortgage loans, are regulated by the central bank of China, known as the People's Bank of China (PBC). All banks need to follow the same lending rules set by the PBC. The PBC regulates interest rates of mortgage loans to be a multiple of the benchmark lending rates it sets for bank loans, which usually depend on loan terms. This multiple has varied over time. It was 0.9 before August 2006, 0.85 from August 2006 to October 2008, and 0.7 from October 2008 to March 2010. After March 2010, the multiple for a first

house was 0.85, and for a second house was 1.1. During our studied decade, the benchmark lending rates for different maturities have stayed between 4 and 8 percent.

An important feature of mortgage loans in China is that all are adjustable rate mortgages (ARMs); there are no fixed rate mortgages.[26] When the PBC changes its benchmark lending rates, interest rates of all mortgage loans are adjusted according to the most recent lending rates. Except for a small number of mortgage loans that are adjusted in the next month or next quarter, the majority of mortgage loans are adjusted on the first day of the next year.

A.4 Mortgage Termination

Default and full prepayment are two ways to terminate a mortgage contract during its term. The default rate in China has been low. According to the Annual Report of China Banking Regulatory Commission,[27] the ratio of non-performing loans in residential mortgages declined steadily from 0.59% in 2009 to 0.26% in 2013, and the average during this 5-year period was 0.36%.[28] The non-performing ratio in residential mortgage loans is much lower than that in credit cards, which was on average 1.59% during the same period. One important reason for the low default rate in China is that all mortgage loans are recourse loans. This allows mortgage lenders to recover losses from mortgage loans by collecting the borrowers' other assets. When a default occurs and the value of the home value is lower than the loan balance, the mortgage lender can request courts to sell the home and collect the borrower's other assets. Furthermore, mortgage refinance, i.e., the process of paying off an existing loan by taking a new loan, is not allowed in China.[29] This rule prevents borrowers from using homes as ATMs.

[26] During 2007 to 2008, some commercial banks issued a small number of fixed rate mortgage loans but stopped the practice.
[27] http://www.cbrc.gov.cn/chinese/home/docView/3C28C92AC84242D188E2064D9098CFD2.html
[28] A loan is defined as non-performing if it is overdue by more than 90 days.
[29] As all mortgage loans in China have floating rates; decreases in interest rates do not motivate mortgage refinancing.

Appendix B: List of Cities by Tiers

- First tier includes: Beijing, Shanghai, Guangzhou, and Shenzhen

- Second tier includes the following 36 cities with brackets denoting cities that are missing from our sample: [Beihai], Changchun, Changsha, Chengdu, Chongqing, Dalian, Fuzhou, [Guiyang], Haikou, Hangzhou, Harbin, Hefei, Hohhot, Jinan, Kunmin, [Lanzhou], Nanchang, Naijin, Nanning, Ningbo, Qingdao, [Sanya], Shenyang, Shijiazhuang, Suzhou, [Taiyuan], Tianjin, Urumqi, Wenzhou, Wuhan, Wuxi, Xi'An, Xiamen, Xining, Yinchuan, Zhengzhou

- Third tier includes the following 85 cities: Xuancheng, Fuyang, Chuzhou, Huangshan, Anqing, Bengbu, Wuhu (from Anhui Province); Ningde, Zhangzhou, Quanzhou (from Fujian Province); Jieyang, Zhongshan, Dongguan, Qingyuan, Yangjiang, Heyuan, Shanwei, Huizhou, Zhaoqing, Jiangmen, Foshan, Shantou, Shaoguan (from Guangdong Province); Hengshui, Langfang, Zhangjiakou, Baoding, Xingtai, Qinhuangdao, Tangshan (from Hebei Province); Jiamusi, Qiqihar (from Heilongjiang Province); Zhumadian, Nanyang, Luohe, Xuchang, Puyang, Xinxiang, Luoyang, Kaifeng (from Henan Province); Changde (from Hunan Province); Xilingol, Baotou (from Inner Mongolia Province); Jiangyan, Suqian, Zhenjiang, Yancheng, Huai'an, Lianyungang, Nantong, Changzhou, Xuzhou (from Jiangsu Province); Fuzhou, Shangrao, Yichun, Xinyu, Jiujiang, Pingxiang, Jingdezhen (from Jiangxi Province); Songyuan, Jilin (from Jilin Province); Wuludao, Chaoyang, Tieling, Panjin, Yingkou, Dandong, Anshan (from Liaoning Province); Liaocheng, Dezhou, Rizhao, Zaozhuang (from Shandong Province); Yuncheng (from Shanxi Province); Dazhou, Nanchong, Leshan, Mianyang, Deyang, Luzhou (from Sichuan Province); Changji (from Xinjiang Province); Taizhou, Jinhua, Shaoxing, Huzhou, Jiaxing (from Zhejiang Province).

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Figure 1: Per Capita Area of Newly Built Residential Housing

For each tier of cities, we divide its annual flow of newly constructed residential housing, measured in square meters, by its urban population in 2012. The National Bureau of Statistics provides annual city-level data on space of newly constructed residential housing from 2002-2013 and resident population from 2005-2012, for 35 large cities only. These cities include all four tier-1 cities: Beijing, Shanghai, Guangzhou, and Shenzhen. The other 31 cities all belong to the tier-2 cities defined in the paper. We use the aggregate of these 31 cities to compute the per capita area built for tier-2 cities. We then subtract these 35 cities from the national aggregates on newly constructed urban housing and urban population to get measures for tier-3 (and other) cities. Resident population includes all people residing six months or more in the area governed by the city in the current year (in contrast to the hukou population). We assume all resident populations in tier-1 and tier-2 cities are urban, which leads to a slight overestimation of urban population in tier-1 and tier-2 cities and, consequently, a slight underestimation of urban population in tier-3 (and other) cities. In 2012, China had a total population of 13.5 billion, out of which 7.2 billion are urban and 6.3 billion are rural. Out of those 7.2 billion who live in cities, 0.7 billion reside in tier-1, 2.4 billion in tier-2, and 4.1 billion in tier-3 by our baseline calculation.

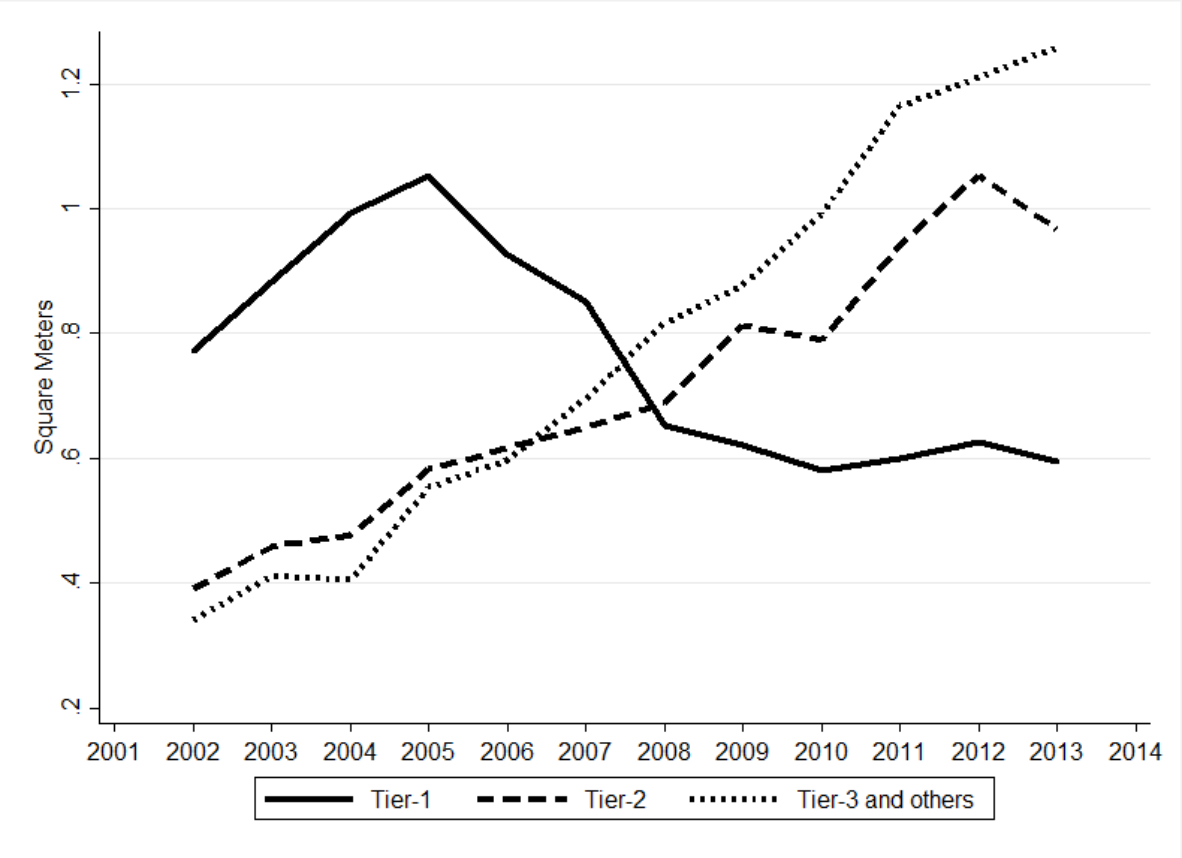


Figure 2: Population in Three Tiers of Cities

There are two lines in each panel. The solid line depicts the total population within the jurisdiction of each tier of cities, while the dashed line depicts the population within the city proper of each tier.



Figure 3: An Illustration of Index Construction Method

The price change from month 1 to month 2 is estimated by the price differences of similar units in development project A in month 1 versus those sold in month 2. The price change from month 2 to month 3 is estimated by the price differences of similar units in development project B sold in month 2 versus those sold in month 3. The price change from month 3 to month 4 is estimated by the price differences of similar units in development projects B and C that are sold in month 3 versus month 4.

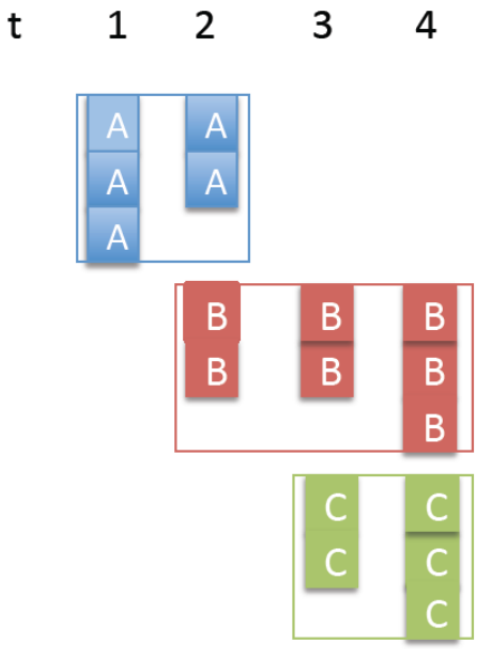


Figure 4: Bank Deposit Rate and National Inflation

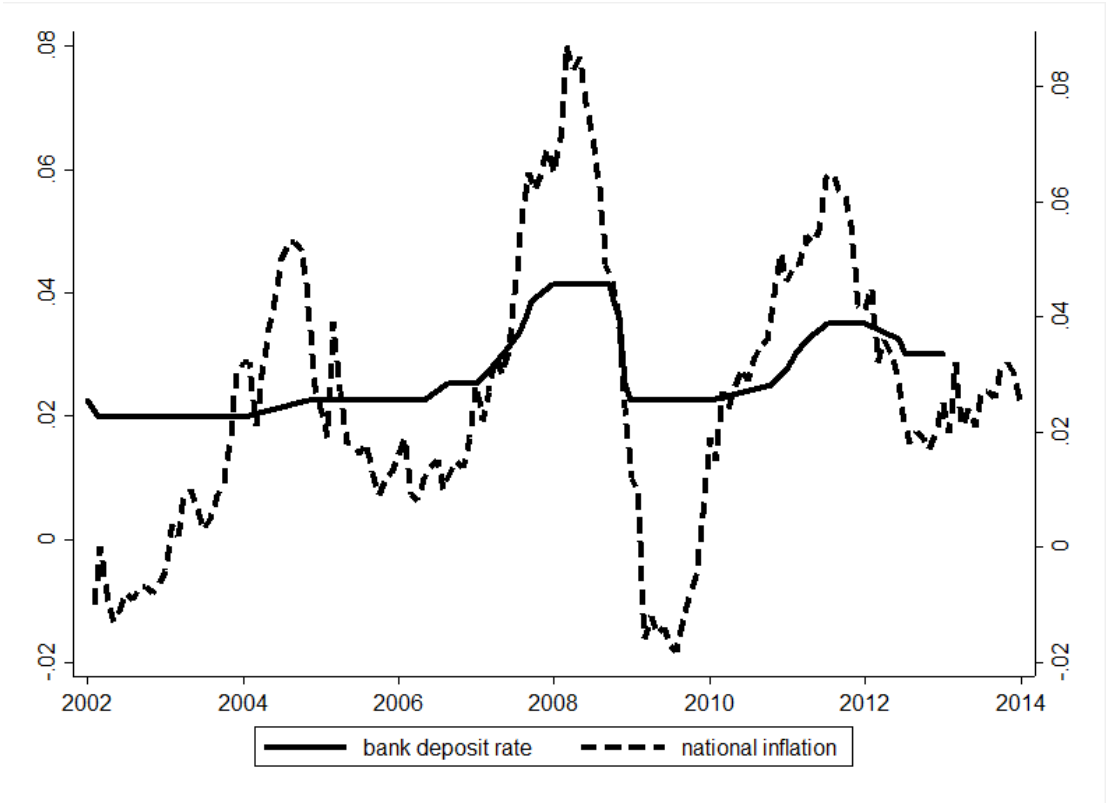


Figure 5: Housing Price Indices for First-Tier Cities

This figure depicts the monthly housing price indices in four separate panels for the four first-tier cities--Beijing, Shanghai, Guangzhou, and Shenzhen-- together with two measures of households' purchasing power: per capita GRP and disposable income (urban). Per capita GRP measures the per capita value of output in the whole city and per capita disposable income (urban) measures the per capita income received by urban residents of the city.

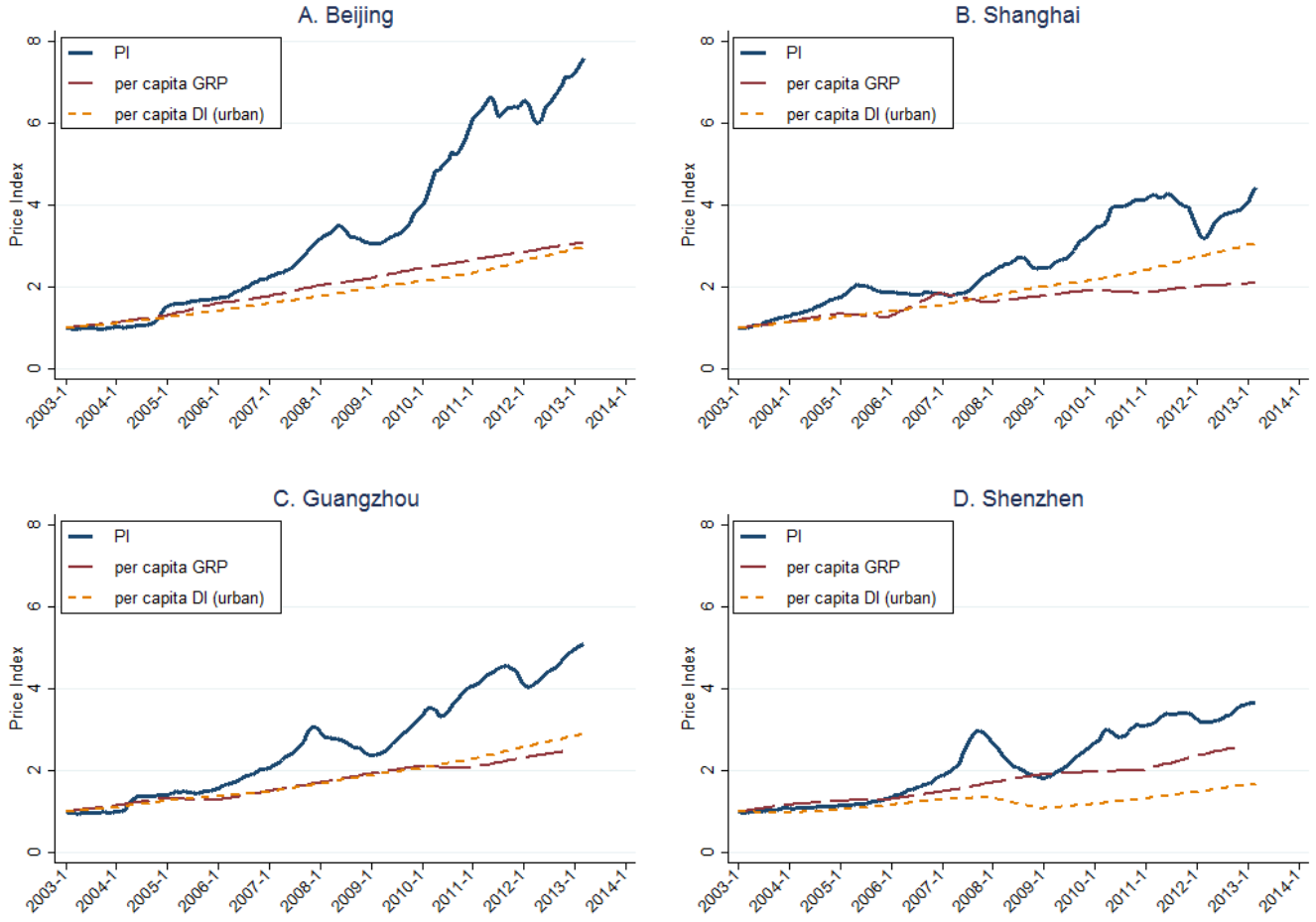


Figure 6: Housing Price Indices for Second- and Third-Tier Cities

This figure depicts the monthly housing price indices in two separate panels for second- and third-tier cities, together with two measures of households' purchasing power: per capita GRP and disposable income (urban). Per capita GRP measures the per capita value of output in the whole city and per capita disposable income (urban) measures the per capita income received by urban residents of the city.

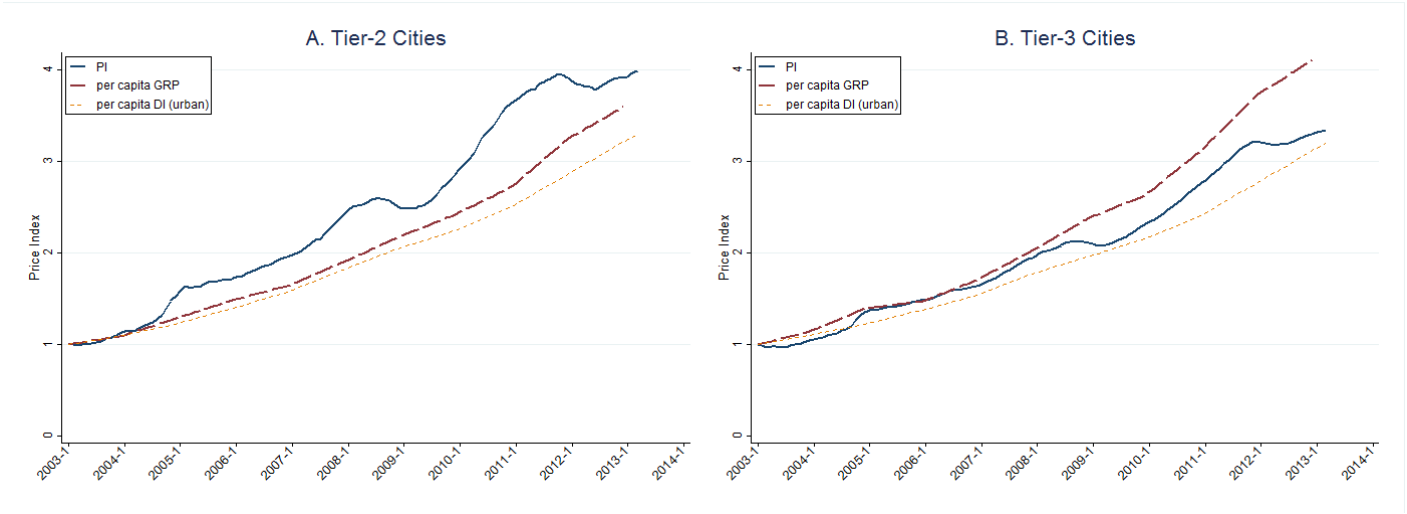
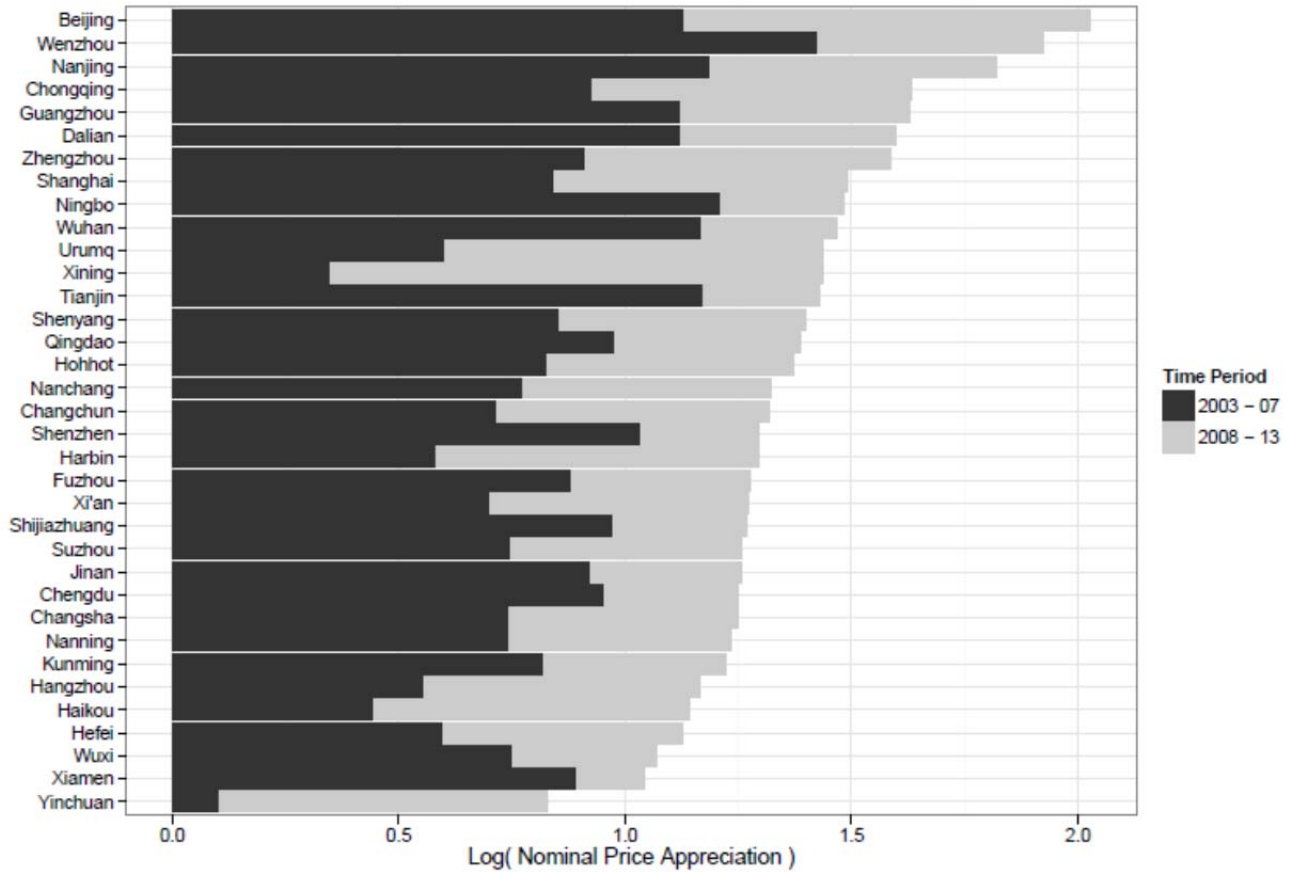


Figure 7: Housing Price Appreciation in Individual Cities

The figure depicts the logarithmic housing price appreciation from January 2003 to March 2013. Each bar represents a city with one part for price appreciation from 2003 -- 2007 and the other part for price appreciation from 2008-2013. Panel A collects the 35 cities in first and second tiers in our sample and Panel B collects the 85 cities in third tier.

Panel A: Cities in First and Second Tiers



Panel B: Cities in Third Tier

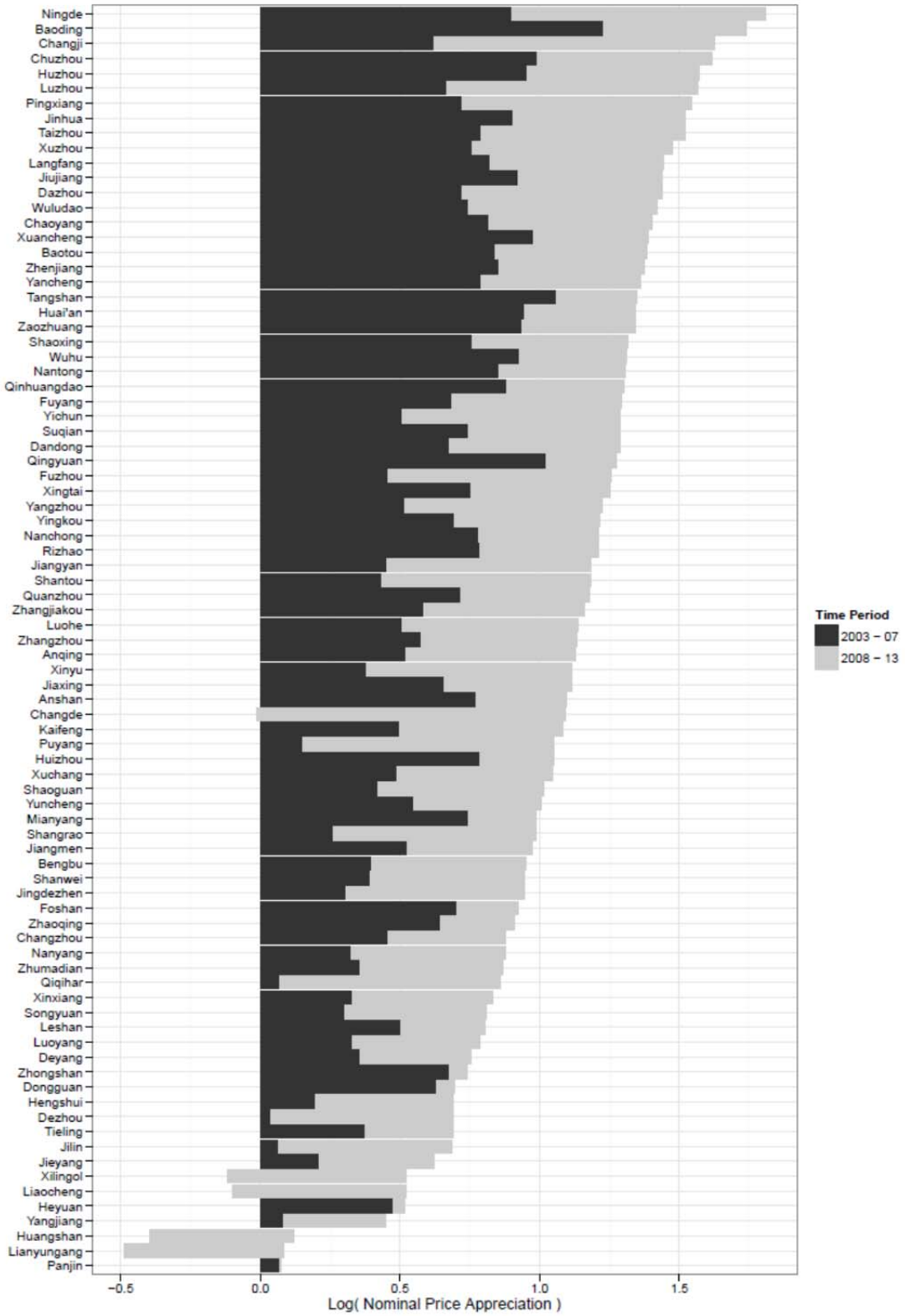


Figure 8: Comparing Housing Price Indices

This figure compares the monthly housing price indices for the four first-tier cities constructed by us with the two official series provided by the National Bureau of Statistics (NBS). In each of the panels, the solid line represents our index, the dotted line presents the NBS average price index, and the dashed line the NBS 70-city index.

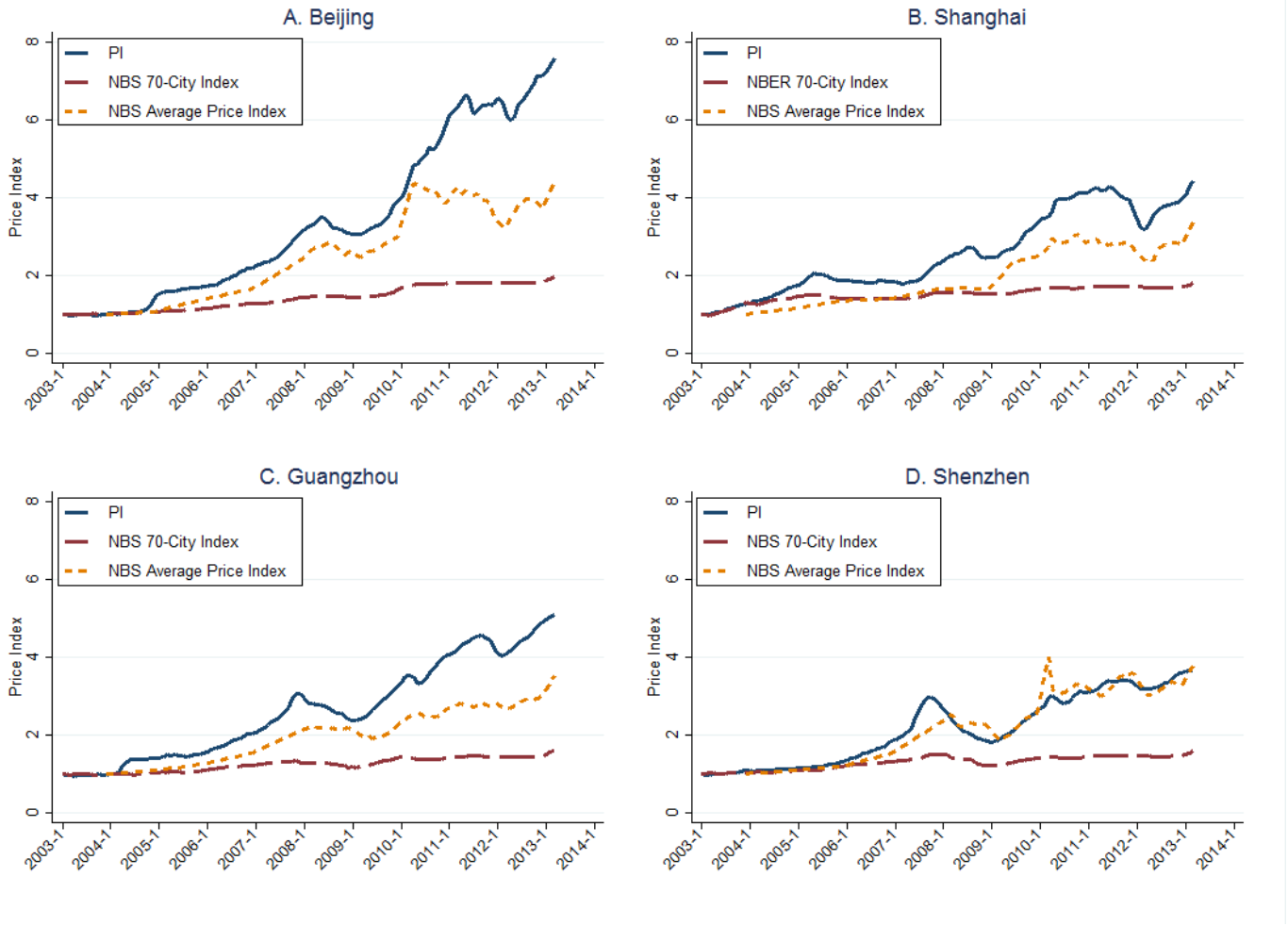


Figure 9: Housing Price and GDP Growth in Japan and Singapore

Panel A depicts the Urban Land Price Index for Japan (average assessment value index) provided by the Japan Real Estate Institute, together with the per capita GDP provided by the Japanese Statistics Bureau (Japan Statistical Yearbook), from 1955 to 2014. Panel B depicts the private property resale price index for Singapore (a median sale price index) provided by the Urban Redevelopment Authority of Singapore, together with the per capita GDP of Singapore provided by the IMF, from 1975 to 2010.

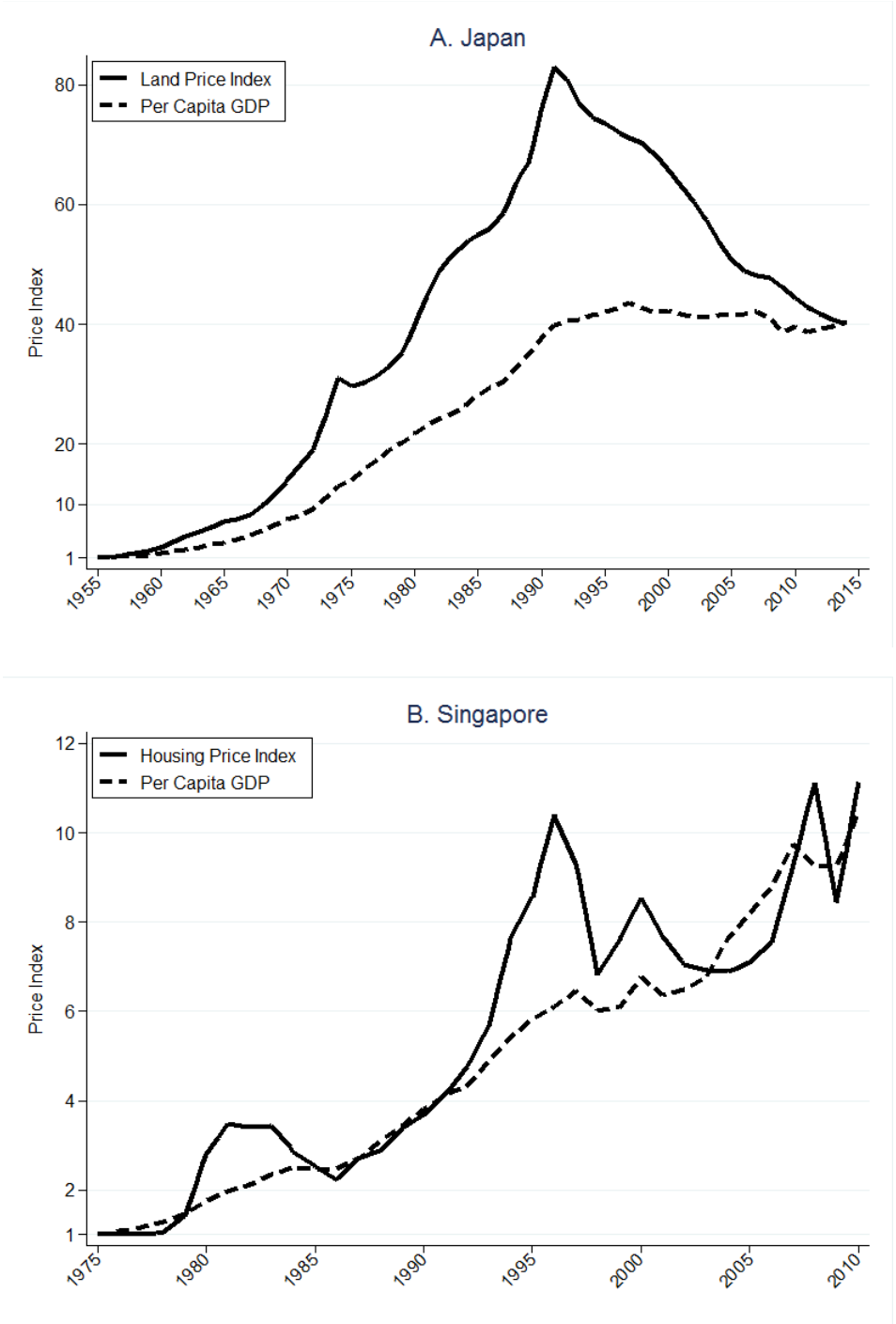
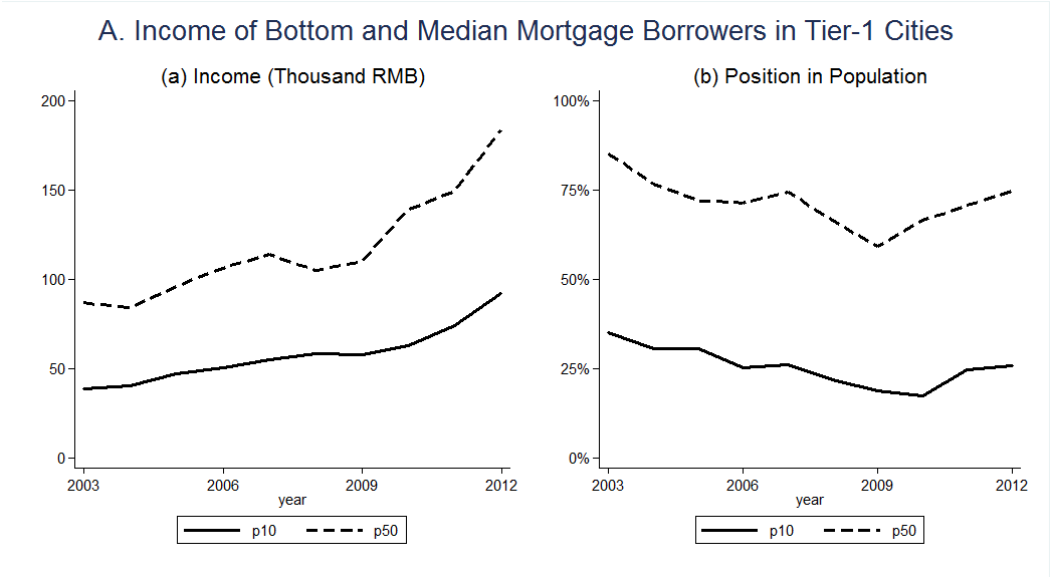
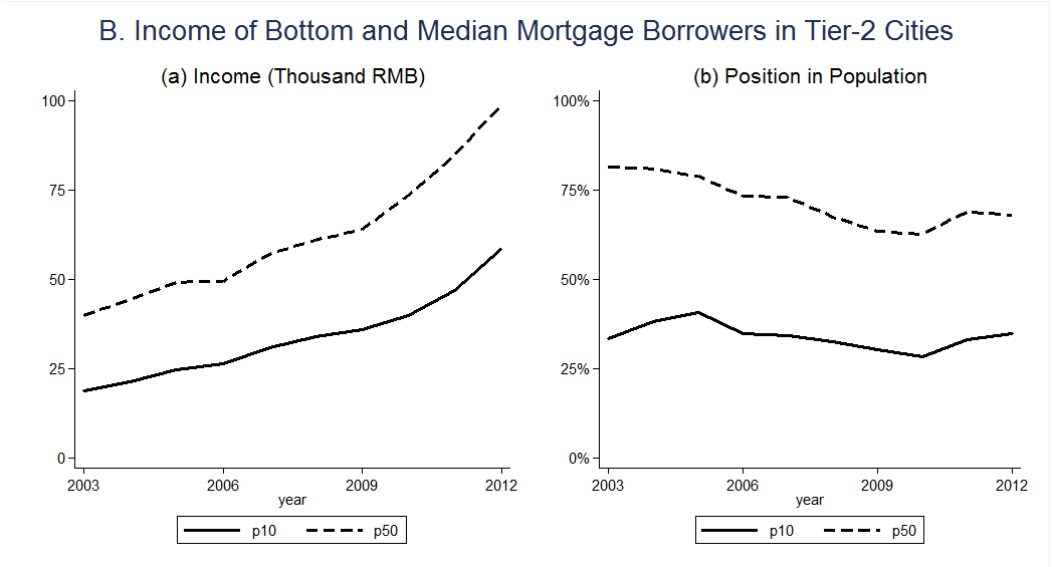


Figure 10: Annual Income of Mortgage Borrowers

This figure depicts the time-series of the household incomes of p10 and p50 for first-, second-, and third-tier cities in Panels A, B, and C, respectively. In panels A and B, the left plot shows the annual income of p10 and p50 (which is averaged across all cities in the tier) from 2003-2012, and the right plot shows the position of p10 and p50 in the income distribution of the city population based on the income distribution reported by the Urban Household Survey (UHS). Panel C shows only the annual income of p10 and p50.





C. Income of Bottom and Median Mortgage Borrowers in Tier-3 Cities

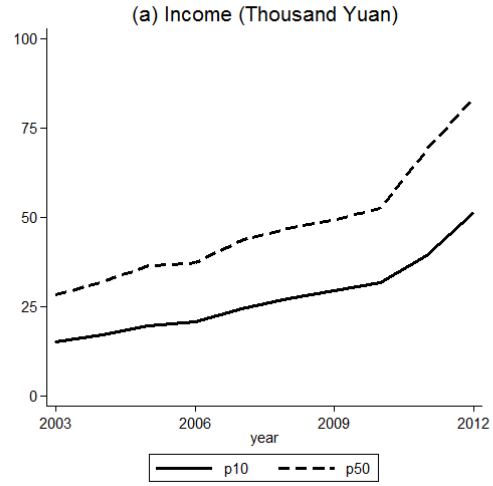


Figure 11: Mortgage Down Payment

The left panel depicts the fraction of mortgage down payment in home value at the time of purchase for bottom-income borrowers in first-, second-, and third-tier cities, and the right panel depicts the fraction of down payment for middle-income borrowers in these three tiers of cities.

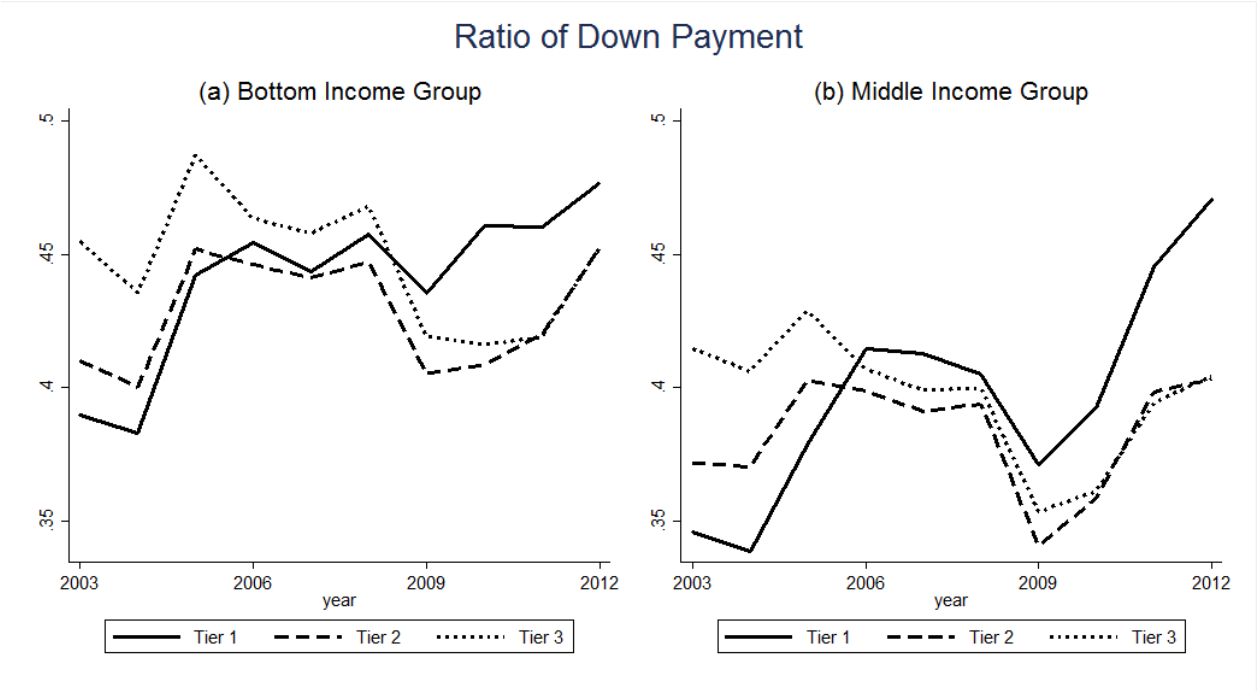


Figure 12: Price-to-Income Ratio of Mortgage Borrowers

This figure depicts the price-to-income ratio of mortgage borrowers in the full sample (top panel) and in the subsample of married borrowers (bottom panel). In each panel, there are two plots, the left plot covers the borrowers in the bottom-income group with a separate line for each of the three tiers of cities, while the right plot covers the borrowers in the middle-income group.

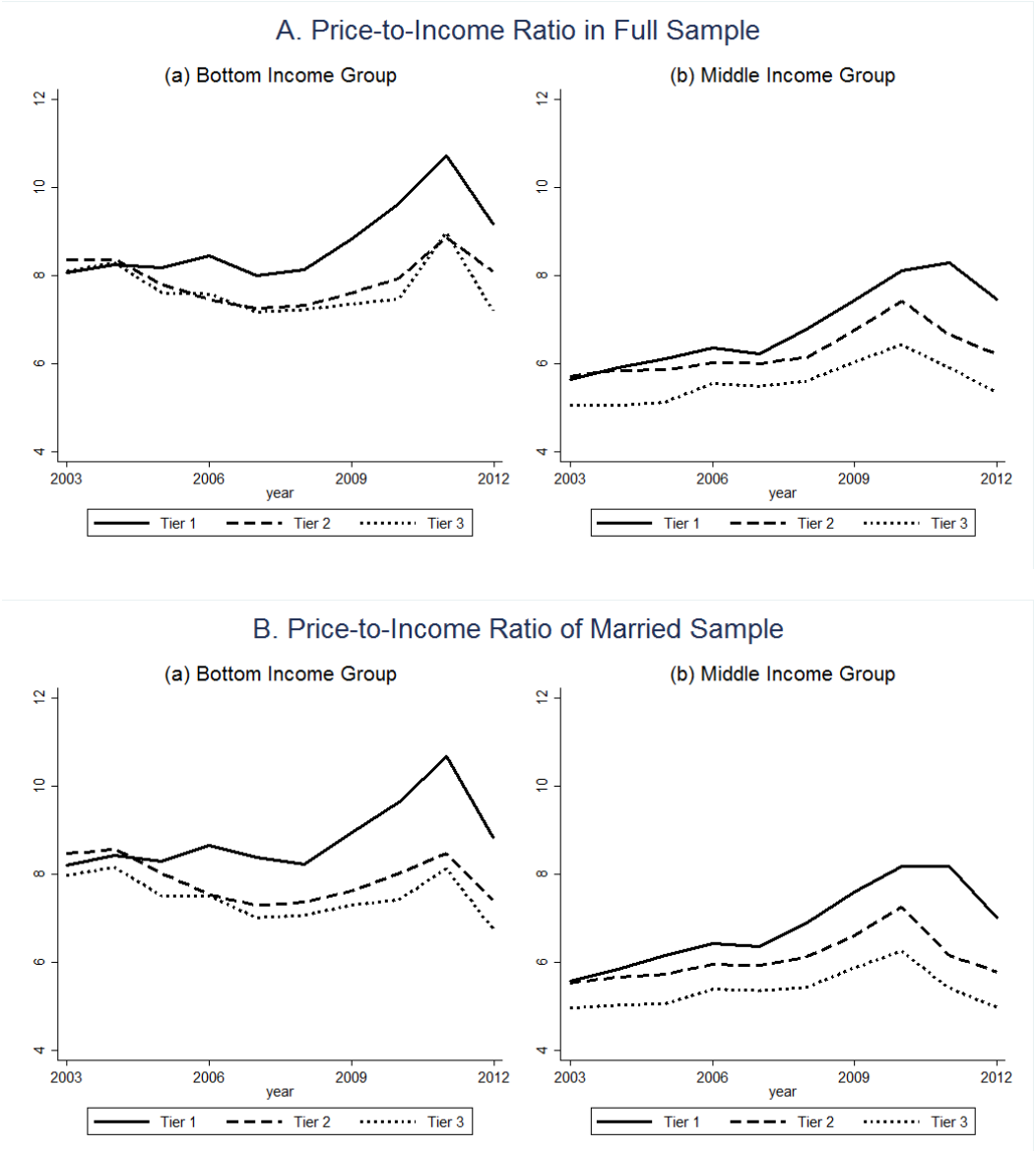


Figure 13: Home Size of Mortgage Borrowers

The left panel depicts the home size of bottom-income borrowers in first-, second-, and third-tier cities, while the right panel depicts that of middle-income borrowers.

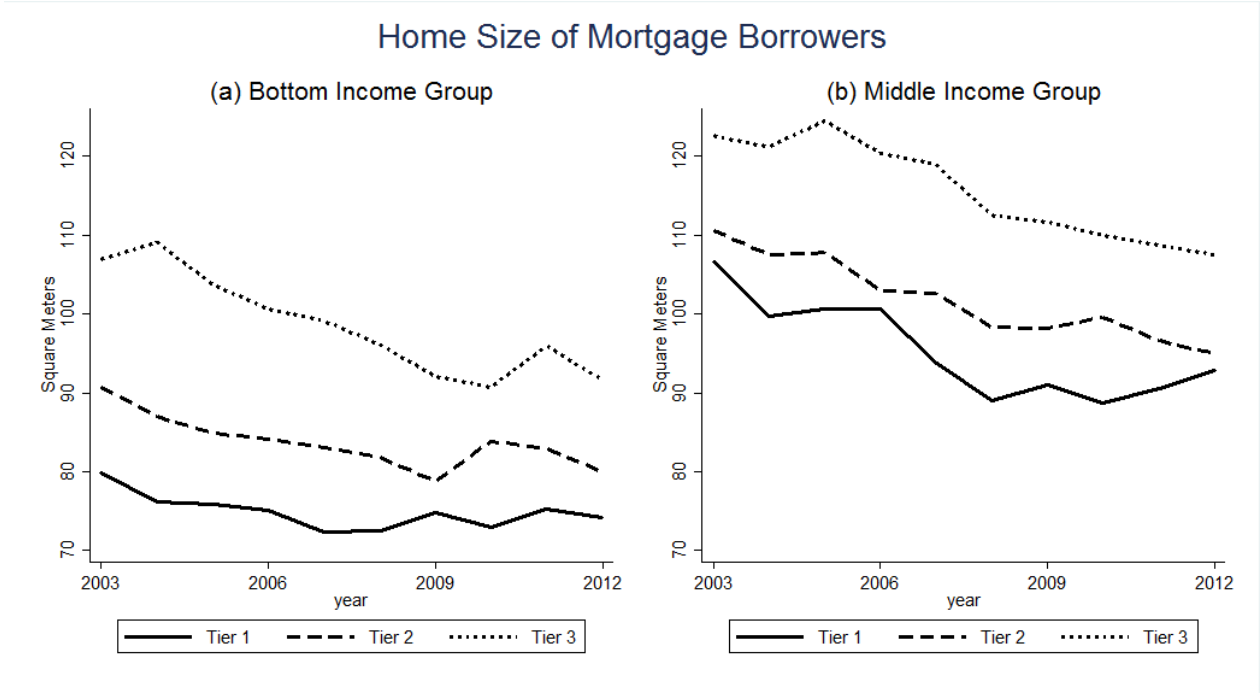


Figure 14: Age of Mortgage Borrowers

The left panel depicts the age of bottom-income borrowers in first, second, and third tier cities, while the right panel depicts that of middle-income borrowers.

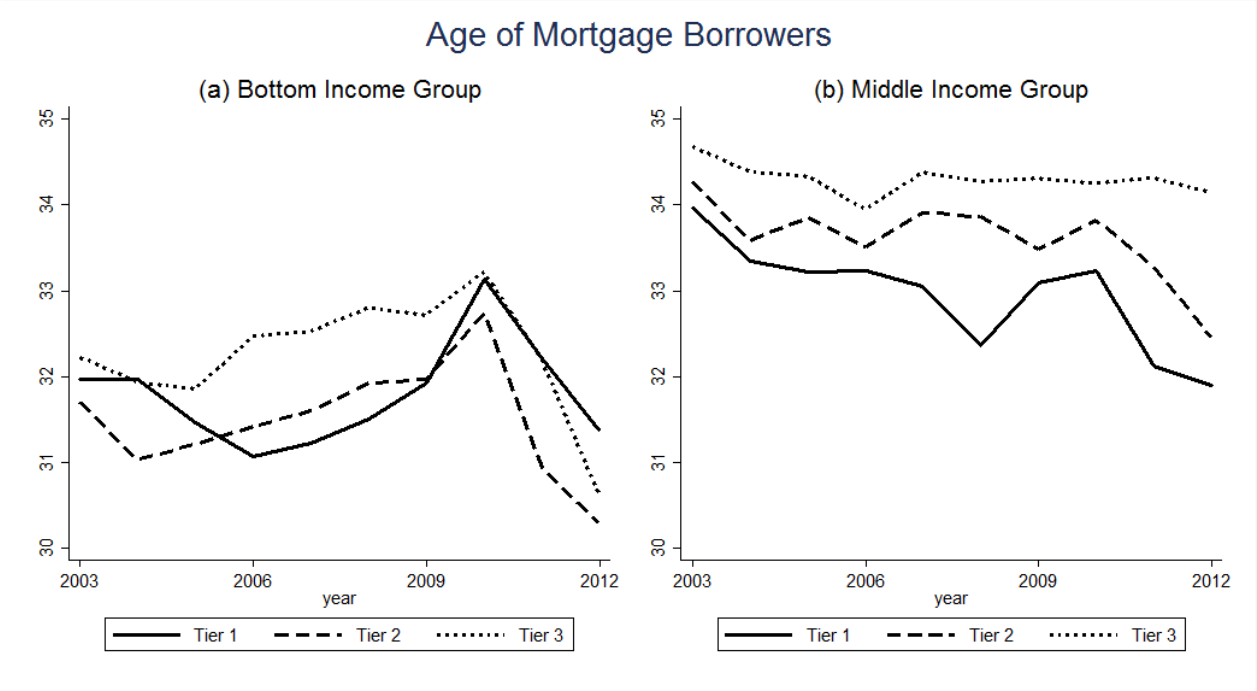


Figure 15: Marital Status of Mortgage Borrowers

The top panel depicts the fractions of single men and single women among middle-income borrowers in three separate plots for first, second, and third tier cities, while the bottom panel depicts these fractions among bottom-income borrowers in three separate plots for first, second, and third tier cities.

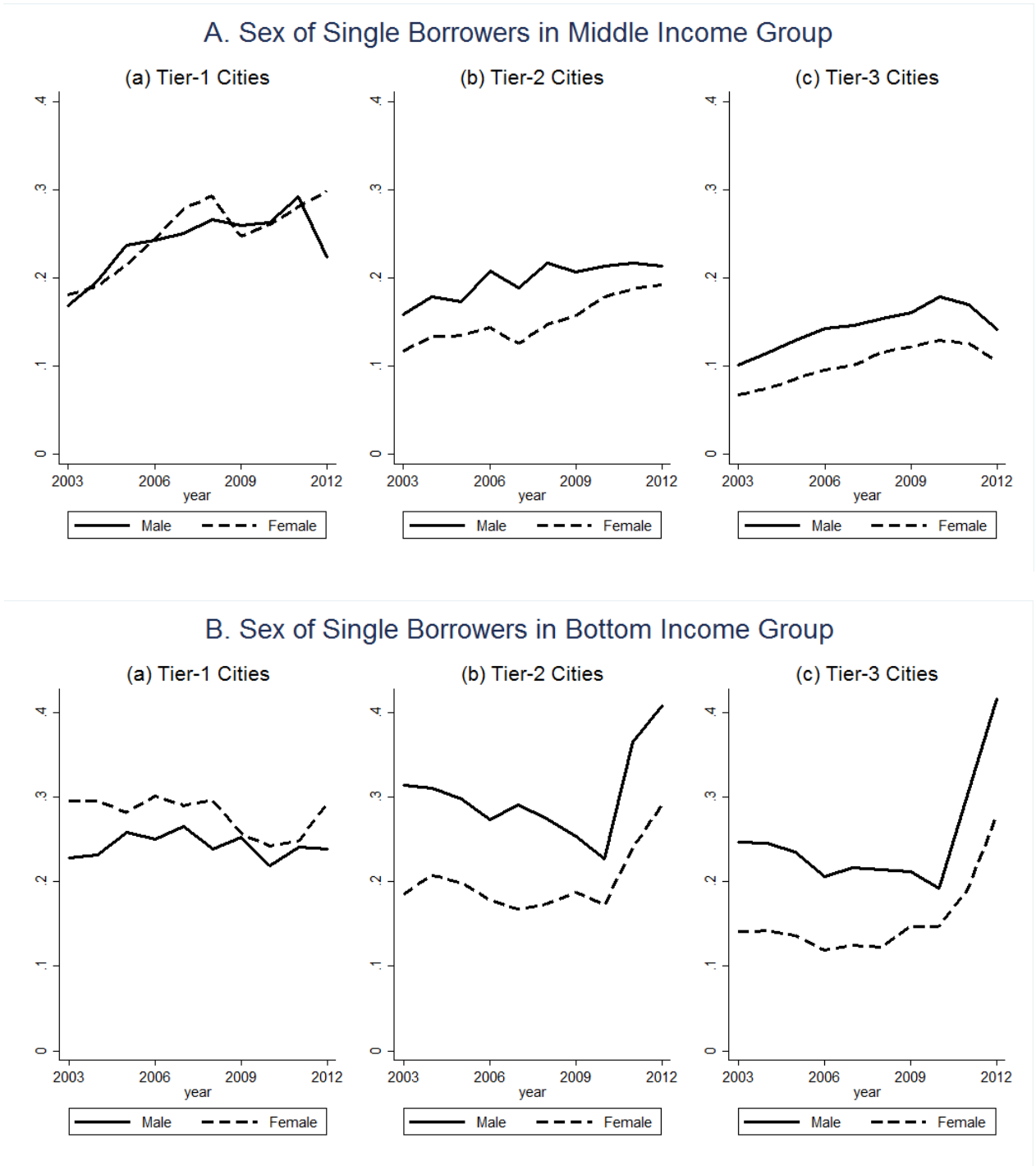


Figure 16: Bank Deposits and Stock Market Capitalization

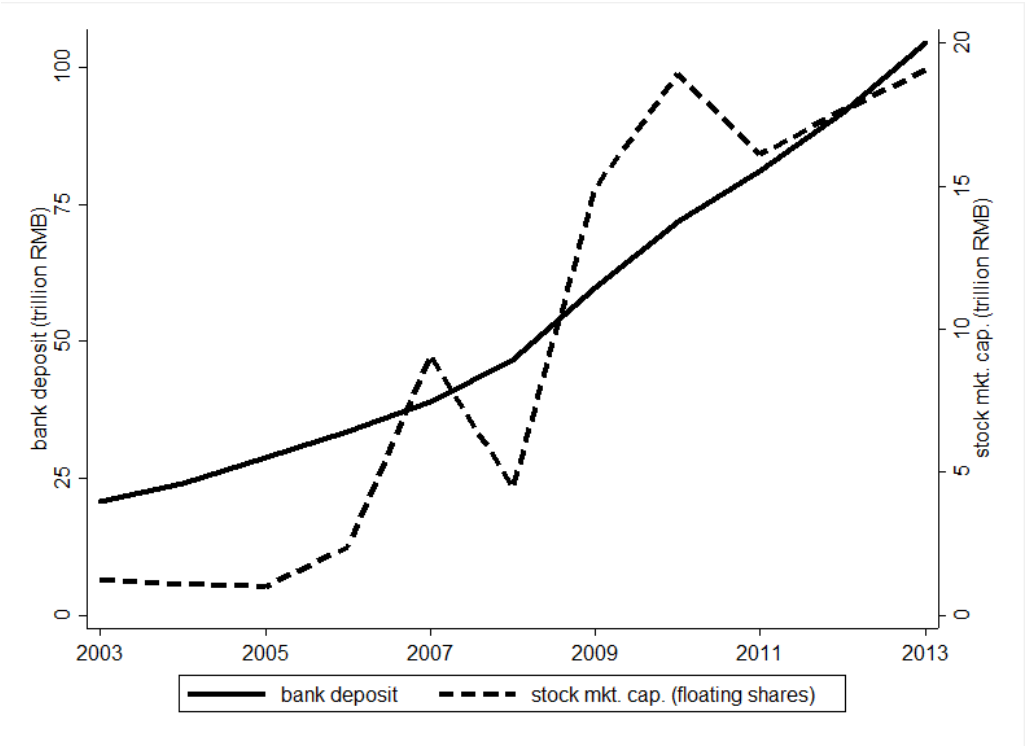


Figure 17: Shanghai Stock Market Index

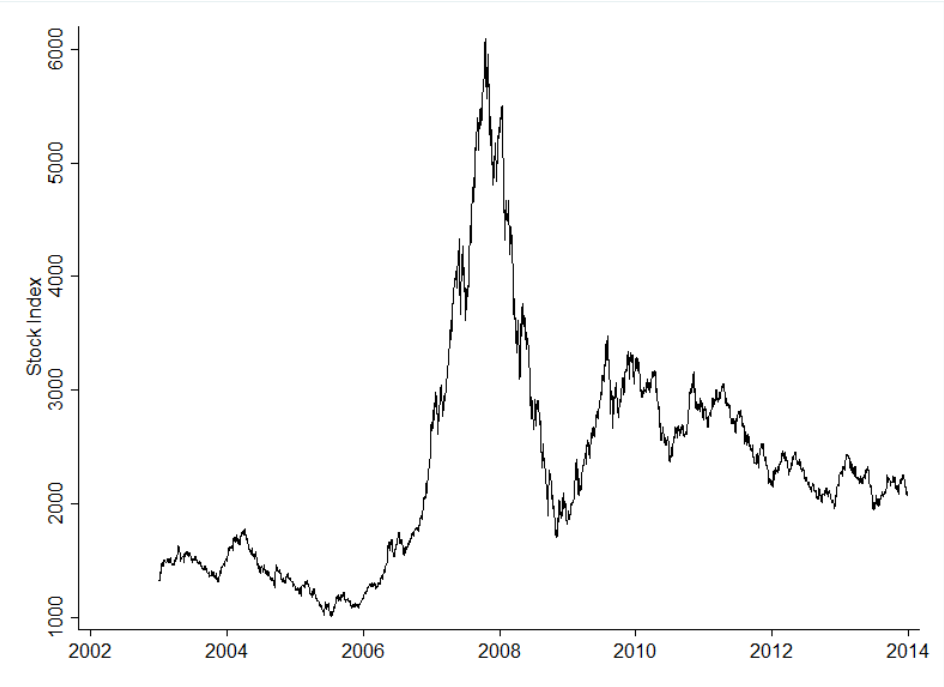


Figure 18: Share of Land Revenue in City Budget

The top panel depicts the national average of share of land sales revenue in cities' fiscal budgets, while the bottom panel depicts the average among first-tier cities, second-tier cities and all other cities. Data Source: China Municipal Statistical Yearbook and China National Land Resource Yearbook.

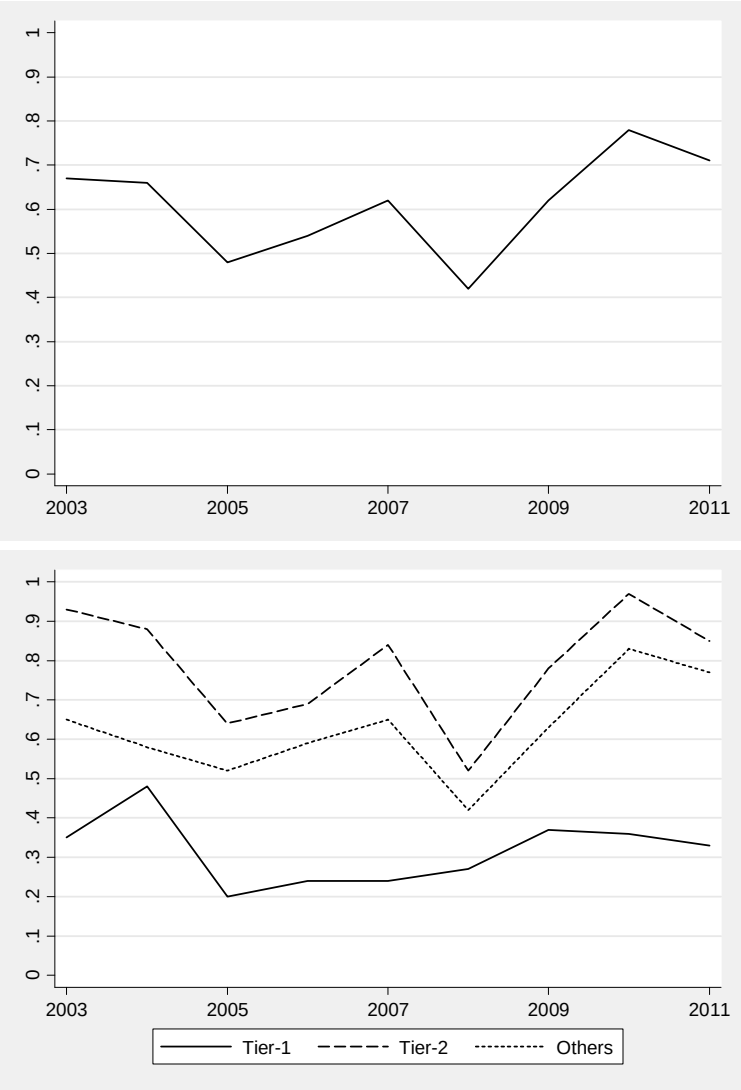


Table 1: Summary Statistics of Housing Return and Growth of GRP and Disposable Income, by Tier of Cities

Panel A: Nominal Growth

Nominal Growth	Obs	January 2003 - December 2007				January 2009 - March 2013				January 2003 - March 2013			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Tier-1 Cities													
Housing Price Index	4	.210	.027	.172	.230	.177	.033	.139	.219	.159	.031	.128	.200
Per capita GRP index	4	.114	.020	.097	.144	.066	.020	.038	.081	.094	.016	.074	.112
Per capita DI index (urban)	4	.099	.025	.061	.116	.102	.003	.098	.105	.093	.028	.051	.110
Tier-2 Cities													
Housing Price Index	31	.168	.056	.021	.290	.116	.034	.043	.216	.132	.022	.082	.189
Per capita GRP index	30	.136	.050	.010	.235	.129	.031	.052	.191	.134	.033	.042	.189
Per capita DI index (urban)	30	.119	.025	.055	.178	.113	.013	.098	.164	.117	.015	.078	.152
Tier-3 Cities													
Housing Price Index	85	.113	.067	-.099	.250	.114	.036	.041	.242	.106	.036	.007	.178
Per capita GRP index	85	.154	.045	.006	.260	.140	.036	.037	.214	.150	.032	.030	.231
Per capita DI index (urban)	74	.118	.020	.059	.186	.117	.011	.087	.141	.117	.012	.079	.154

Panel B: Real Growth

Real Growth	Obs	January 2003 - December 2007				January 2009 - March 2013				January 2003 - March 2013			
		Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
Tier-1 Cities													
Housing Price Index	4	.187	.027	.148	.206	.151	.033	.113	.193	.131	.031	.100	.172
Per capita GRP index	4	.090	.020	.074	.120	.040	.020	.012	.055	.067	.016	.046	.085
Per capita DI index (urban)	4	.075	.025	.038	.092	.076	.003	.072	.079	.066	.028	.024	.083
Tier-2 Cities													
Housing Price Index	31	.145	.056	-.002	.266	.090	.034	.017	.190	.105	.022	.054	.162
Per capita GRP index	30	.113	.050	-.013	.212	.103	.031	.026	.165	.107	.033	.015	.161
Per capita DI index (urban)	30	.095	.025	.031	.154	.087	.013	.072	.138	.090	.015	.050	.125
Tier-3 Cities													
Housing Price Index	85	.090	.067	-.123	.227	.089	.036	.015	.216	.079	.036	-.021	.150
Per capita GRP index	85	.131	.045	-.018	.236	.114	.036	.011	.188	.123	.032	.003	.204
Per capita DI index (urban)	74	.094	.020	.036	.162	.091	.011	.061	.115	.089	.012	.052	.127

Table 2: Fraction of Second Mortgages

	2011	2012	2013
First-Tier Cities	5.3%	5.2%	11.8%
Second-Tier Cities	2.0%	2.4%	3.3%
Third-Tier Cities	1.0%	1.3%	1.8%

Table 3: Summary Statistics of Annual Returns of the Shanghai Stock Market Index (2003-2013)

	Mean	Std. Dev.	Skewness
2003-2013	.073	.515	-.153
2003-2008	.0898	.662	-.337
2009-2013	.053	.339	1.182

Table 4: Summary Statistics of Annual Housing Returns (2003-2013)

Full Sample (2003-2013)			
	Mean	Std. Dev.	Skewness
First-Tier Index	.157	.154	-.674
Second-Tier Index	.135	.0989	.564
Third-Tier Index	.110	.075	.092

Before 2009 (2003-2008)			
	Mean	Std. Dev.	Skewness
First-Tier Index	.204	.105	-.059
Second-Tier Index	.173	.099	.852
Third-Tier Index	.117	.095	-.028

After 2009 (2009-2013)			
	Mean	Std. Dev.	Skewness
First-Tier Index	.109	.191	-.249
Second-Tier Index	.097	.094	.474
Third-Tier Index	.103	.059	-.057