



Determinants of house prices in China: a panel-corrected regression approach

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Abstract

This paper uses annual data from 31 provinces, municipalities and autonomous regions in China from 2000 to 2018 to examine the determinants of Chinese house prices with a panel data regression method. Our finding suggests that land price, loans of real estate developers, per capita saving and the proportion of people with college or above educational degrees significantly drive up house prices, while the number of unemployed population has a significant negative impact. These five variables account for 72 percent variations in house prices across the country. Other economic fundamentals such as inflation, interest rate, per capita gross domestic products (GDP), and rent cost do not have significant influences on house prices. The econometric model is then used to assess the existence of house price bubbles in those provincial-level divisions in China by comparing their actual price levels with those predicted by the model. If the trend of house price growth during 2002–2014 found in the present study is the true long-run trend of house prices in China, with a few exceptions, the house prices in most provincial-level divisions are not overvalued by the end of 2014.

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1 Introduction

China's economy has experienced rapid growth during the last two decades. Accompanying the rapid development is the incredible enlargement of various internal markets. Housing market is among one of the most active markets in China and has been playing an important role in the Chinese economy. Since the urban housing system reform in 1998, which abolished welfare housing distribution, house price has hardly ever decreased in China (Ma 2010). China's average house price has quadrupled between 2000 and 2018 (Fig. 1). There have been fierce debates about whether price bubbles exist in China's housing market given the continuous price appreciation (e.g., Ahuja et al. 2010; Dreger and Zhang 2013). There are concerns with the increasingly high house price from all sides, because housing assets now constitute the largest single source of Chinese household wealth. If a bubble exists, once it bursts, a sharp drop in house price would greatly damage the real economy. China may need many years to recover from the shock, just as experiences of other countries (e.g., Janssen 2009; Malpezzi and Wachter 2005).

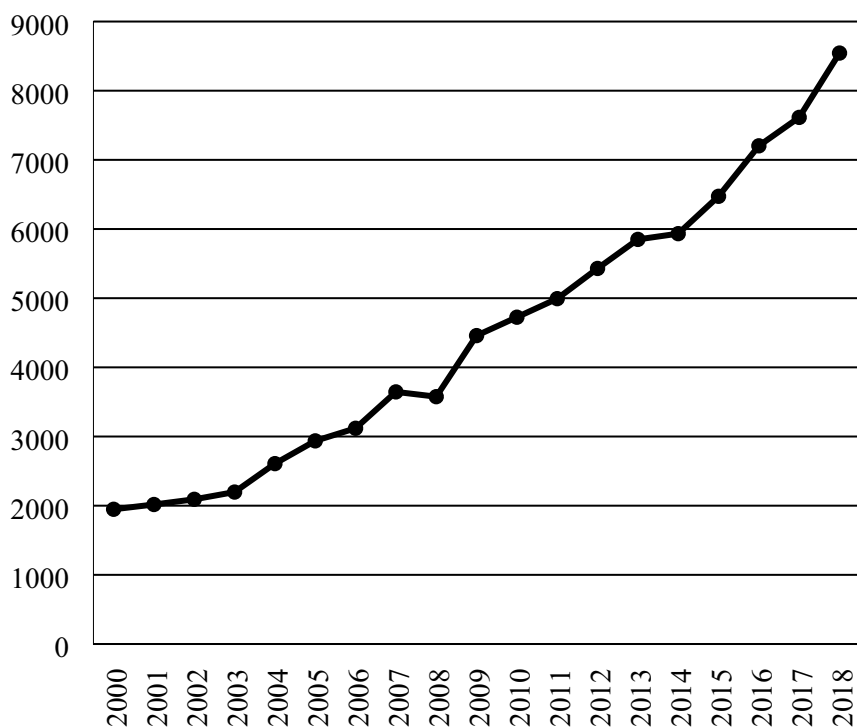


Fig. 1 Average house selling price. The average commercial house selling prices in China. The sample period is 2000–2018 with 19 observations. The average house prices are expressed as CNY per square meter. *Source:* China Statistic Yearbook 2020

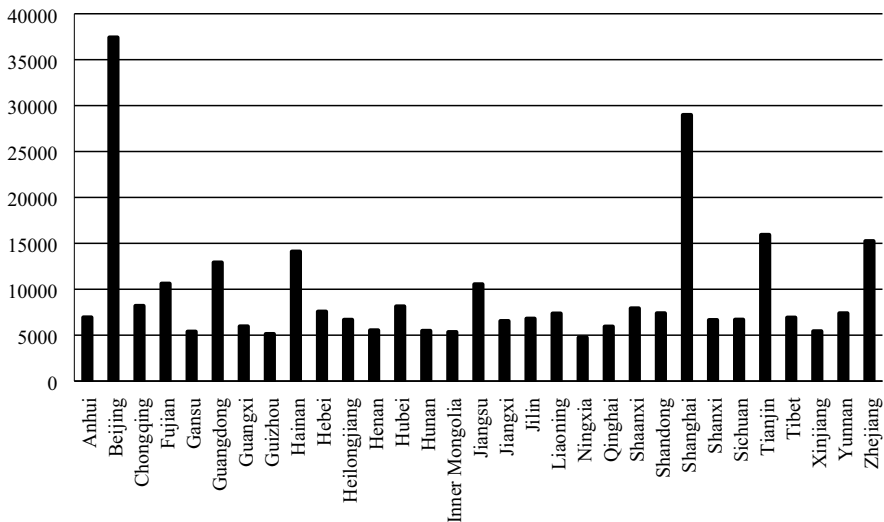


Fig. 2 Average provincial house prices of 31 provinces, municipalities and autonomous regions in 2018. The average housing prices for all the 31 Chinese regions respectively. The sample period is 2018 with 31 observations. The average house prices are expressed as CNY per square meter. *Source:* China Statistics Bureau

Although many researches have been conducted on Chinese housing market, there are still gaps in our knowledge. Firstly, most of the existing researches focused on either specific cities or provinces (e.g., Hui and Wang 2014; Zhang and Rasiah 2016), the major cities (e.g., Wu et al. 2012; Yang et al. 2018) or the overall country (e.g., Shen 2012; Zhang et al. 2012). Few researches consider the huge heterogeneity in house prices across mainland China's 31 provincial-level divisions. For example, Beijing's average housing price at the end of 2018 was 37,420.19 CNY per square meter, eight times that of Ningxia at only 4736.94 CNY (Fig. 2). Secondly, documented researches mainly focused on a few explanatory variables, such as per capita gross domestic products (GDP), interest rate, and population growth. There could be other social and economic variables that influence house prices but have not been examined.

This study collects data from 31 municipalities, provinces and autonomous regions in China from 2000 to 2018 and undertakes a panel data analysis. We examine the impact of 30 macroeconomic and social variables, from both the supply and demand sides, on house price. We find that land price, loans of real estate developers, per capita saving and the proportion of people with college or above educational degrees significantly drive up house prices, while the number of unemployed population has a significant negative impact. We further compare the actual house prices with prices predicted by our model. If the trend of house price growth during 2002–2014 is the true long-run trend, with a few exceptions, the house prices in most provincial-level divisions are not overvalued by the end of 2014.

This paper contributes to the current literature in two aspects. First, we develop a house price model with nine determinants from 30 potential variables, which differs

from those in previous studies. Many of the 30 variables have never been investigated by other researchers before. A broader investigation may help us get a fuller picture of the relationship between house prices and other social and economic phenomena. We also find that five determinants among the nine provide most of the explanatory power.

Second, our results on potential house price bubbles in provinces complement to the debates on housing price bubble. We find that housing prices are not significantly overvalued in China as a whole during 2014, which is consistent with Ahuja et al. (2010)'s earlier finding. However, there are signs of price disconnection from fundamentals by the end of 2014 in some provincial divisions, such as Tibet, Hainan, and Shanghai, which may indicate the possibility of price bubbles.

The rest of the paper is arranged as follows. The next section is an overview of Chinese housing market over the past four decades. Section 3 is literature review. We present data collection and analysis method in Section 4, followed by results and discussions. Conclusion and recommendations for further research bring the paper to a close.

2 Housing market in China

Before and during the early years of China's reform and opening, the housing condition of Chinese people was very poor. In October 1978, the State Council approved and issued *Report on Speeding up Urban Housing Construction* submitted by the State Construction Commission. The document reveals that the average housing area per person in cities in China was 3.6 square meters. It proposes to allow overseas Chinese to build private houses, individuals to build houses with public assistance, and encourage and organize individuals to raise fund to build houses, to supplement housing investment by government and collectives. Following this document, housing properties began to be sold to individuals in 1979, but private housing market did not take off until the government abolished welfare housing distribution in 1998 (Dreger and Zhang 2013).

To address the severe housing shortage and underinvestment in housing, the Central Committee of the Communist Party of China (CPC) and the State Council approved and issued in June 1980 *Report Outline of the National Capital Construction Work Conference* from the State Construction Commission, which formally started the policy to commoditize residential housing and to let state, collectives and employees jointly share housing costs. Although the policy encourages employees to buy properties subsidized by their enterprises and state, there was little willingness among employees because of their low incomes and the low rent for public housing. In January 1986, the Housing System Reform Leading Group of the State Council was formed. It issued *Implementation Plan of Housing System Reform in Cities and Towns in Stages and Batches across the Country* in March 1988, which proposes to increase rents and wages in order to encourage employees to buy properties. Because of China's economic and political situation in the late 1980s, those reform policies did not achieve expected outcomes.

To move the housing reform forward and marketize housing provision, the State Council issued *Notice on Continuing to Actively and Steadily Carry out Urban Housing System Reform* in June 1991, and approved and issued in October 1991 *Opinions on Comprehensively Promoting the Reform of Urban Housing System* drafted by the Housing System Reform Leading Group of the State Council. The two documents stipulate: (1) increasing rent for public housing step by step; (2) implementing a system of state, collective and individual joint investment in housing, and setting up municipal, collective and individual housing fund; and (3) buyers of public houses at market price have full ownership. The documents also pointed out that the Housing Provident Fund is an effective way for individual housing fund. However, because of the existence of welfare housing provision by government departments and state-owned enterprises (SOEs), urban residents still did not show a strong willingness to buy housing properties, which often had to be sold at much discounted prices.

To comprehensively marketize housing provision, the State Council issued *Decision on Deepening Urban Housing System Reform* in July 1994. It reiterates the policies in the two documents issued in 1991, instructs to carry out housing provident fund system in an all-round way and change distribution of public housing in kind to distribution of monetary wages and calls for building affordable housing for low- and middle-income families and commercial housing for high income families. In August 1996, General Office of the State Council issued *Opinions on Strengthening the Management of State-owned Housing Sales Income* and *Opinions on Strengthening the Management of Housing Provident Fund* prepared by the Housing System Reform Leading Group of the State Council. The two documents help consolidate progresses in the marketization of housing provision.

A booming housing market in China was finally initiated by the State Council document *Notice on Further Deepening the Reform of Urban Housing System and Accelerating Housing Construction* issued on July 3, 1998. It reiterates policies in early documents, monetizes housing provision and completely stops welfare distribution of housing in kind, and calls for socialization and professionalization of housing management. In August 1999, the Ministry of Construction issued *Notice on Further Promoting the Reform of Existing Public Housing*, which stipulates all public housing should be sold except those which are not appropriate to sell. In August 2003, the State Council issued *Notice on Promoting Sustained and Healthy Development of Real Estate Market*, which identifies real estate industry as a pillar of the national economy and advocates commercial housing to replace affordable housing as the mainstay of construction. Following these policies, house prices began to rise rapidly.

Housing market is closely related to land market. In China, government is the only land supplier, controlling the quantity, structure and timing of land supply (Du et al. 2011; Zhang et al. 2013). To enhance transparency and competition on land demand, Chinese government initiated in 2002 a market-oriented tender/auction/listing method for developers to acquire land. The method was fully implemented on August 31, 2004, for all land resources. Land sales became an important source of revenue for local government. According to Ahuja et al. (2010), land sales accounted for as much as 30 percent of government revenue in 2009. In order to get

higher fiscal revenue to support local development, local governments strongly support housing industry and encourage SOEs to bid for land for housing development. The financial strength and fund-raising ability of SOEs due to their deep links with state-owned banks raised the overall land price in the market (Du et al. 2011). As a result, both house and land prices rose dramatically after the implementation of these policies.

Afraid of house price bubbles, the government took a number of tightening measures from January 2007 to August 2008 to cool down housing market. These measures included imposing value-added tax on land transactions, raising the minimum down-payment ratio and the minimum mortgage rate for second mortgage, etc. The outbreak of the 2007–2009 global financial crisis interrupted the implementation of these restrictive measures. As the world economy slowed down, Chinese economy was affected as well. Export-oriented industry suffered most during the crisis (Ma 2010). To prevent the economy from further deterioration, Chinese government initiated a four trillion CNY stimulus package and revoked the previous restrictive policies. From October 2008 to May 2009, government implemented a series of policies to stimulate house investment and purchase. House price recovered in the third quarter of 2009 and resumed its fast rising trend since then (Fig. 1). By the end of 2009, Chinese house price has reached a historical high. The government restarted measures to tighten housing market again.

Over the past four decades, especially since 1998, China's housing policy has moved away from a traditional welfare orientation to a monetized allocation system through a series of reform policies with distinctive Chinese characteristics, such as strict control by government of land supply, mortgage rate, down-payment ratio, etc. The current system has encouraged people to become homeowners and stimulated growth of China's housing industry. In terms of addressing severe housing shortage that triggered housing reform, China's housing reform and housing industry have been a big success. By 2018, the per capita living space for urban citizens reached 39 square meters, exceeding that of many developed countries (National Bureau of Statistics of China 2019).

3 Literature review

Housing price is determined by economic fundamentals (Wen and Goodman 2013). Many empirical studies use exogenous macroeconomic variables to explain house prices. Demographic change has been revealed by Mankiw and Weil (1989) to be an important determinant on US house prices in the 1970s. Capozza et al. (2002) find that population growth rate has stable relationship with house price. Schnure (2005) finds that one percent increase in unemployment rate leads to one percent decrease in housing price. Real income growth has been identified by Capozza et al. (2002) to have stable relationship with house price in US housing market. Potepan (1996) suggests household income as one of the most significant factors causing housing prices to fluctuate between US metropolitan areas. Hu et al. (2006) show that house prices in China are driven by economic fundamentals, such as personal income growth and

change of interest rates. Li and Chand (2013) also demonstrate that level of income is one of the primary determinants of house prices.

However, house prices often deviate from what economic fundamentals predict. Yu (2010) finds no stable relationship between house price and economic fundamentals in China. On the contrary, house price has been deviating from economic fundamentals since government started macro-control of the real estate market. Ma (2010) provides a psychological explanation that the main driving force of soaring house price is people's expectation that house price will continue to increase, which Wen and Goodman (2013) have got similar findings.

An important factor in forming house price is land supply or the land price for residential building development, but empirical studies have not reached a consensus. Some studies show that land price affects house price. Priemus (2003) shows that land price affects house price in the Netherlands. With panel data sets collected from Beijing, Shanghai, Tianjin and Chongqing, Du et al. (2011) find that there exists a long-run equilibrium between Chinese urban housing and land markets. Using annual data from 29 provinces from 1998 to 2009, Li and Chand (2013) demonstrate that incomes, construction costs, impending marriages, user costs and land prices are the primary determinants of house prices. Using spatial regression and geographical detector technique, Wang et al. (2017) show that the proportion of renters, floating population, wage level, the cost of land, the housing market and city service level have positive effects on house price, whereas living space has a negative effect.

There are also studies that do not show a significant role for land price in determining house price. Zhang et al. (2012) find the real economic variables such as land price, personal disposable income, GDP, imports, exports and other factors such as stock index are not independently significant; it is the monetary variables that primarily determine Chinese house prices. Such monetary variables include mortgage rate, broad money supply, producer price and real effective exchange rate. Wu et al. (2015) show that although local governments' budget has a positive effect on land prices, it is the factors from demand side, such as amenities, income and the user cost of housing capital, that have been pulling up the housing prices.

The rapid growth in house prices across the country has caused concerns in China on whether the booming housing market has led to house price bubbles since the early 2000s. Among the studies that investigate whether there is a price bubble in China's housing market, some studies investigate whether price bubbles exist in some particular cities. Shen et al. (2005) find that a price bubble might exist in Shanghai in 2003 as its house prices deviated 22 percent from the market fundamental values. By contrast, house price in Beijing seemed normal in 2003. In contrast, a later study by Hou (2010) concludes that Beijing's housing market might have gone through three housing bubbles. Chen et al. (2013) reveal that Beijing's house price index was significantly larger than the equilibrium value based on relative economic fundamental variables including income, inflation, interest rate and construction cost from 2004 to 2007. Hui and Wang (2014) investigate the Beijing and Shanghai housing markets during 1998–2012. They find that price anomalies are found occasionally, but are still reasonable for most of the time. There appears to be still

no consensus among researchers on whether there are house price bubbles in large cities such as Beijing and Shanghai.

Some studies are concerned with whether China or its large cities as a whole experience house price bubble, but there is no consensus either. Using both panel regression and asset pricing approaches, Ahuja et al. (2010) find that housing prices were not significantly overvalued in China as a whole during the first half of 2010, although there were signs of price disconnection from fundamentals in the mass-market segments of Shanghai and Shenzhen as well as the luxury segments of Beijing and Nanjing. Dreger and Zhang (2013) use panel integration techniques to examine the data set for 35 major Chinese cities from 1998 to 2009 and conclude that there was a bubble which was about 25 percent higher than the equilibrium value implied by the fundamentals by the end of 2009. They further argue that the bubble was extremely huge in the southeastern coastal cities and special economic zones. Using time-series data for four largest cities in China, Liu et al. (2017) demonstrate that it is the bubbles that drive house prices to stand high.

The studies reviewed above provide valuable insights for understanding house prices in China. However, there are still issues that warrant further investigation. First, there are conflicting findings on house price determination in these studies. Some variables are significant in one study, but not significant in another study. It is worthwhile to re-examine these variables. Second, due to the different models that are used to set up the house price determination model, researchers also find mixed evidence on whether there exist house price bubbles, which also needs further investigation. Third, the housing market is affected by many macroeconomic factors and policies. At different periods of time, the relative importance of different factors could be different. Most existing studies use either cross-sectional or time-series data with relatively small numbers of variables, which might not be sufficient to explain the variations in house price over time and across a wide range of geography. In order to better understand factors that underlie house price changes in China, it seems necessary to set up a model that includes more variables and covers many years.

4 Data and methodology

In the present study, we use econometric methods to examine the determinants of house price in China. We begin with a description of data source and variables and then introduce our regression models and validity tests.

4.1 Data

Annual data covering 31 provinces, autonomous regions and municipalities from 2000 to 2018 are retrieved. Housing data after 2001 are regarded as of high quality (Hou 2010). The bulk of the data is sourced from ESP Data Platform and China Statistics Bureau. The vacant values are then searched from China Statistic Yearbooks 2000–2019 and some official websites. The wide coverage of provinces enables us to have an overview of the whole Chinese housing market, which has been used by other

studies before (Li and Chand 2013; Liang and Gao 2007; Peng et al. 2008). A few missing values, such as Tibet's values for some specific years, are not available anywhere. However, as the proportion of the missing value only accounts for 1.7 percent of the overall data sheet, we think the existing data set is credible and sufficient.

4.2 Variable

House price denotes the nominal average selling price of commercial residential buildings, which include both ordinary commercial residential buildings and high-end ones such as villas and high-grade apartments. "Economical houses", i.e., affordable residential housing sold at lower than market prices to low-income households, are not included, because their supply is strictly controlled by government regulations and their prices are predetermined by government directly. Moreover, it only accounts for a very small portion of the overall housing supply in the market (less than five percent) in recent years (Xie 2011).

Based on relevant literature, 30 variables from 22 economic and social fundamentals (Table 1) are selected with the purpose to cover as wide as possible variables and to maximize the reliability of the analysis. The data form an unbalanced panel data set. Below are preliminary descriptions of the explanatory variables as well as their intuitive relationships with the dependent variable. The expected sign of the influence of each variable on house price in Table 1 represents our hypothesis regarding the impact of that variable on house price.

Two methods are used to calculate annual interest rate. The first is to use year-end interest rate data that are collected from central bank's official website directly. The second is to use the whole year's geometric mean of interest rate to represent annual interest rate. The function to calculate the geometric mean of interest rate is:

$$R = \left(\prod_i^n (1 + r_i)^{\Delta t_i / 365} \right) - 1 \quad (1)$$

where R stands for geometric average annual interest rate, r_i stands for the interest rate in period i , Δt_i is the number of days in period i , n stands for the number of periods with different interest rates within one year. In the following analysis, the interest rates calculated by both ways will be examined.

4.3 Model description

Since China is a large country with marked regional differences which should be taken into consideration, an empirical panel data regression analysis which possesses both cross-sectional and time-series dimensions is chosen to test the factors that influence house prices in China. In a competitive housing market, an equivalent price is reached when housing supply equals to demand (Quigley 1999). The interactions can be described as

Table 1 Descriptions of all the explanatory variables

Variable denotation	Variable description	Unit	Expected sign
CCOST	Construction cost (Capozza et al. 2002; Poterpan 1996)	CNY/sq.m	+
CONPI	Price index of construction materials	Last year = 100	+
CPI	General consumer price index	Last year = 100	+
EDU	Proportion of population with college or above educational degree (Yang et al. 2018)	%	+
ENERGYPI	Price index of electricity, water and fuel (Fuerst et al. 2015)	Last year = 100	-
EXCH	Exchange rate (Pavlova and Rigobon 2007; Zhang et al. 2012)	RMB/dollar	+
EXPORT	Export as a percentage of GDP	%	-
FIXEDPI	Price index of fixed assets investment (Ma 2010)	Last year = 100	-
HAREA	Completed Floor space of buildings (Wen and Goodman 2013)	10,000 m ²	-
HPF	Annual amount of housing provident fund collection (Chen and Deng 2014; Li and Yi 2007; Yeung and Howes 2006; Zhang and Rasiah 2016)	100,000,000 CNY	+
HPFRATE	Individual housing provident fund loan interest rate (5 years and above)	%	-
HOUSEHOLD	Number of household		+
HOMESIZE	Average number of people per household		-
INTEREST	Five year benchmark bank lending interest rate (Chen et al. 2013; Crouhy et al. 2008; Kishor and Marfatta 2017)	%	-
IMPORT	Import as a percentage of GDP	%	+
LOAN	Domestic loan of real estate developers (Panagiotidis and Printzis 2016)	10,000 CNY	+
LP	Land price per unit floor area (Du et al. 2011; Li and Chand 2013; Wang et al. 2017)	CNY/sq.m	+
PCSAVING	Per capita saving of urban and rural area	CNY	+
PCGDP	per capita local GDP (Shen et al. 2005)	CNY	+
RENTPI	Price index of rent (Hamink et al. 2012; Hou 2010)	Last year = 100	-
RINCOME	Rural households per capital net income	CNY	+
SAVING	Savings deposit in urban and rural areas	100 million CNY	+
SP	Shanghai Stock Exchange composite index (Shen et al. 2005)		-
TAX	Local tax revenue	100 million CNY	+

Table 1 (continued)

Variable denotation	Variable description	Unit	Expected sign
UINCOME	Urban households per capital disposable income (Shen et al. 2005)	CNY	+
UNEMPP	Unemployment population	10,000 persons	-
UNEMPRATE	Unemployment rate (Schnure 2005)	%	-
UNMARRIED	Unmarried population (Li and Chand 2013)		+
URBAN	Urban population	10,000 persons	+
WAGE	Average wage of staff and workers (Wang et al. 2017)	CNY	+

$$HP_{i,t} = f(Q_{i,t}^S, Q_{i,t}^D) \quad (2)$$

where HP denotes house price, Q^D and Q^S are the quantities of houses that are demanded and supplied in the market, i stands for individual provinces, whereas t captures the time period.

Under this demand–supply framework, we put housing completion cost (CCOST), price index of building and decoration materials (CONPI), price index of fixed assets investment (FIXEDPI), completed floor space of buildings (HAREA), domestic loans of real estate developers (LOAN), land prices (LP) on the supply side. On the demand side, housing demand is a function of people's education level (EDU), price index of electricity, water and fuel (ENERGYPI), number of household (HOUSEHOLD), number of people per household (HOME-SIZE), amount of housing provident fund collection (HPF), individual housing provident fund loan interest rate (HPFRATE), per capita saving (PCSAVING), savings deposit by urban and rural residence (SAVING), per capita GDP (PCGDP), price index of rent (RENTPI), per capita rural households net income (RINCOME), Shanghai stock exchange composite index (SP), per capita urban household disposable income (UINCOME), average wage of staff and workers (WAGE), number of unemployed population (UNEMPP), unemployment rate (UNEMPRATE), urban population (URBAN), and unmarried population (UNMARRIED). As consumer price index (CPI), exchange rate (EXCH), export, import, interest rate (INTEREST) and tax revenue of local government (TAX) affect both the demand and supply of houses, we add them as well. The house price determination model is thus expressed as:

$$\begin{aligned} HP_{i,t} = f(&CCOST_{i,t}, CONPI_{i,t}, CPI_{i,t}, EDU_{i,t}, ENERGYPI_{i,t}, EXCH_{i,t}, EXPORT_{i,t}, \\ &FIXEDPI_{i,t}, HAREA_{i,t}, HOMESIZE_{i,t}, HOUSEHOLD_{i,t}, HPF_{i,t}, \\ &HPFRATE_{i,t}, IMPORT_{i,t}, INTEREST_{i,t}, LOAN_{i,t}, LP_{i,t}, PCSAVING_{i,t}, \\ &PCGDP_{i,t}, RENTPI_{i,t}, RINCOME_{i,t}, SP_{i,t}, TAX_{i,t}, SAVING_{i,t}, WAGE_{i,t}, \\ &UINCOME_{i,t}, UNEMPP_{i,t}, UNEMPRATE_{i,t}, UNMARRIED_{i,t}, URBAN_{i,t}, Z_{i,t}) \end{aligned} \quad (3)$$

where Z is a vector of exogenous variables and contains, among other things, factors affecting house price that are omitted from the economic model, i denotes individual provinces and t is the time period as defined before. We assume that Eq. (3) is a linear function and all independent variables have linear coefficients.

The above equation will be examined by regression analysis. We apply the variance inflation factor (VIF) test stepwise by removing the variable with the highest VIF score. Only variables with VIF less than 10 will be retained in the later equation. R square is used to evaluate the amount of variations of the dependent variable explained by independent variables. The contributions to R square by the variables which are insignificant are then removed stepwise by excluding the most insignificant variable and rerunning the regression. If deletion of the variable only affects the adjusted R square marginally, it will be deleted. By the same method, the next most insignificant factor will be tested again, and so on. Only variables whose removal reduces substantially the adjusted R square will be retained in the final equation.

4.4 Robustness tests

OLS assumes homoscedasticity and no autocorrelation. Additionally, time-series data should be stationary or cointegrated. Panel data need to have no contemporaneous correlation for correct estimation of the regression parameters. Heteroscedasticity is tested by a modified Wald statistic; serial correlation by Wooldridge test; stationarity by a Levin–Lin–Chu-type unit-root test; cointegration by a Kao test; and contemporaneous correlation by Pesaran CD test. If there are problems with the above assumptions, models that tolerate such problems will be used.

5 Results and discussion

In this section, we will perform firstly descriptive statistics, estimate and improve our regression models, and assess potential price overvaluation in different regions by comparing the actual house prices with the calculated house prices by the final model we have estimated.

5.1 Descriptive statistics

The descriptive statistics of the variables are listed in Table 2. The lowest house price comes from Jiangxi province in 2000, which is only 854 CNY per square meter, while the highest house price appears in Beijing in 2018, which is as high as 37,420.19 CNY per square meter. Averagely, house price is 4470.58 CNY per square meter across all the regions from 2000 to 2018. The average annual completed floor space of building is 23,155.18 k square meter. The highest land price is 52.5 k CNY per square meter, which is from Beijing in 2015. The land cost accounts for 74.42 percent of house prices (dividing the mean of *HP* by the mean of *LP*).

The house price growth rates between 2001 and 2018 are shown in Fig. 3, which indicates a wide dispersion in the house price growth rates across the 31 provincial-level divisions. We could find three features from Fig. 3. Firstly, the annual growth rates are generally above zero, indicating an upward trend during this period. Secondly, there is some level of convergence in the price growth rate among provincial divisions. Finally, there are also some extreme outliers. The (unweighted) provincial house price growth rate distribution is shown in Fig. 4, which indicates that nearly 90 percent of the year-on-year price growth rate is positive for the sample period.

5.2 Fixed effect linear regression analysis

Wald test is used to choose between the pooled regression model and the fixed effects regression model. Breusch–Pagan Lagrange Multiplier test is used for the selection between the pooled regression model and the random effects model. Both tests show that pooled regression is weaker in explaining house prices and there is cross-sectional heterogeneity in the given data set. The Hausman test shows

Table 2 Descriptive statistics of all variables

Variable	Frequency	Mean	SD	Min	Max
CCOST	558	1949	922	644	6064
CONPI	527	102.00	3.15	92.50	122.70
CPI	589	102.30	1.97	96.70	110.10
EDU	465	9.76	6.72	0.79	47.61
ENERGYPI	527	103.50	3.81	92.17	117.60
EXCH	589	7.21	0.83	6.14	8.28
EXPORT	589	14.87	17.87	0.73	91.59
FIXEDPI	569	102.50	3.07	96.00	113.30
HAREA	589	2315.52	2011.43	6.66	10,512.57
HOUSEHOLD	465	34,870	74,457	526	495,703
HOMESIZE	465	3.21	0.42	2.33	5.03
HP	589	4470.58	4139.19	854.00	37,420.19
HPF	155	540.97	443.24	41.77	2292.03
HPFRATE1	589	4.15	0.57	3.25	5.22
HPFRATE2	589	4.20	0.54	3.25	5.03
INTEREST1	589	6.05	0.76	4.90	7.83
INTEREST2	589	6.12	0.74	4.90	7.60
IMPORT	589	14.07	17.12	0.35	89.27
LOAN	556	350.97	511.57	0.08	4083.46
LP	463	0.33	0.63	0.01	5.25
PCSAVING	477	22,919	31,179	1436	311,048
PGGDP	589	32,395	25,580	2759	140,211
RENTPI	527	103.80	4.12	94.60	143.10
RINCOME	589	7002	5076	1331	30,375
SAVING	477	8086	8473	40	52,411
SP	589	2434	808	1154	4238
TAX	555	1012	1300	5	8872
UINCOME	589	18,620	11,317	4724	68,034
UNEMPP	552	23.58	14.26	1.00	75.60
UNEMPRATE	552	3.55	0.71	0.80	6.50
UNMARRIED	465	18,429	40,639	587	380,284
URBAN	558	2024	1406	58	7802
WAGE	558	35,137	23,202	6918	134,994

HPFRATE1 and INTEREST1 are year-end rates, and HPFRATE2 and INTEREST2 are the whole year's geometric mean of HPF rate and interest rate, respectively

that error terms are correlated with regressors, so the fixed effect model is more appropriate.

VIF test is used to evaluate the severity of multicollinearity among independent variables. After the selection with VIF test, ten variables (HAREA, LOAN, EDU, SP, HOUSEHOLD, EXPORT, LP, PCSAVING, UNEMPP, UNMARRIED) are left in the model without serious multicollinearity problem. A fixed effect linear

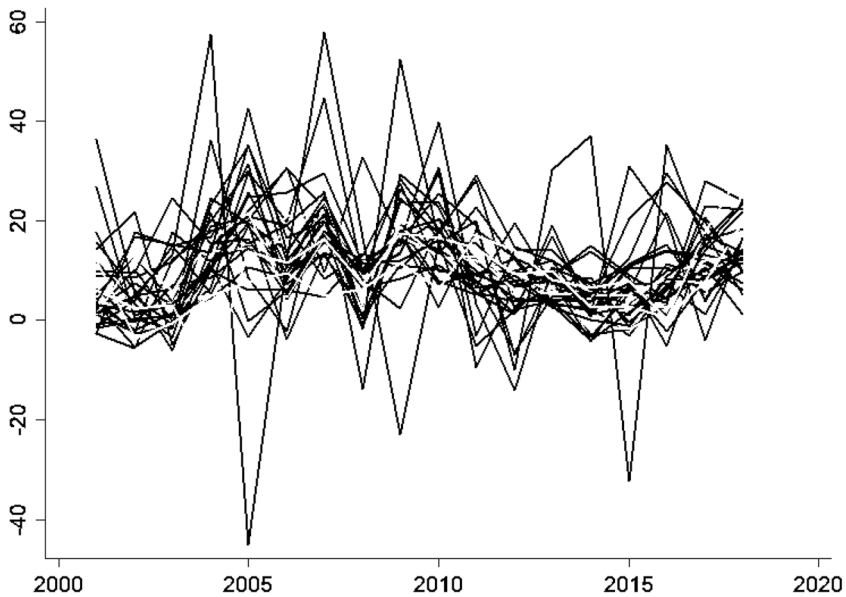


Fig. 3 Annual house price growth rate. The annual growth rate of house prices of 31 provinces, municipalities and autonomous regions in China between 2001 and 2018. Y-axis is growth rate of house price measured in %. *Source:* China Statistics Bureau

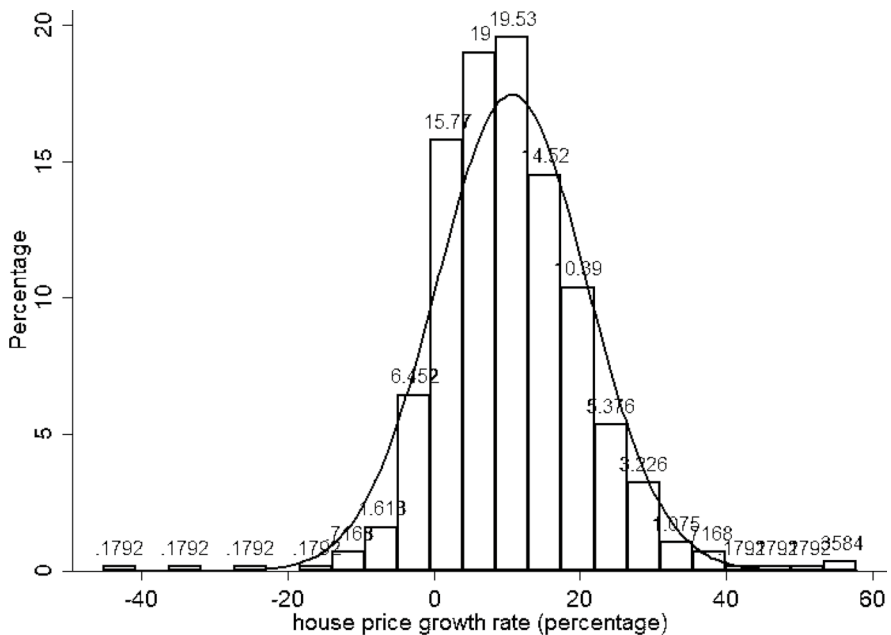


Fig. 4 Normal distribution of provincial house price growth rates. The frequency distribution of house price growth rates for 31 provinces, municipalities and autonomous regions from 2001 to 2018 in China. Both Y- and X-axis are measured in %

Table 3 Result of fixed effect linear regression model

HP	Coef.	Std. Err.	<i>t</i>	<i>P</i> > <i>t</i>
HAREA	−0.33	0.075	−4.33	0.000
LOAN	2.54	0.337	7.54	0.000
EDU	273.38	24.831	11.01	0.000
SP	0.40	0.076	5.26	0.000
HOUSEHOLD	0.00	0.001	2.64	0.009
EXPORT	−70.25	11.796	−5.96	0.000
LP	632.38	184.568	3.43	0.001
PCAVING	0.03	0.004	7.69	0.000
UNEMPP	51.54	14.893	3.46	0.001
UNMARRIED	−5746.76	3863.200	−1.49	0.138
CONSTANT	591.20	857.98	0.69	0.491
<i>R</i> ²	Within	0.8119		
	Between	0.5029		
	Overall	0.6569		
<i>F</i> -statistic (10,331)		142.90	Prob> <i>F</i>	0.0000
Number of obs		372		

regression model is set up as shown in Table 3. Nine of the independent variables are very significant with $P < 0.01$.

To identify potential econometric problems associated with the above model, we did a series of postestimation tests. A modified Wald test for groupwise homoscedasticity in the residuals of the model suggests the existence of heteroscedasticity (with a Chi-square=8130.38 and $P=0.0000$). A Wooldridge test was employed to check serial correlation in the panel data. With an $F=128.091$ and $P=0.0000$, we rejected the null of no serial correlation between the first differences of the error terms and concluded that the data set we are using shows strong signs of first-order autocorrelation. We did a Pesaran's cross-sectional dependence test and confirmed the existence of contemporaneous correlation (Pesaran's test of cross-sectional independence=6.289, $P=0.0000$). We tested whether the variables in the model have unit roots one by one. The results indicated that most of them contain unit roots. The variables in the regression were not cointegrated either. The heteroscedasticity, serial correlation, contemporaneous correlation and nonstationarity issues need to be remedied. We try to improve the regression model by removing UNMARRIED from the ten independent variables and estimate the reduced model. All the remaining nine variables are very significant with $P < 0.01$, but the validity issues still remain.

5.3 Panel-correlated standard errors regression model

In order to address the econometric problems encountered in the preceding section, we use regression with panel-correlated standard errors (PCSE) to estimate linear cross-sectional time-series models. The PCSE approach assumes that the disturbances are heteroscedastic and contemporaneously correlated across panels.

Table 4 Results of panel-correlated standard errors (PCSE) regression

Variable	(1)	(2)	(3)	(4)	(5)
HAREA	−0.18 (0.11)	−0.15 (0.11)			
LOAN	2.62*** (0.61)	2.54*** (0.59)	2.29*** (0.52)	2.34*** (0.53)	2.33*** (0.54)
EDU	99.48*** (34.35)	101.70*** (34.62)	113.36*** (33.76)	109.67*** (34.23)	110.53*** (34.72)
LP	423.03*** (163.42)	421.37*** (158.38)	394.90*** (150.38)	392.13** (155.28)	436.56*** (162.19)
PCSAVING	837.49*** (157.23)	809.42*** (158.29)	701.23*** (154.40)	718.46*** (158.91)	714.49*** (159.13)
SP	0.15** (0.07)	0.16** (0.07)	0.15** (0.07)	0.14* (0.08)	
HOUSEHOLD	1.18* (0.69)	1.12 (0.70)	0.90 (0.66)		
EXPORT	−4.06 (10.96)				
UNEMPP	−14.85*** (5.67)	−16.10** (6.30)	−23.96*** (7.95)	−22.69*** (8.53)	−23.51*** (8.60)
CONSTANT	−4656.14*** (1591.48)	−4432.53*** (1544.34)	−3621.22** (1590.31)	−3745.58** (1666.96)	−3306.54* (1705.84)
Observations	372	372	372	372	372
Number of province	31	31	31	31	31
R^2	0.74	0.74	0.72	0.73	0.72
Wald Chi square	647.83	473.99	278.46	246.34	237.87

Standard errors are in parentheses. ***, **, * indicate significance level at 0.01, 0.05, and 0.1 respectively

When autocorrelation is specified, PCSE regression model produces Prais–Winsten estimates. We apply PCSE regression and derive a model reported in Model 1 of Table 4.

Comparing with the fixed effect model, two variables (HAREA and EXPORT) in the PCSE model are not significant at 90 percent confidence level any more. We remove the most insignificant variable (EXPORT) and redo the regression, which results in Model 2 of Table 4. Among the eight independent variables, neither HAREA nor HOUSEHOLD is significant. We remove the more insignificant variable HAREA and redo the regression and get Model 3. HOUSEHOLD is not significant in Model 3. We remove it and get Model 4. SP is only marginally significant (at 90 percent confidence level) in Model 4. We remove it further and get the final Model 5. In Model 5, all five independent variables are significant at the 99 percent confidence level. All five statistics reported by Kao test of cointegration (including modified Dickey–Fuller t , Dickey–Fuller t , augmented Dickey–Fuller t , unadjusted modified Dickey–Fuller t , and unadjusted Dickey–Fuller t) suggest that the null hypothesis can be rejected, and all panels are cointegrated. The R^2 of the PCSE

regression in Model 1 is 0.74, while it is 0.72 in Model 5. This implies that removing the insignificant or marginally significant variable does not impact the explaining power of our model much.

Ahuja et al. (2010) argue that first-tier cities such as Beijing and Shanghai are more likely to show sign of excessive price growth and speculation. Du et al. (2011) think that macropolicies may have a more direct and significant impact on the four provincial-level municipalities (Beijing, Shanghai, Tianjin and Chongqing), compared with other cities under provincial government's administration. Liu (2018) argues that provincial-level panel data contain municipalities (such as Beijing and Shanghai) which are actually not provinces, but big cities, thus leading to estimation bias. To test whether our model is robust with the selection of regions, we redo all the analysis by excluding the municipalities; we also exclude Beijing, Shanghai, Tianjin, and Chongqing, the four provincial-level municipalities, as well as Tibet, which is regarded as the least developed region in China, one by one. All the results are similar, suggesting that the current model is robust in predicting Chinese housing market.

Our results strongly suggest that domestic loan of real estate developers, the proportion of people with higher education, land prices, per capita year-end saving, and the number of unemployed population are the main driving forces of Chinese house prices. Their signs are all in accord with our previous expectation, which means that the higher the loans, land prices, per capita savings, and proportion of highly educated population, the higher the house price. The more the unemployed population, the lower the house price. The five variables can explain 72 percent of the variations in the house price in China.

Domestic loan of real estate developers greatly influences house prices. Our results show that for additional 100 million CNY's domestic loan to real estate developers, house prices increase 2.33 CNY per square meter, *ceteris paribus*. As domestic loan enables real estate developers to have more fund to bid for land and to buy equipment and materials, it will increase land price and construction costs. Panagiotidis and Printzis (2016) find that mortgage loan is the most important variable for the house price index in Greece. Our results are in line with their findings. Our results show that construction cost and energy consumption level do not have significant influence on house prices, neither does rent price. Their impact may have been captured by other variables.

Education level of the population has a positive impact on house prices. One percentage increase in the proportion of highly educated population will increase the house price by 110.53 CNY, *ceteris paribus*. The proportion of people with higher education is an important indicator of economic growth. Real estate economists have begun to explore its influence on housing price recently (Yang et al. 2018). People with higher education tend to have higher income and could afford more expensive houses, therefore driving up the house demand.

Land price is another significant factor in determining house prices. This confirms Li and Chand (2013)'s finding. Du et al. (2011) conclude that there existed a long-run equilibrium between Chinese urban housing and land markets. The importance of land policy and land supply is also demonstrated by Priemus (2003) and Yu (2010). In our analysis, one percent increase in land price leads to 436.56 CNY's

increase in house price.¹ As land supply is monopolized by the state in China, the local government can play an influential role in moderating the housing price through its control on the land market.

Per capita saving has positive influences on house price. Chinese people tend to save more owing to inadequacy of social insurance system. Buying houses was for the Chinese household a form of saving and best investment in the past 20 years. High residential savings mean high demand for housing and high capacity to buy. Our results suggest that one percent increase in the per capita saving will increase house price by 714.49 CNY per square meter. To the best of our knowledge, this is the first study to directly test the effect of saving on housing price.

The present finding differs from previous studies which find household or personal income being a key determinant of house price (Capozza et al. 2002; Chen et al. 2013; Hou 2010; Hu et al. 2006; Li and Chand 2013; Potepan 1996; Shen et al. 2005). The difference may arise from the range of variables being investigated. In our study, per capita GDP, rural income, urban income and average wage of staff and workers are all examined. None of them is a significant factor, probably because their impact on house price has been mainly captured by per capita saving and other variables. With a low VIF in the regressions, per capita saving has more unique influence on house prices. This is reasonable because for a given household, the disposable income can be regarded as the sum of consumption and saving. Some researchers have the view that Chinese people use saving to buy houses as an alternative to investment in the financial market (e.g., Ma 2010), while others hold the view that housing has a dual nature as a consumption good and an investment vehicle (e.g., Yang et al. 2018). Our results corroborate the first view. Although various studies have shown the importance of income in determining house price (e.g., Li and Chand 2013), they do not include both income and saving such that they could not examine the impact of saving. Housing investment depends on the wealth of household, which could be better represented by per capita saving rather than other proxies.

Both Mankiw and Weil (1989) and Capozza et al. (2002) show that demographic change is a determinant of house price. Li and Chand (2013) find that impending marriages are the primary determinant of house prices. In our present analysis, unmarried population has no significant effect on house prices, probably because unmarried population is relatively stable with a huge population base in China. Urban population and family size do not have significant effect either, probably due to their effects being captured by other variables that are nearly collinear with them. Among the several population-related variables in our study, we find that the number of unemployed population is an important factor that influences house prices. An increase of 10,000 unemployed will reduce the house price by 23.51 CNY per square meter, *ceteris paribus*. Schnure (2005) concludes that one percent increase in unemployment rate leads to one percent decrease of housing price. With more

¹ In order to make sure the variables cointegrated in the model, we use the natural logarithm of land price instead of the level of land price.

unemployment, fewer people could afford to buy houses. The demand for house will decrease, thus leading to a decline in house prices.

As most households in China use housing provident fund to buy residential houses (Chen and Deng 2014; Yeung and Howes 2006), we expect that the amount of annual housing provident fund collection will positively affect house price, whereas the loan rate of housing provident fund has a negative relationship with house price. Annual housing provident fund collection has no significant influence on house price in the present study, probably because its data are only available since 2014, while our sample starts from 2000. The loan rate of housing provident fund has a negative relationship with house price, which is not significant probably because its impact has been captured by other variables.

Interest rate as a key government's monetary policy tool has been found to play an active role in many previous studies (Chen et al. 2013; Crouhy et al. 2008; Garino and Sarno 2004; Hatzvi and Otto 2008; Hou 2010; Hu et al. 2006; Krinsman 2007; Peng and Hudson-Wilson 2002; Unterman 2009; Zhang et al. 2012). However, it does not play a significant role in our analysis, probably because its impact has also been captured by other variables. On the demand side, an increase in interest rate raises costs of buying house and reduces demand, and thus house price will decrease. On the supply side, an increase in interest rate raises capital cost for housing developers. It may have two consequences: developers with a large hoard may stop hoarding and start to sell, which tend to reduce house prices in the short term; developers may reduce production and raise house prices in the longer term, making the overall effect of interest increase less clearcut.

In fact, variables which influence both house supply and demand, including inflation (represented by consumer price index), exchange rate, export, import and local government's tax revenue are all insignificant in our present study. Our results are inconsistent with Zhang et al. (2012) and Pavlova and Rigobon (2007) who document the important role of exchange rate on asset prices, and also inconsistent with Wang et al. (2011), who show that urban economic openness alone accounts for about 15.90 percent of the appreciation of Chinese real estate prices during the sample period. The difference between our finding and previous studies may also arise from the numbers of variables examined. The present study includes more variables which make more unique contribution and capture the impact of those factors found significant in previous studies.

5.4 Using current models to interpret house price data

If the price trend found in the present study is the proper trend of Chinese housing market, we could use the present model to identify potential price overvaluation/undervaluation. The predicted house prices for most provinces and autonomous regions from 2002 to 2014² match well with their actual prices (Fig. 5).

² The prediction is done until 2014 because saving's data are not available since 2015.

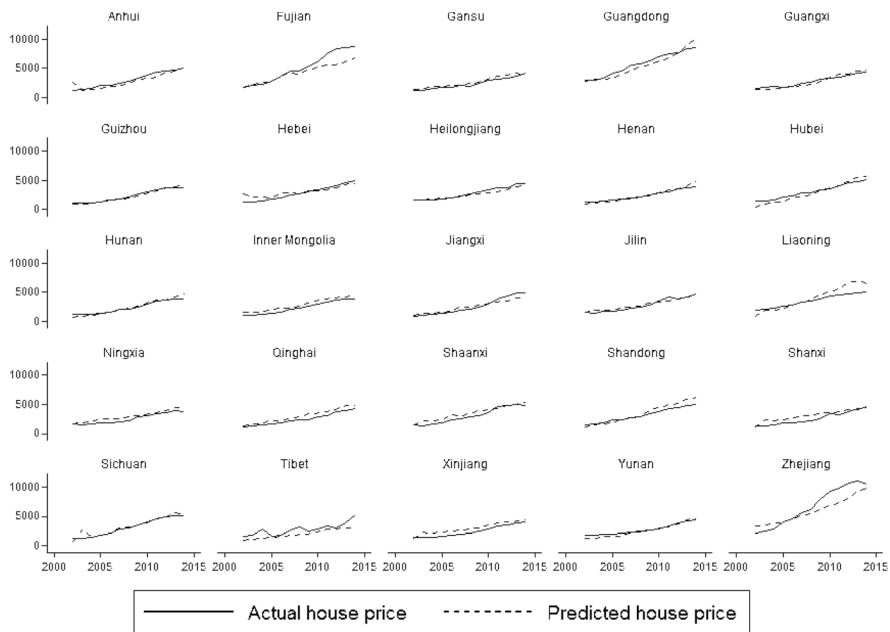


Fig. 5 Comparison between actual house prices with house prices predicted by PCSE model. The actual house prices and predicted house prices by PCSE model for 25 regions in China from 2002 to 2014. Y-axis is measured in CNY per square meter. X-axis is year

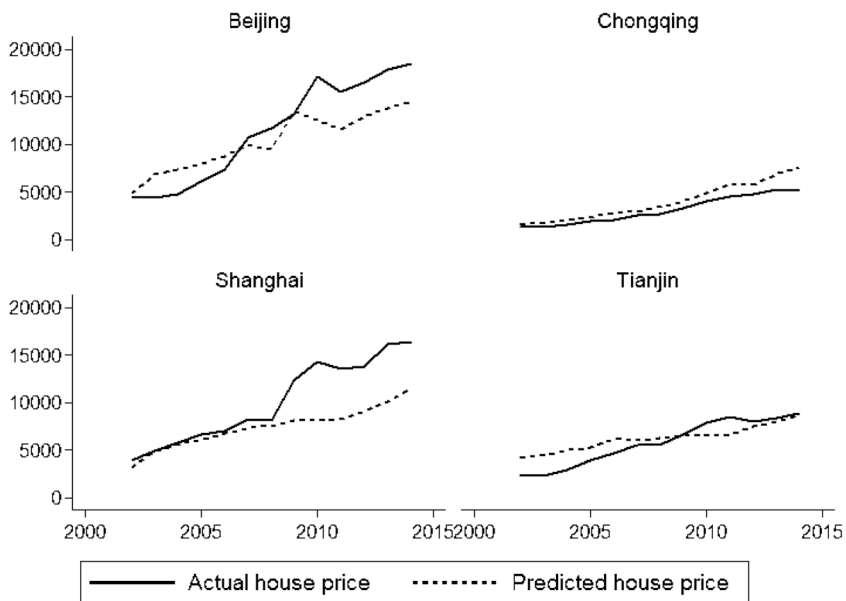


Fig. 6 Actual house prices versus predicted house prices of municipalities. The actual house prices and the predicted house prices for four municipalities, Beijing, Shanghai, Tianjin and Chongqing, from 2002 to 2014. Y-axis is measured in CNY per square meter. X axis is year

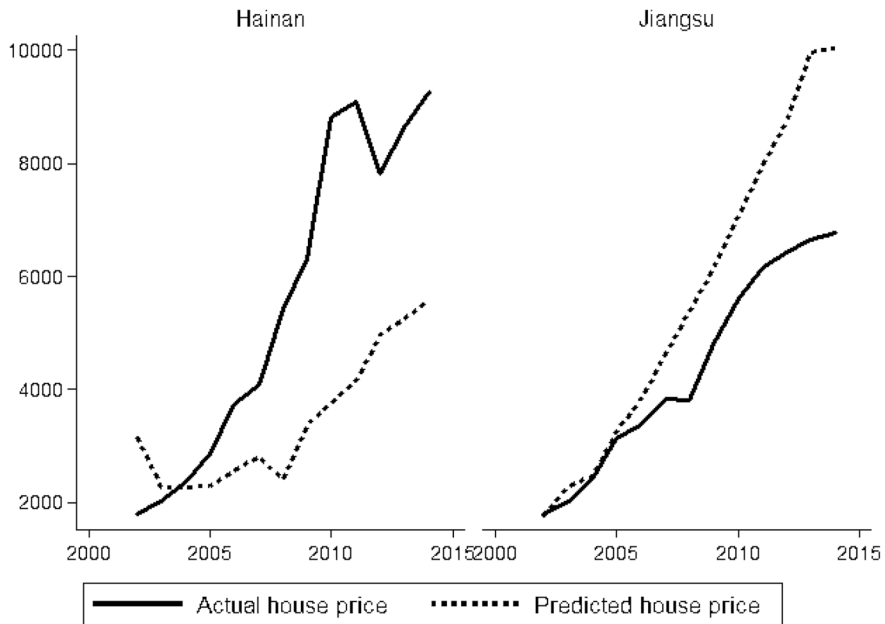


Fig. 7 Actual house prices versus predicted house prices of Hainan and Jiangsu provinces. The actual house prices and the predicted house prices from the PCSE regression model for Hainan and Jiangsu provinces from 2002 to 2014. Y-axis is measured in CNY per square meter. X axis is year

The actual house prices and predicted values of the four municipalities are shown in Fig. 6. The two curves for Chongqing are very close except for year 2014. Predicted values for Tianjin fluctuated around the actual house price, but in general are in line with the actual price. With big fluctuations during most of the observation period, Beijing's house price seems normal in 2002, undervalued until 2006 when it begins to rise above the predicted values, and much greater than the predicted values since 2009, suggesting a possible housing bubble after 2009. Shanghai's house price matches the prediction relatively well between 2002 and 2008, suggesting no bubble before 2009. Our result is different from that of Shen et al. (2005), who conclude that Shanghai's house prices deviated 22 percent from the market fundamental values and there might be a bubble in 2003. Shanghai's house price exceeds its predicted price sharply in 2009 and continues to be well above the predicted value.

Besides Beijing and Shanghai, Hainan's house price has been exceeding its predicted price since 2005 (Fig. 7), suggesting the existence of a price bubble in Hainan. Jiangsu's properties appear to be undervalued since 2005, with the actual house price lower than the predicted house price (Fig. 7).

If we define price overvaluation as actual house price exceeding the predicted price from PCSE model by more than 20 percent, and price undervaluation as actual house price being lower than the predicted price by 20 percent, price overvaluation happens in Beijing, Fujian, Hainan, Jiangxi, Shanghai, and Tibet in 2014 (Fig. 8). Tibet tops the list with an overvaluation as high as 73.97 percent.

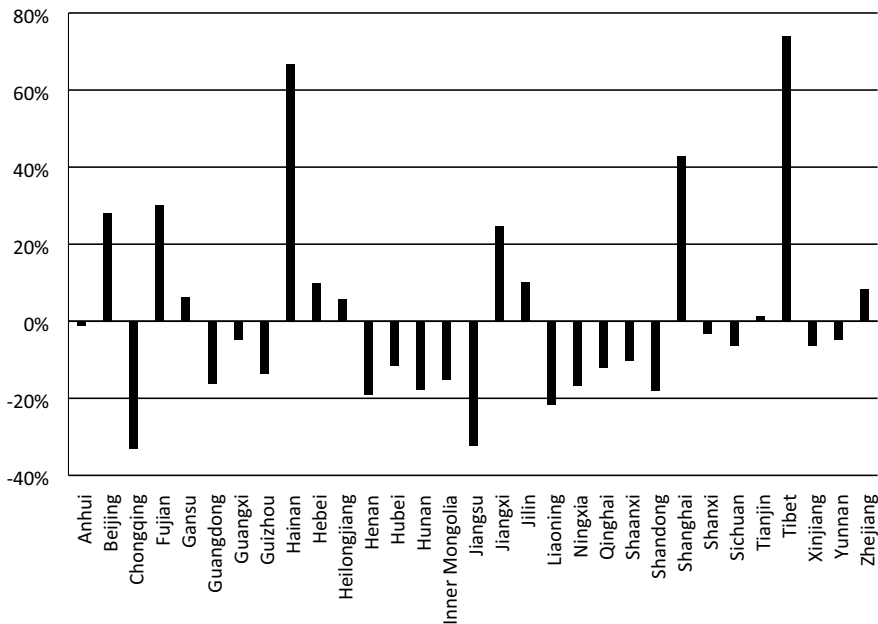


Fig. 8 Percentage difference between theoretical house price (from PCSE model) and actual house price. The percentage difference between predicted house price and actual house price for 31 provinces, municipalities and autonomous regions in China in 2014. The difference is computed as actual price divided by theoretical price minus one

Hainan follows with a difference of 66.70 percent. House prices in Jiangsu, Chongqing, and Liaoning are undervalued in 2014 (Fig. 8).

Overall, our findings show that housing prices are not significantly overvalued in China as a whole during 2014, which is consistent with Ahuja et al. (2010)'s earlier finding. It should be noted that the above analysis is based upon the assumption that the house price trend found in the analyzed period is the true long-term trend rather than a special phenomenon during a bubble forming period. Moreover, house price may change from city to city inside the same province. An overall reasonable average provincial house price could not guarantee a sensible house price of big cities inside the province. In an undervalued province, the house price of certain specific cities may still be overvalued. The relationship between provincial house price and municipal house price warrants further research.

6 Conclusion

The housing reform to solve housing shortage and government policies to promote economic growth have led to a booming housing market in China. The high house price in some regions causes concerns about price bubbles and associated financial risk. Therefore, it is important for policy makers as well as researchers to understand

house price determination in China. Researchers have conducted many insightful studies (Ahuja et al. 2010; Dreger and Zhang 2013; Du et al. 2011; Li and Chand 2013; Zhang et al. 2013). The present study on the determinants of house prices in 31 provinces, municipalities and autonomous regions finds that domestic loans of real estate developers, proportion of people with college or above educational degree, land price, per capita saving and the number of unemployed population are the most significant determinants among 30 socioeconomic variables. Since we examine many variables that have not been investigated previously for house price determination, we have identified factors that are more correlated with house price than such factors as real income and interest rate, which are usually considered key determinants of house price by previous studies.

When the present house price regression model is used to assess the existence of overvaluation or undervaluation in actual house prices in the 31 provincial divisions, house prices are not overvalued in most regions in China by the end of 2014. This result confirms some previous studies (Ahuja et al. 2010). However, there are a few regions where house prices deviate substantially from what the present model predicts. Among them, the house prices in Tibet, Hainan, Fujian, Beijing, Jiangxi and Shanghai appear to be overvalued, and those in Jiangsu, Liaoning and Chongqing are undervalued.

The present findings have some important policy implications. Since on the demand side, the proportion of people with college or above educational degree and per capita saving have positive influences and the number of unemployed population has a negative influence on house price, if the local government wants to have a booming housing market, the best approach is to promote local economic growth. It is the booming economy that leads to a high proportion of people with college or above educational degree, high per capita saving and low unemployed population. On the supply side, domestic loans of real estate developers and land price are the main drivers of house price. Therefore, if the government wants to prevent house price rising too fast, restricting domestic loans to real estate developers and increasing land supply to reduce land price would be the best approach. According to our present findings, focusing government regulatory efforts on the demand side, which seems a common practice in China, is not effective, as the three main determinants on the demand side are not sensitive to the usual regulatory measures.

Our research is based on an annual panel data set collected from provincial level. Quarterly or monthly data would be more informative in examining variables that change more frequently. China's National Statistic Bureau also provides monthly house price indexes for 70 large- and medium-sized Chinese cities, and the monthly Chinese real estate climate index. Research on particular cities is also important, because it provides specific information for local policy-makers. To fully understand the house price determination mechanism, we need researches conducted at different levels, with different time intervals, and using various methods.

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