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Bubbles in China's Housing Market

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The housing market in China has been booming since the housing reform in the 1990s. This has raised concerns around the world that the Chinese housing market is a bubble about to burst, particularly after the 2008 Global Financial Crisis which was triggered by a housing bubble burst. After implementing a number of empirical methods with panel data that cover 30 provinces/municipalities from 2002 to 2020, the results show that house price is cointegrated with the relevant market fundamentals in the long run. At the same time, short-run fluctuations and deviations in house prices from market fundamentals also exist. The estimation results identify two distinct features of the housing bubble. The first feature is that there are two obvious bubble periods. The first bubble period is from 2009 to 2013 and the second bubble period is from 2017 to 2020. The second feature is that the size of the bubble varies among the different regions. The largest bubble occurred in Hainan province in 2010, which is as large as 40% of the equilibrium value determined by market fundamentals. As for the national average, the largest bubble is also recorded in 2010, the size of which is 11% of the equilibrium value determined by market fundamentals.

Keywords

Housing bubble; Fundamentals; Provincial data; Chinese housing market

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1. Introduction

The term bubble was used for the first time to describe an economic event during the "Tulip mania" period of time in the Netherlands in the 17th century, which is generally considered as the first recorded asset bubble in history. Following the tulip bubble, several other well-known bubble events also occurred, such as the South Sea Bubble in Great Britain and Mississippi Stock Bubble in France both in the 18th century (Garber, 1990). Since then, more and more researchers have investigated bubbles as an economic phenomenon. Housing bubbles also exist in many countries and regions across the world. In the 1990s, the bursting of a housing bubble resulted in a decade long economic recession in Japan and a sharp drop in asset prices in many Asian economies (Schnabi, 2015). Another major Asian economy, Hong Kong, also experienced a major housing bubble burst in 1997, which had a catastrophic impact on its economy (Jao, 2001). Moreover, the 2008 Global Financial Crisis was triggered by a housing bubble burst associated with the subprime crisis in the United States (Claessens et al., 2010). Most recently, whether there is a bubble in the housing market in China has become a popular topic of discussion.

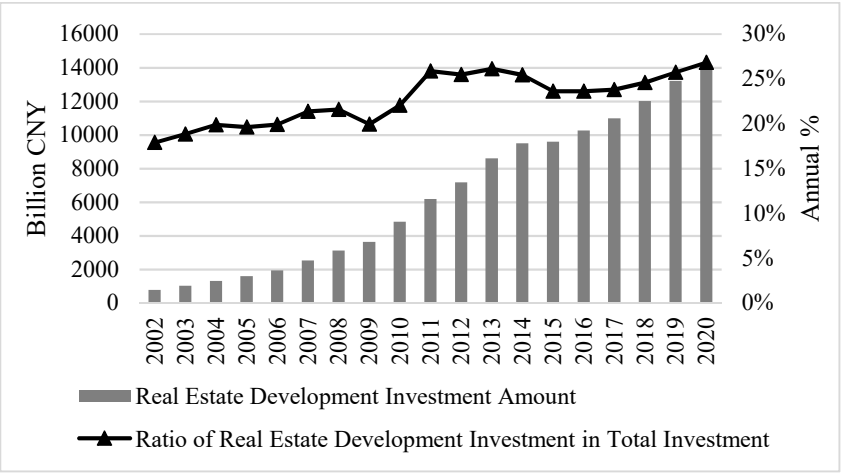
In the 1980s, the Chinese government implemented several housing reform policies to transform the state-allocation housing system into a market-oriented system (Chen and Gao, 1993). Before the housing reform, all of the apartments in the city were owned by the government or state-owned enterprises, and allocated to urban citizens at very low prices (Dreger and Zhang, 2013). The Chinese government has since been actively promoting investment in the real estate market. The real estate industry has a long industrial chain and can drive the development of many industries, such as construction, décor, home appliances, and so on and so forth. In 2015, 70% of the produced cement, 70% of the produced glass, 40% of the produced wood products, 25% of the produced steel and 25% of the produced plastic were used for the housing construction sector in China (Zhang, 2019). Investment in real estate development grew from 779.09 billion yuan (USD equivalent (2023)[1]: $106.77 billion USD) in 2002 to 14.14 trillion yuan (USD equivalent (2023): $1.94 billion USD) in 2020, which is approximately an 18 times increase. The ratio of real estate development investment to total investment increased from 17.91% in 2002 to 26.83% in 2020, which is shown in Figure 1[2].

The GDP growth rate in China remained within the range of 2.3% and 14.2% from 2002 to 2020, which is an average growth rate of 8.7%. At the same time, the real estate industry grew between 4.2% and 32.9% from 2002 to 2020, recording an average growth rate as high as 15.8%, as shown in Figure 2[3]. These

[1] 1 CNY = 0.137039 USD, Sept 20, 2023
[2] Source: National Bureau of Statistics. https://data.stats.gov.cn. Last accessed May 13, 2022.
[3] ibid

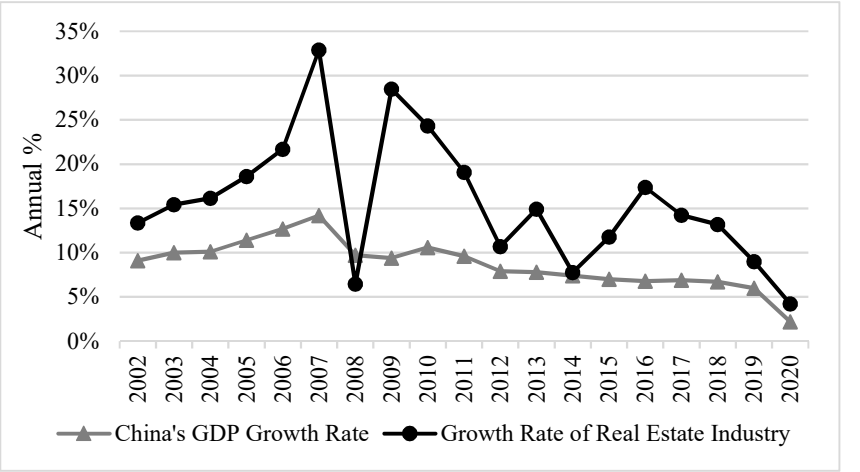
statistics show that the real estate sector plays a predominant role in the economy of China.

Figure 1 Investment in Real Estate Development in China



On the other hand, the Chinese government owns all of the land although the buildings and houses belong to individuals. Enterprises and individuals are only allowed to purchase the right to use urban land from the government for 70 years for residential purposes, 50 years for industrial purposes and 40 years for commercial purposes (Wu et al., 2012). The Chinese economy has been developing rapidly but largely in a few select areas, thus resulting in the concentration of job opportunities and public resources in a few highly developed regions as well as an immense gap between the urban and rural areas. This asymmetrical regional development contributes to migration from the less developed regions to the regional or national economic centers. Unlike many other countries, particularly Western countries, the Chinese usually do not rent housing. Homeownership plays an important role in the Chinese culture and a house is considered a necessity for marriage, thus creating tremendous demand for houses (Glaeser et al., 2017). On the supply side, the local governments control the supply of land and the overall real estate development plans. With soaring land prices (LPs) and rapid growth of the housing market, land selling has become the main source of revenue for local governments, accounting for around 30% of their total revenue (Gabrieli et al., 2018a). Therefore, the local governments are incentivized to push up the housing price (HP) as well as the LP (Gabrieli et al. 2018a). National wealth is rapidly transferred from private households to the government through housing market transactions.

Figure 2 GDP Growth Rate and Real Estate Industry Growth Rate



The housing market in China has been booming since 2000. The house price index increased by 332% from 2000 to 2015 (Gabrieli et al., 2018a). The real estate price in Beijing, Shenzhen and Shanghai almost quadrupled during the period of 2008-2017 (Zhi et al., 2019). Some economists were concerned and warned about the potential collapse of the Chinese real estate market. The phenomenon of "ghost cities" in China was considered as evidence of a housing bubble about to burst (Jiang et al., 2017; Aveline-Dubach, 2020). Surprisingly, beyond all expectations of a bubble bursting, real estate market prices began to increase again in highly developed Chinese cities, such as Shenzhen and Shanghai. In addition, the price increase trend even spread to less developed small cities, without any evidence that implies a dramatic price downturn by far (Aveline-Dubach, 2020). The fluctuations and bursting of a housing bubble have a significant influence on both the real economy and financial system. The output losses caused by the bursting of housing bubbles can be twice that of stock bubbles. A sharp drop in house prices (HPs) is more serious than a stock market crash because real estate are among the most important properties underlying bank loans, and house ownership is associated with most of the population (POP) (Goodhart and Hofmann, 2008). On the other hand, some researchers have rejected the bubble hypothesis. They find that the real estate boom could be justified by economic factors such as rapid economic development, urbanization, excessive liquidity and social factors like the cultural preference for owning a house among the Chinese people (Mak et al., 2007).

In light of the 2008 Global Financial Crisis, the Chinese central government implemented a massive 4-trillion yuan (USD equivalent (2023): $0.55 trillion USD) investment package in November 2008 with the aim to stimulate the domestic economy, which further pushed the housing boom (Wu, 2014). At the

same time, the central bank of China implemented a lax monetary policy which resulted in excessive monetary liquidity. The commercial banks were increasingly lenient toward real estate mortgage loans (He et al., 2013). Furthermore, the underdeveloped financial market together with the strong preference for housing ownership further contributed to the speculative investment in the real estate market, particularly after the stock market crashes in 2008 and 2015 (Liu and Xiong, 2018). The overheating real estate market associated with the increasing financial fragility has raised the concern of the Chinese central government, who in turn, has implemented a number of restrictions on housing purchases to control the overheating real estate market since 2004 (Zhang and Fung, 2006).

The continuous growth and fluctuations in HPs have raised concerns about a potential housing bubble. While China has experienced rapid economic development and urbanization, along with a strong cultural preference for homeownership, the dynamics of the housing market and its relationship with market fundamentals remain unclear. Moreover, the significant impacts of the housing market on the real economy and financial system necessitate a comprehensive understanding of the existence, size, and duration of housing bubbles in different regions of China. Hence, this paper investigates the dynamic relationship between HP and market fundamentals in China, identifies the existence of a housing bubble, and evaluates the size and duration of this housing bubble in different regions of China.

The article is organized as follows. The next section reviews the relevant literature. A discussion of a theoretical framework on housing bubbles is provided in Section 3. The methods to detect bubbles as well as econometric issues are discussed in Section 4. The empirical results are presented in Section 5. Finally, Section 6 concludes.

2. Literature Review

2.1 Housing Price Boom

Housing bubbles exist in many countries and regions across the world. The housing market in China has been booming along with rapid economic growth, particularly in the major cities such as Shanghai, Beijing, Shenzhen and Guangzhou. Based on a theoretical framework that HP is determined by local market fundamentals, Liu et al. (2017) measure the housing bubble in 35 big cities and 30 provinces in China during the period 1994-2014 by analyzing a panel data set. Their results indicate that housing bubbles existed in 10 provinces during the period 2007-2014. They also compare the differences between the housing bubbles in China and Japan. They argue that the recent housing bubble in China is less serious than the bubble in Japan in the 1980s, hence it is unlikely that Chinese housing bubble will burst and the housing

market in China will most probably have a soft landing just like Japan in the 1970s.

Glaeser et al. (2017) compare the housing boom in China with that in the United States and find that the housing booms in the two countries have quite different features from one another. First, the HP increases much faster in China than in the United States. Second, the construction of new housing space in China is much greater than the construction in the United States during the housing boom. From 2011 to 2014, 45.9 billion square feet floor space of residential building was built in China. On the contrary, from 2003 to 2006, only 16 billion square feet was built in the United States. Third, unoccupied houses held by households and housing inventories held by real estate developers are much larger in China compared with the United States. Fourth, the Chinese government plays a greater role in the real estate market compared with the United States. By analyzing both the demand and supply sides, Glaeser et al. (2017) conclude that the real estate market boom is not a bubble that is about to burst. The future development of the housing market in China depends largely on the policy of the Chinese government.

2.2 Housing Bubble Measure

Different empirical methods have been used to test the existence and measure the size of housing bubbles in China. One approach is the structural model which estimates the equilibrium value of real estate based on demand and supply side market fundamentals, such as income, POP, LP, lending interest rate (LI) and so on and so forth. In other words, the HP should be cointegrated will the value of the market fundamentals in the long run. To identify the existence and measure the size of housing bubbles in Japan and China, Liu et al. (2017) establish a structural model based on supply and demand side market fundamentals to analyze the price determination mechanism in the housing market.

Gabrieli et al. (2018a) estimate housing bubble dynamics in China with a state space model and find evidence of housing bubbles, particularly after 2010. The average deviation between the estimated fundamental and actual prices is over 40% and the deviation peaked at 80% in 2012. The estimated size of the housing bubble in this study is significantly higher than that in other studies. Shih et al. (2014) adopt a cointegration test with loan-to-income ratios and structural changes based on the real estate price data of 28 Chinese provinces from Q1 2000 to Q4 2012. Their results suggest the existence of bubbles and an affordability problem in most Chinese provinces. In addition, Dreger and Zhang (2013) investigate HP with the panel cointegration method based on panel data that cover 35 Chinese cities. Their empirical results suggest a housing bubble with the size of 15% of the equilibrium value determined by economic fundamentals existed in China in 2010. The size of the bubble in the southeastern coast and special economic zones (SEZs) is larger than that in the

other regions. For example, the housing bubble in Haikou city (Hainan province) blew up to 40% of the equilibrium value in 2010.

On the other hand, several studies find no or very weak evidence of housing bubbles in China. Ren et al. (2012) investigate the housing market in China by applying the rational expectation bubble theory. Based on data of 35 Chinese cities, they estimate the fundamental value of houses by discounting predicted future rental income. No evidence is found to confirm the existence of housing bubbles in China. Furthermore, Chen and Funke (2013) apply a recursive unit root test to identify the existence and duration of a speculative housing bubble in China. Their empirical results show that except for the period of 2009-2010, actual real estate price is basically in line with the economic fundamentals, of China so the evidence for a speculative bubble is weak.

Note that there are contradicting findings among researchers in analyses of housing bubbles in China, thus implying the difference in the definition of a bubble among the different groups of researchers. The group that supports the existence of bubbles estimates the equilibrium HP by using economic fundamentals and any deviation of actual market price from the equilibrium price is identified as a bubble. On the contrary, the group that rejects the existence of bubbles argues that only a persistent deviation of actual HP from the equilibrium price can confirm the existence of a bubble. This persistence can be shown as the explosive behavior in recursive unit root tests (Chen and Han, 2014).

To the best of our knowledge, most of the existing studies focus on the large cities in the national or regional economic centers, mainly Tiers 1 and 2 cities and a small number of Tier 3 cities when analyzing housing bubbles in China. Few studies examine the housing market in the Tiers 4 and 5 cities, which account for roughly two-thirds of the 338 prefecture-level cities in China. This research contributes to the literature by analyzing the housing market bubbles with provincial level data, which include the information of 219 Tiers 4 and 5 cities. Besides, most of the existing studies use data only up to around the year 2015. This research contributes to the literature by using the latest available data up to 2020, which can also reflect the impact of COVID-19 on the housing market in China.

3. Theoretical Framework for Bubbles in Housing Market

A bubble is used to describe the continuous overpricing of assets. A bubble refers to a period when the price of assets exceeds the equilibrium value determined by market fundamentals because investors believe that the assets can be sold at a higher price in the future. In his General Theory of Employment, Interest and Money, John Keynes classified investors into two groups. The first group of investors purchase an asset because of the fundamental value and the

second group of investors are speculators who purchase assets because of the future resale value (Brunnermeier and Oehmke, 2013). The bubble is of interest to economists because the price of assets affects the allocation of capital and resources in the economy. The presence of a bubble could distort the investment decisions of economic agents, thus resulting in excessive investment in overpriced assets. For instance, bubbles in the housing market could result in inefficient new home construction.

The history of asset price bubble theories can be traced back to the 1980s and many theories have been developed to explain the buildup of asset price bubbles. Brunnermeier and Oehmke (2013) classify these theories into the following categories: the rational bubble (Blanchard and Watson, 1982), overlapping generations (Tirole, 1985), informational friction (Abreu and Brunnermeier, 2003), delegated investment (Allen and Gorton, 1993) and heterogeneous belief (Miller, 1977). Regardless of which factors contribute to a bubble, housing bubbles can be defined as the time period when HP increases sharply above the equilibrium value which is determined by market fundamentals, such as rent, income, POP, interest rate, LP and so on and so forth. Furthermore, HP could increase explosively during speculative bubble periods. The existence and size of housing bubbles can be tested and measured by using different empirical methods (Kholodilin et al., 2018).

A bubble indicates the price of an asset that deviates from its fundamental value, which usually results in a reverse expectation followed by a sharp decrease in prices or a bubble crash. According to the basic economic theory, the price of goods is determined by the interaction between market demand and supply. Thus, it is necessary to estimate the fundamental value of real estate determined by market fundamentals to identify the existence of bubble and measure its size. Based on such a theoretical framework, Hui and Shen (2006) and Hui and Wang (2014) identify housing bubble in China by investigating the deviation of actual HP from the equilibrium price determined by the demand for and supply of housing.

This research establishes a theoretical model based on the equilibrium between housing demand and supply. House price is determined by the interaction between housing demand and supply in a competitive housing market (Quigley, 1999). The interaction is expressed by:

$$HP = f(H^D, H^S) \tag{1}$$

where H^S and H^D represent HP, the determinants of house supply and house demand, respectively. House demand is a function of HP and market fundamentals, such as gross domestic product (GDP) per capita, POP and LI. The GDP per capita is a key market fundamental. GDP per capita increase results in income increase and then housing demand increase. Real estate is not only an asset but also a consumption good. Therefore, when the GDP per capita growth causes inflation, people tend to purchase houses or apartments for

hedging purposes, and consequently contribute to demand increase in the housing market. POP increases suggest POP growth in a certain area, which results in an increase in real estate demand. Since the LI is highly correlated with the mortgage rate, changes in LI can affect the costs of consumers who rely on mortgage loans, hence affecting housing demand. Therefore, the demand function for houses is as follows:

$$H^D = d(P, GDP, POP, LI) \tag{2}$$

On the other hand, housing supply is a function of the HP and market fundamentals, namely LI, LP and investment of developers (INV). The LI represents the financial cost of house development investment. A decrease in LIs stimulates borrowing of the house developers, thus increasing the housing supply. An increase in LIs pushes up the financial cost of the house developers, thus reducing house supply. Similarly, a change in LP affects the cost of the developers, hence influencing house supply. In addition, investment in real estate development is a measurement of the expectations and, confidence of developers, as well as the capital circumstances of industries, which can also affect house supply. Hence, the supply function for houses is expressed as:

$$H^S = s(P, LP, LI, INV) \tag{3}$$

After substituting Equations (2) and (3) into Equation (1) and solving for HP, the following function of HP is obtained, which is also the theoretical model of this research:

$$HP = f(\ GDP, POP, LI, LP, INV) \tag{4}$$

Based on the above theoretical model, an empirical analysis of the Chinese housing market is conducted in this research work. First, this research study investigates the dynamic relationship between HP and market fundamentals in China based on the theoretical model established between HP and the main economic determinants. Secondly, this research identifies the existence of a bubble in the housing market in China and evaluates the size and duration of the housing bubble in different regions of China.

4. Data and Empirical Methods

4.1 Data

The panel data for the variables in this research, namely HP, GDP, POP, LI, LP, and INV, are collected annually for the period between 2002 and 2020 from the database of the China National Bureau of Statistics and 30 provinces/municipalities are included in the panel data. The proxy of HP is the average selling price of commercial residential buildings which is measured in yuan per square meter. On the demand side, per capita GDP is measured in yuan per person. POP is measured by 10,000 persons at the end of the year in the region. The LI is proxied by the longer than 5-year long-term official

benchmark interest rate of financial institution loans, which is set by the People's Bank of China. On the supply side, LP is proxied by the value of land purchased by enterprises for real estate development in yuan per square meter, which is calculated by dividing the total value of the land purchased by enterprises for real estate development by land space purchased by enterprises for real estate development in the year. The INV is proxied by the investment actually completed by enterprises for the development of residential buildings in 100 million yuan (USD equivalent (2023): $13.71 million USD). To remove the influence of inflation, all of the nominal data is deflated by the consumer price index to obtain data in real terms. In addition, all of the data are transformed into a log form. Log transformation compresses the scale in which the variables are measured, thereby reducing a tenfold difference between two values to a twofold difference.

4.2 Empirical Methods

First, a unit root test for panel data in Im et al. (2003) (hereinafter referred to as the IPS test) is conducted in this research work to investigate the long-term relationship between HPs and market fundamentals in China. Second, the cointegration test in Pedroni (1999, 2004) is conducted to identify a long-run relationship between non-stationary HP and market fundamentals series after testing for data stationarity. Third, this research study performs a standard Granger causality test to investigate the causation and predictability between economic factors.

4.3 Panel Regression

Based on the above theoretical framework, logarithmic forms of HP (LHP), GDP per capita (LGDP), population (LPOP), land price (LLP), and investment in housing development (LINV), and LI are entered into a multiple linear panel regression model with a cross-section fixed effect, which is expressed as Equation (5), and estimated with the panel least squares estimation method:

$$\begin{aligned} LHP_{it} = \beta_0 + \beta_1 LGDP_{it} + \beta_2 LPOP_{it} + \beta_3 LLP_{it} + \beta_4 LINV_{it} \\ + \beta_5 LI_{it} + u_{it} \\ i = 1,2,\dots,N; t = 1,2,\dots,T \end{aligned} \tag{5}$$

where u_{it} represents a residual term, i represents a certain province among all 30 provinces in the sample and t represents a certain year between 2002 and 2020.

In addition, it is crucial to consider that provinces in China span a vast geographical region, encompassing both urban and rural areas that demonstrate substantial disparities. Numerous studies have consistently emphasized the

variations in economic development observed across different regions in China (Zhang et al., 2017). Therefore, to thoroughly examine the regional discrepancies in housing bubbles, we have conducted regression analyses that are segmented into three regions. The National Development and Reform Commission (NDRC) of China has implemented a three-region classification system for all provinces within the country. The eastern region pertains to the most economically developed provinces, while the western region comprises the least economically developed ones. The middle region, on the other hand, encompasses provinces with an economic development that falls between the aforementioned regions. It is noteworthy that economic policies are formulated based on this classification, which makes the system a crucial tool that policymakers use to evaluate and address regional economic disparities. Table 7 presents the classification of the provinces into the three aforementioned regions.

4.4 Measurement of Housing Bubble

Hui and Wang (2014) argue that defining the deviation between theoretical HP determined by market fundamentals in a regression and actual HP as a bubble is not precise because this deviation includes the random disturbance term that appears in all regression models. Based on this viewpoint, this research defines the random disturbance term as $u_{it} = e_{it} + \pi_{it}$, where e_{it} represents the rational fluctuation of HP included in the random disturbance term, and π_{it} represents abnormal movement, thus implying a bubble or underpricing. Therefore, the following equation is formed:

$$u_{it} = LHP_{it} - LHP_{it}^{*} = e_{it} + \pi_{it} \tag{6}$$

Then, the bubble size is defined as Equation (7), where P denotes the actual HP and P^{*} denotes the estimated HP:

$$BS = \frac{P - P^{*}}{P^{*}} \times 100\% \tag{7}$$

Substituting Equations (5) and (6) into (7) transforms the bubble size equation into the following form:

$$\begin{aligned} BS = \frac{P - P^{*}}{P^{*}} \times 100\% = \frac{e^{LRP} - e^{LRP^{*}}}{e^{LRP^{*}}} \times 100\% \\ = \left(e^{(LRP - LRP^{*})} - 1\right) \times 100\% = (e^{u} - 1) \times 100 \end{aligned} \tag{8}$$

The boundary of the rational fluctuation e_{it} is defined as b = standard error of regression. According to Equation (6), if $-b < u_{it} = e_{it} + \pi_{it} < b$ and $\pi_{it} = 0$, there is no housing bubble. If $u_{it} = e_{it} + \pi_{it} > b$ and $\pi_{it} > 0$, there is the existence of a housing bubble. If $u_{it} = e_{it} + \pi_{it} < -b$ and $\pi_{it} < 0$, there is underpricing of housing. Based on the panel least squares estimation result of the multiple linear panel regression model in Equation (5), the size of the

housing bubble in 30 Chinese provinces/municipalities is estimated according to Equation (8).

5. Results

5.1 Descriptive Statistics and Correlation

The descriptive statistics of the variables selected in this research are reported in Table 1. The correlations among the selected variables are reported in Table 2. According to the table, the correlations between HP and the variables GDP, LP and INV are positive. The correlations between HP and POP and LI are negative.

Table 1 Measurement Scales and References for the Proposed Constructs

Variable	Mean	Standard Deviation	Minimum (Province)		Maximum (Province)	
HP	4043.51	3372.34	907.00	(Jiangxi)	26953.41	(Beijing)
GDP	27652.85	18163.97	3257.00	(Guizhou)	104702.70	(Beijing)
POP	4472.27	2732.69	529.00	(Qinghai)	12624.00	(Guangdong)
LP	4480.16	9701.27	155.38	(Xinjiang)	87756.34	(Shanghai)
INV	1079.84	1167.68	9.48	(Qinghai)	7521.01	(Guangdong)
LI	5.95	0.78	4.90	N/A	7.485	N/A

Notes: HP denotes house price, GDP denotes gross domestic product per capita, POP is population, LP is land price, INV is investment in real estate development, and LI represents lending interest rate.

Table 2 Correlations Among the Selected Variables

Variables	HP	GDP	POP	LP	INV	LI
HP	1.0000	0.8917	-0.0905	0.8698	0.3791	-0.3015
GDP	0.8917	1.0000	0.0088	0.7388	0.5807	-0.3741
POP	-0.0905	0.0088	1.0000	-0.0578	0.6058	-0.0334
LP	0.8698	0.7388	-0.0578	1.0000	0.2986	-0.3597
INV	0.3791	0.5807	0.6058	0.2986	1.0000	-0.3345
LI	-0.3015	-0.3741	-0.0334	-0.3597	-0.3345	1.0000

Notes: HP denotes house price, GDP denotes gross domestic product per capita, POP is population, LP is land price, INV is investment in real estate development, and LI represents lending interest rate.

5.2 Data Stationarity and Cointegration

The results of the IPS test indicate that all of the variables in the panel data are stationary after the first differencing and integrated of order one I(1), as Table 3 shows.

Since both HP and market fundamental variables are integrated in the same order, naturally the next step is to test for cointegration in the panel data. The procedure for conducting the group ADF t-statistic in Pedroni (1999) between HP and the market fundamentals is shown in Table 4. Although HP is cointegrated with all of the market fundamentals, the cointegration relationships are based on the cointegration equation with deterministic trends with both individual intercepts and trends. With the specified trend term, HPs could move far from the market fundamentals, thus implying evidence of a housing bubble.

Table 3 Panel Data Unit Root Test

Variable	IPS Test Statistics (P-value)				Result
	Level		First Difference		
LHP	2.5292	(0.9943)	-13.3878	(0.0000)	I(1)*
LGDP	10.7560	(1.0000)	-5.1933	(0.0000)	I(1)*
LPOP	3.8830	(0.9999)	-9.8717	(0.0000)	I(1)*
LLP	6.2624	(1.0000)	-19.7583	(0.0000)	I(1)*
LINV	1.7581	(0.9606)	-8.3793	(0.0000)	I(1)*
LI	1.2210	(0.8890)	-10.5285	(0.0000)	I(1)*

Notes: Significance at the 1% level is denoted as *. HP denotes house price, GDP denotes gross domestic product per capita, POP is population, LP is land price, INV is investment in real estate development, and LI represents lending interest rate.

Table 4 Panel Cointegration Test

Variable	Group ADF t-statistic	P-value	Result
LHP & LGDP	-6.3093	0.0000	Cointegrated*
LHP & LPOP	-5.6301	0.0000	Cointegrated*
LHP & LLP	-3.9491	0.0000	Cointegrated*
LHP & LINV	-5.9616	0.0000	Cointegrated*
LHP & LI	-5.7307	0.0000	Cointegrated*
LHP, LGDP, LPOP, LLP, LINV & LI	-2.6714	0.0038	Cointegrated*

Notes: Significance at the 1% level is denoted as *. HP denotes house price, GDP denotes gross domestic product per capita, POP is population, LP is land price, INV is investment in real estate development, and LI represents lending interest rate.

5.3 Granger Causality Test

The Granger causality test requires the data under investigation to be stationary. The panel data of this research is integrated of order one I(1) and stationary after the first differencing. Therefore, pair-wise Granger causality tests with a standard panel specific form are used to investigate the causal relation between the first differenced HP variable and the first differenced market fundamental variables, as summarized in Table 5.

The results show a bidirectional causal relation between the changes in GDP per capita and HP, which indicates that the HP increase in China is to a certain extent due to the increased house demand resulting from the growth of income. At the same time, the change in HP also Granger causes the change in GDP per capita, which is because of the capital gains from the constant appreciation of HP. The huge wealth effect along with the housing boom in China stimulates speculations in the real estate market, thus generating a housing bubble. Another reason for this casual relation from HP to GDP per capita is that the real estate industry in China plays a crucial role in the national economy and contributes to a large portion of the GDP. By employing similar empirical methods with Beijing and Shanghai data from 1998 to 2012, Hui and Wang (2014) also find that HP and disposable income are cointegrated and disposable income has a positive influence on HP.

Table 5 Summary of Granger Causality Test

Variable (First Difference)	F-statistic	P-value	Result
LGDP => LHP	3.0734	0.0061	Y***
LHP => LGDP	4.2694	0.0004	Y***
LPOP => LHP	1.2014	0.3049	N
LHP => LPOP	2.0874	0.0541	Y*
LLP => LHP	0.8442	0.5365	N
LHP => LLP	0.8340	0.5442	N
LINV => LHP	2.3171	0.0331	Y**
LHP => LINV	6.6863	0.0000	Y***
LI => LHP	13.6557	0.0000	Y***
LHP => LI	16.2242	0.0000	Y***

Notes: x => y represents null hypothesis that x does not Granger cause y. N denotes the acceptance of null hypothesis. Y denotes the rejection of null hypothesis. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

The results also show that the change in HP Granger causes the change in POP. The reason for this unidirectional causality relation is that continuous HP growth increases the cost of marriage as well the cost of living of Chinese people, especially the younger generation. Therefore, young people delay marriage, which contributes to a low birth rate and a slower POP growth. The

one-child policy and aging POP have resulted in a declining demographic trend in China. This declining demographic trend is most severe in third-tier cities, but less severe in first-tier cities because of the migration from small to large cities. Although the Chinese government abolished the one-child policy in 2016, POP growth is unlikely to pick up again in the short term because the escalating HP delays marriage and increases the unwillingness for people to have children (Rogoff and Yang, 2020). The results of the Granger causality tests show that the causal effect from POP to HP is not significant. This is probably because POP is not an appropriate sociodemographic proxy that affects the demand of housing in China. Dreger and Zhang (2013) argue that the size of households in China are becoming smaller and there is an increasing number of single-family homes compared with before. This trend of smaller home size contributes to additional housing demand. Therefore, the number of families is probably more appropriate to be used as a sociodemographic proxy that affects the demand of housing.

A two-way causality relationship between the change in investment in housing development and the change in HPs is shown in the results. This indicates that the HP growth in China has encouraged real estate developers to invest in the housing industry to pursue profit. At the same time, investment in the housing industry further promotes the development of the real estate industry in China, thus resulting in the changes in HP. This two-way causality relationship between the changes in investment in housing development and HP mainly reflects the influence of the supply side on the HP.

The results also show a bidirectional causal relation between LI and HP, mainly because an increase in the former increases the borrowing cost of home purchasers as well as real estate developers, thus reducing the demand for and supply of houses and resulting in a change in the HP. On the other hand, the causality from HP to LI is mainly because when the housing market is overheated, the People's Bank of China increases the LI to cool down the market or when the growth of HP slows down, the People's Bank of China reduces the LI to stimulate the market. Xu and Chen (2012) investigate the impact of several important monetary policy variables on HP in China. Their empirical results show that a decline in the long-term LI accelerates HP growth, while an increase in the long-term LI decelerates home price growth. Liang and Cao (2007) examine the long-run relationship and causality among HP, bank lending and interest rate in China. They find that interest rate and bank lending Granger cause HP in the long run. By implementing a state space model to investigate the dynamics of a bubble in China's housing market, Gabrieli et al. (2018a) find evidence that the interest rate policy does not limit the housing bubble effectively after 2011. They argue that the existence of shadow banking contributes to the inefficacy of the interest rate policy in China. It remains questionable whether the effect of monetary policy is amplified or weakened by shadow banking. Gabrieli et al. (2018b) argue that an independent shadow banking system coexists with the official monetary policy framework in China. The shadow banking sector magnifies the impacts of increased money supply

while dampens the effects of restrictive monetary policy based on interest rate. The inability to contain a housing bubble is largely because of the oppositional role of shadow banking, given that practically all official interest rate increases in the recent decade are motivated by housing market related policy objectives.

5.4 Panel Regression

A series of four regressions are performed to investigate the relationship between HP and its explanatory variables. The first regression includes data from all provinces, while the subsequent three regressions are conducted after grouping the provinces into three regions, namely, eastern, middle, and western regions. The regression results are presented in Table 6, which shows the static panel data estimates of the models.

Table 6 Estimation Results of Panel Regression Model

Dependent Variable: LHP				
Independent Variable	**All**	**Eastern**	**Middle**	**Western**
LGDP	0.62*** (0.04)	0.73*** (0.09)	0.66*** (0.06)	0.62*** (0.08)
LPOP	0.54*** (0.09)	0.81*** (0.17)	-0.42* (0.24)	-0.45** (0.18)
LLP	0.11*** (0.01)	0.07*** (0.02)	0.08*** (0.02)	0.06*** (0.02)
LINV	-0.03* (0.02)	-0.03 (0.03)	-0.03 (0.03)	-0.01 (0.05)
LI	0.06 (0.05)	-0.01 (0.09)	-0.06 (0.08)	-0.03 (0.09)
Constant	-3.16*** (0.8)	-6.21*** (1.31)	4.66** (2.15)	5.06*** (1.47)
Hausman Test	45.92***	44.78***	18.03***	25.59***
No. of Observations	570	209	190	171
No. of Groups	30	11	10	9
R^2	0.49	0.12	0.68	0.36

Notes: Standard errors are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.

To ensure the reliability of the models, a Hausman test is conducted, which yields significant results, thus indicating that the fixed effects estimates may be consistent. A variance inflation factor (VIF) test is also performed to check for multicollinearity in the model. The VIF values are all less than 10, thus indicating that there are no multicollinearity problems.

The estimation results suggest that, on average, a 1% increase in the GDP is associated with a 0.6%-0.7% increase in HPs across all samples. This finding is consistent with the results of the Granger causality test, which indicates that the growth in Chinese HPs is partly due to an increase in housing demand that results from rising incomes. Additionally, due to the underperformance of the capital market in recent years, wealthy Chinese individuals have chosen to invest in real estate with the expectation of further price increases, further driving up HPs. Dreger and Zhang (2013) conduct a panel cointegration analysis with data that cover 35 cities from 1998 to 2010 to investigate the relationship between HPs and GDP per capita in China. Their empirical results show that these two variables are cointegrated and the estimation of the cointegrating vectors suggests that real income per capita has a positive impact on real HPs.

The impact of POP on HPs exhibits significant variability across the sample. Specifically, the estimation results reveal that for the full sample and the sub-sample pertaining to the eastern region, a 1% increase in POP leads to a corresponding increase in HPs, on average by 0.54% and 0.81%, respectively. In contrast, for the sub-samples that pertain to the middle and western regions, a 1% increase in POP is associated with a decrease in HPs, on average by -0.42% and -0.45%, respectively. This variability could be explained by differences in economic growth and demand for housing across regions. For example, the eastern region, with its strong economic growth and large concentration of job opportunities, may attract a larger POP, thus leading to an increase in demand for housing and higher HPs. In contrast, the middle and western regions are economically less developed provinces, and may experience POP growth due to factors such as natural POP increase or migration of people who are seeking lower living costs. In these cases, the increase in POP may not be accompanied by a corresponding increase in demand for housing, which would lead to an oversupply of housing and a decrease in HPs. Li and Chand (2013) provide additional support for these findings, and explain that HPs in more developed provinces with large-scale immigration movement and POP growth may face limited land supply for residential use. On the other hand, less developed provinces that are experiencing smaller-scale migration movements are not as restricted by limited land supply, which may contribute to the different dynamics observed in HPs.

Across all of the samples, there is a positive and significant relationship between LP and HP. In the full sample, the estimated coefficient of LLP is 0.11, which indicates that a 1% increase in LP leads to an average increase of 0.11% in HP. For sub-samples within each of the three regions, the estimated coefficient of the LLP ranges from 0.06 to 0.08. This result indicates that the increase in LP increases the cost of real estate developers hence the developers must increase the HPs to maintain their profit. Du et al. (2011) study the impact of land policy on the relationship between LP and HP in China. By analyzing panel data that cover 4 Chinese cities, namely Beijing, Chongqing, Shanghai and Tianjin, they find that a long-term equilibrium relation exists between urban

land and housing markets in China. Wu et al. (2012) investigate the urban land market and land supply system in Beijing. Their results show that LP accounted for 60% of the house value in Beijing in early 2010, thus indicating that land is more expensive than the structure of the house. The land sale revenue increased from 542 billion yuan (USD equivalent (2023): $74.28 USD) to 1.6 trillion yuan (USD equivalent (2023): $0.22 trillion USD) in 2009. At the same time, the total revenue of Chinese local governments was 986 billion yuan (USD equivalent (2023): $135 billion USD) in 2003 and 3.3 trillion yuan (USD equivalent (2023): $0.45 trillion USD) in 2009. The income from land sale accounts for a large portion of the revenue of Chinese local governments. The policy and decision of the local governments could significantly affect the LP because they are the monopoly supplier of the land market. Wu et al. (2012) conclude that the increase in LP has been a key driving force of the housing boom in China.

The results suggest a negative relationship between investment in housing development and HP across all samples, but only the full sample shows a significant result. In contrast, the estimates for the three sub-regional samples are all insignificant. This is mainly because the investment in the real estate sector increases the supply of houses, which results in a decrease in the HP. The economic growth model of China is investment driven. The investment in fixed assets accounts for over 70 percent of the total GDP in recent years (Rogoff and Yang, 2020). A significant part of fixed assets investment is allocated to the housing industry. In 2018, investment in housing development contributed to around 13 percent of the GDP, while the highest ratio of housing development to GDP was only around 7 percent in the United States in 2005 (Rogoff and Yang, 2020).

The analysis indicates that the loan interest rate has a positive relationship with HP for the full sample, but a negative relationship for the sub-regional samples. However, all of the estimated coefficients are insignificant for all of the samples. The lack of statistical significance may suggest that other factors beyond the LI are more important in determining the HPs in the samples.

5.5 Measurement of Housing Bubble

According to Equation (6), the rational fluctuation e_{it} is removed, and only the abnormal movement π_{it} is used to measure the housing bubble. Based on the estimation results of the panel least square regression of Equation (5), the housing bubble in the 30 provinces/municipalities is measured based on Equation (8), as described in Tables 5.7 and 5.8. Two distinct features of the size of the housing bubble in the 30 provinces/municipalities from 2002 to 2020 are found according to the estimated bubble size.

The first feature is that there are two obvious bubble periods. The first bubble period is from 2009 to 2013 and the second bubble period is from 2017 to 2020.

Bubbles are detected in 11 provinces/municipalities and 14 provinces/municipalities during the first bubble and second bubble periods, respectively. The main trigger of the first bubble period is the tremendous stimulus package with a total investment of 4 trillion yuan (USD equivalent (2023): $0.55 trillion USD) by the Chinese central government to mitigate the negative impact of the 2008 Global Financial Crisis on the economy. The economic stimulus package mainly focused on investing in infrastructure construction as well as real estate development. Another contributing factor of the first bubble period is the easy monetary policy by the People's Bank of China. A huge portion of the liquidity entered the real estate sector, which contributed to the formation of a housing bubble. As the housing sector continued to boom, real estate developers continued to construct new houses with bank loans, which resulted in an over supply of houses. Consequently, developers experienced difficulties in selling houses and repaying their bank loan, which threatened the stability of the financial system as well as the macroeconomy. At the same time, housing affordability was also becoming more and more serious. Under this circumstance, the Chinese central government implemented a series of measures to cool down the overheated housing market, including strict limitations on new real estate construction, mortgage loans as well as purchase of houses. These measures resulted in a soft landing of the first bubble period and prevented the bubble from bursting which could have had a catastrophic impact on the macroeconomy.

Several reasons contributed to the second bubble period. The first is that in order to mitigate the downward pressure of economic growth, the People's Bank of China cut interest rate, thus reducing the cost of both real estate developers and house purchasers. Meanwhile, the Chinese central and local governments loosened limitations on real estate transactions and construction, which resulted in the recovery of the real estate sector. The second is that the People's Bank of China implemented a series of easy monetary policies to dampen the negative economic impact of COVID-19, and a large portion of liquidity entered the real estate sector, which contributed to the rapid HP growth. The third is that the local governments still regard the real estate market as an engine in promoting regional economic growth and rely on land sale as well as tax revenue from the real estate sector. Therefore, local governments are reluctant to implement restrictions on the housing market. The fourth is the impact of COVID-19 which has led to a sharp decrease in income. At the same time, HPs stayed the same, thus resulting in a growing housing bubble.

The second feature is that the size of bubbles varies among different regions. Some regions experienced large bubbles and other regions experienced small bubbles. The largest housing bubble was found in Hainan, which peaked at 40.39% in 2010. This phenomenon can be attributed to various factors, including the unique characteristics of Hainan as the largest SEZ in China and the rapid economic growth experienced in the region since its designation in 1988 (Gu and Wall, 2007). Since its designation as an SEZ, Hainan has undergone extraordinary growth in its transitional economy, which has been

given the moniker of the 'Hainan phenomenon'. The openness of the economic reforms has attracted significant inflows of global and domestic speculative capital into the region. Alongside this, there has been a notable increase in in-migration and tourism developments. While symbolizing the economic opportunities brought about by the reforms, these factors have also presented challenges for social and urban planning in Hainan. The influx of speculative capital and increased investment in the real estate market have likely played a role in the formation and expansion of the housing bubble in Hainan.

As the political and cultural center of China, it is not surprising to see significant housing bubbles observed in Beijing since 2016. Similarly, as the business centre of China, Shanghai has also experienced significant housing bubbles during this period of time. These cities, with their strong economic growth and attractive investment opportunities, can generate substantial demand for housing, thus leading to inflated property prices and the formation of housing bubbles (Fang et al., 2015). Furthermore, the significant housing bubbles observed in Hebei and Heilongjiang provinces can be attributed, in part, to the spillover effects of economic development in Beijing. As its neighboring provinces, they may have benefited from the economic growth and investment activities that emanated from Beijing. This spillover effect can contribute to increased demand for housing in these regions, potentially leading to the formation of housing bubbles.

As discussed in the literature review, there are generally two strands of literature that focus on the housing bubble in China. The first strand, which is also the majority of the relevant literature, confirms the existence of bubbles and provides a measurement of the bubble size. Interestingly, although this strand of studies has identified the existence of housing bubbles, most of the researchers argue that the housing bubble dynamics are justified by the rapid urbanization process and economic development in China. The second strand of literature finds no or very weak evidence of housing bubbles in China. Only a minority of the relevant literature concludes that there is no bubble in the housing market in China. The empirical results of this study are in line with the first strand of the literature.

Table 7 Size of Housing Bubbles in 30 provinces in China: 2002 to 2010 (%)

Region	Province/ Municipality	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Eastern	Beijing		-15.6	-23.3	-10.2					4.6		-0.3				1.7	20.5	13.5	7.0	16.6
	Fujian	-1.8									1.4	1.8	2.3				-1.5		-0.3	-2.0
	Guangdong	4.5					0.4							-1.4						
	Hainan	-32.6	-24.2	-13.1				17.5	14.4	40.4	18.7				-2.9	-3.8				
	Hebei	-0.3	-7.7	-9.8	-3.2	-0.7										6.5	13.7	15.5	6.1	2.1
	Jiangsu				0.01										-2.0					0.1
	Liaoning																			0.3
	Shandong							-1.4											2.3	0.9
	Shanghai	-8.3					-12.9	-19.9								8.6			6.0	21.6
	Tianjin		-3.5				5.7			0.4	3.5	-0.6	-2.7	-19.1	-3.7	0.1	0.2			
	Zhejiang	-14.2	-15.0	-19.0					4.1	8.2	1.9									3.2
Middle	Anhui	-4.0			0.7															10.7
	Guangxi	9.8	3.9	5.1					2.5						-3.8					
	Heilongjiang			-4.0	-0.3			-2.0									7.7	7.9	9.7	10.0
	Henan	0.4																		
	Hubei				4.6	0.3	4.0								-1.3					
	Hunan																			
	Inner Mongolia																			2.7
	Jiangxi	-6.0	-7.9	-2.2	-0.02			-2.0				4.6	7.2	2.0						
	Jilin							-0.8										7.5	4.2	
	Shanxi						-2.9	-8.8			-0.4								0.8	2.5
Western	Chongqing									0.4					-1.6	-9.4				
	Gansu					-16.1		-8.3						2.9						
	Guizhou		0.1						8.6	21.1	13.9				-6.0	-15.4	-11.1	-5.3	-12.1	-20.7

(Continued…)

(Table 7 Continued)

Region	Province/ Municipality	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
	Ningxia	22.5	12.6	10.7	3.9				1.0						-1.2	-14.3	-15.6	-15.7		
	Qinghai														-8.1	-18.9			3.9	12.0
	Shaanxi	8.0												-3.5	-2.8	-2.8				
	Sichuan		-38.6	-4.7					3.9	2.5	1.3									
	Xinjiang	12.6	1.3																	
	Yunnan	22.4	10.3	1.0	1.4	3.6								-4.2		-10.0				
	Average	**0.9**	**-7.0**	**-5.9**	**-0.3**	**-3.2**	**-1.1**	**-3.2**	**5.8**	**11.1**	**5.8**	**1.4**	**2.2**	**-3.9**	**-3.3**	**-5.1**	**2.0**	**3.9**	**2.8**	**4.3**

Notes: The size of each bubble represents a percentage of the fundamental value derived from the cointegrating relationship. Missing values in the data are due to residuals that fall below the standard deviation threshold and are not considered as bubbles.

6. Conclusion

The housing boom has lasted for over two decades since the housing reform in the 1990s. After implementing a number of empirical methods, this research study finds that HP is cointegrated with relevant market fundamentals in the long run, namely GDP per capita, POP, LP, LI and INV. At the same time, short run fluctuations and deviations of HP from market fundamentals also exist. In addition, this research work estimates the size and duration of housing bubbles across 30 provinces/municipalities in China. Based on the estimation results, two distinct features of their housing bubbles from 2002 to 2020 are identified. The first feature is that there are two obvious bubble periods. The first bubble period is from 2009 to 2013 and the second bubble period is from 2017 to 2020. Bubbles are detected in 11 and 14 provinces/municipalities during the first and second bubble periods, respectively. The second feature is that the size of the bubbles varies among the different regions. Some regions experienced huge housing bubbles at a certain period, while most of the regions experienced moderate overpricing for most of the time. The largest bubble occurred in Hainan province in 2010, which is as large as 40% of the equilibrium value determined by the market fundamentals. In terms of the national average, the largest bubble was also recorded in 2010, which is 10% of the equilibrium value determined by the market fundamentals.

From many perspectives, the housing boom in China in the past two decades seems like a typical housing bubble. HP has been soaring. New construction is massive. Housing vacancy has been prevailing. It is tempting to conclude that a bubble burst is inevitable by viewing these facts. However, the scenario is largely uncertain as the evidence and analysis in this research have tried to demonstrate. Moreover, the Chinese government plays a critical role in the housing market. The demand for houses is still strong because of the urbanization process. Therefore, if the Chinese government strictly limits the new supply of houses, the price can probably be maintained at the current level. The government can also choose to purchase the excess inventory in the real estate market and convert the houses into social housing which the government began to do so in 2015, and can also maintain HP stability. However, this approach could generate huge social and economic costs. Employment in the real estate related industries would plummet. The revenue of local governments from land sales and housing-related taxation would fall sharply. The economic growth in highly productive cities would drop significantly. The alternative approach of the Chinese government is to maintain high levels of housing construction activity and housing supply, which could result in very low or even negative expected returns to housing investment. In this case, the welfare of future home purchasers would increase, while current homeowners would suffer from the price decline. The objectives of price stability and economic growth are often in conflict. In the case of the housing market, maintaining high HPs by restricting the house supply could undermine the economic growth generated from the real estate related industries. The housing market in China

is definitely a housing boom with Chinese characteristics. Just like most of the aspects in modern China, their fate eventually depends on the decisions of the Chinese government.

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