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Regime-switching Housing Price Cycle in China

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Abstract

This paper aims to examine the house price cycle at the province level in China using the three-regime Markov-switching model. Our findings indicate that, in Xinjiang, Chongqing and Jiangsu, there was no secular slowdown in growth since the rapid-growth regime re-emerged at some stage. While during economic downturns and periods of rapid economic growth, house prices fall and grow fastest, respectively, in the central region. However, during a normal growth regime, house prices increase fastest in the eastern provinces. These findings indicate regional heterogeneity in China. We also investigated the determinant factors of regime switching in each region. Our results show that output growth and real lending rates are two common factors in the co-movement of the smooth probabilities of recession. Therefore, it should be possible to apply a uniform housing policy for the whole country, but only when house prices are in recession. However, in most cases, the government should implement a different policy according to the local conditions and determinant factors of each region.

Keywords: House price cycle, Markov switching model, China
JEL Classifications: C34, E32, R30

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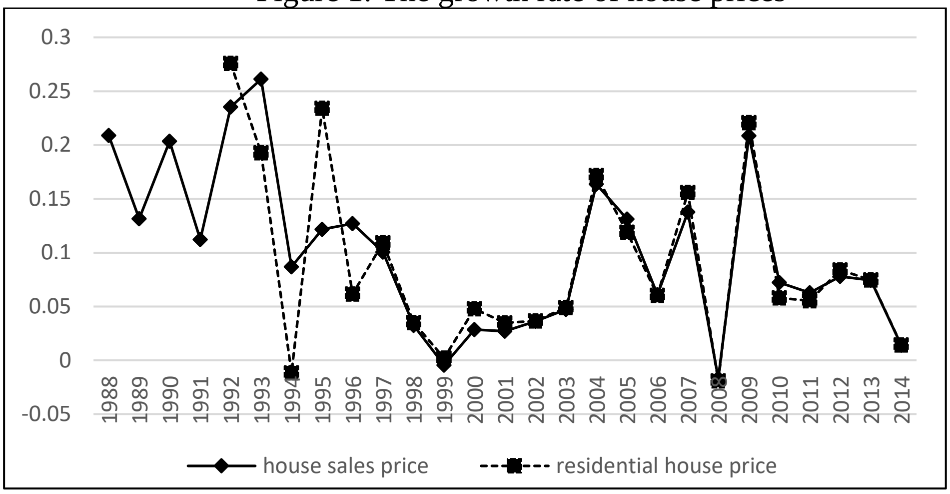
1. Introduction

From 1978 to 1991, in China the value of real estate manifested itself gradually, and the housing market became established with the promotion of housing system reform and land use reform. In early 1992, the government proposed accelerating the pace of housing reform in the southern region. Following this, the development and investment of real estate grew rapidly and led to a real estate bubble in some provinces. When the government started the first round of tightening macroeconomic policy, the Hainan real estate bubble burst in 1992, sending China's rapidly developing real estate sector into a downturn which continued until 1994 (Figure 1). Since 1998, with the monetisation reform of China's housing distribution, real estate prices have shown a rising trend. Also, in 1998, China's housing market was affected by the Asian financial crisis and by house price recession, while the duration, fluctuation range and severity of the residential market cycle were not affected due to the relatively closed market economy. With the gradual recovery of the economy, the residential market entered into a stable period of fluctuation from 2001 to 2003. Especially in 2003, the residential market became more prosperous and enjoyed a long period of expansion. Later, the global financial turmoil initiated by the subprime mortgage crisis severely damaged the residential house market in China once again, because of the high degree of openness of China's market economy. With strong demand in China, residential house prices increased sharply in 2009, but this was followed by a contraction period; in 2011, the amplitude of fluctuation was relatively small. In view of this, we can conclude that a house price cycle exists in China.

Figure 1: The growth rate of house prices



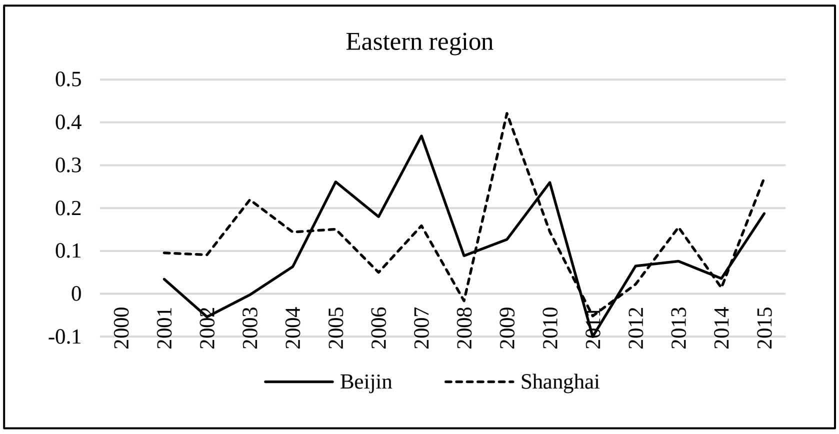
Source: CEIC database.

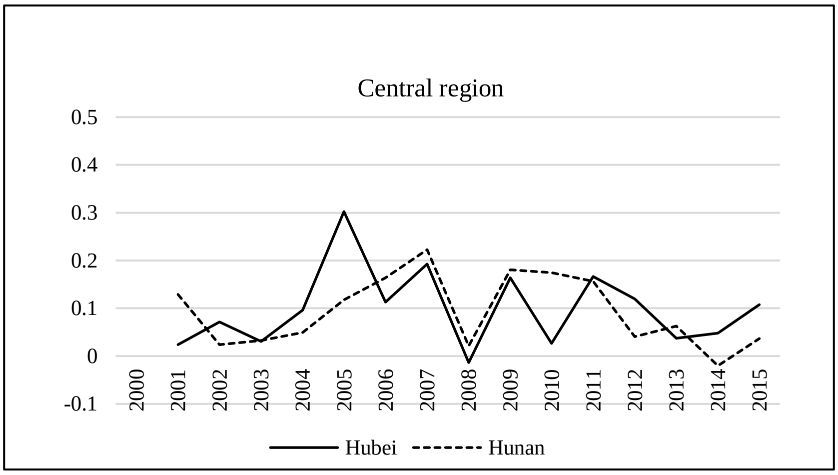
China is a big country which can be divided into three main regions: eastern, central, and western.[1] The development of the eastern region is better than the other regions due to its excellent location and because it has the highest population size in China, while the economy of the western region is relatively backward, and its internal

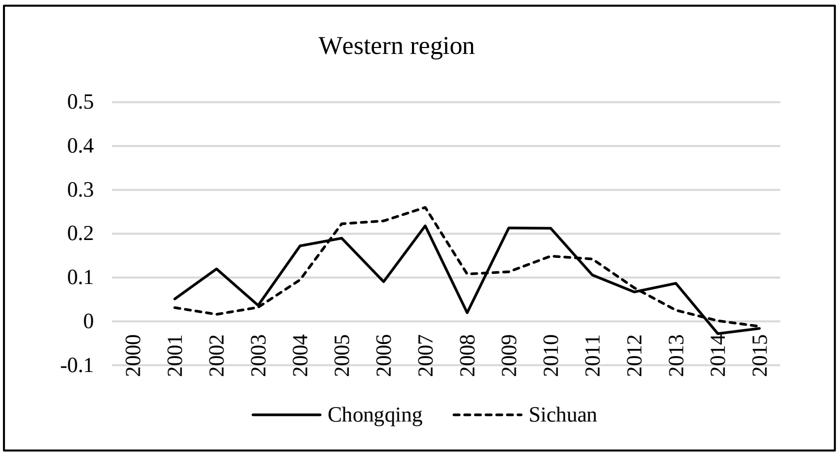
[1] Eastern Region: Hainan, Shanghai, Beijing, Zhejiang, Jiangsu, Hebei, Tianjin, Fujian, Shandong, Guangdong, Liaoning
Central Region: Jiangxi, Shanxi, Henan, Hunan, Hubei, Anhui, Jilin, Heilongjiang
Western Region: Gansu, Inner Mongolia, Qinghai, Shaanxi, Chongqing, Guangxi, Guizhou, Yunnan, Xinjiang, Ningxia, Sichuan

development extremely uneven. We used a province-level rather than region level study since house prices exhibit heterogeneity across regions, as well as within regions. For example, economic growth in a few western provinces, such as Chongqing and Sichuan, exceeds that of the central region or approaches the expansion of coastal areas. Therefore, using province-level data can provide additional information to support understanding of the house price cycle in China. The immovability and regional consumption of real estate products mean that development of the industry has obvious regional characteristics and produce externalities in terms of regional economic development. Furthermore, factors including the level of economic development, openness of information, and natural resource endowments of a region will determine the supply and development of its real estate products (Liang and Gao, 2007). For this reason, fluctuations within the house price cycle will have distinct regional characteristics due to a variety of factors. Despite house prices rising over the long term, house prices in the eastern region are higher than those in the central and western regions (Figure 2). According to (Fang et al. (2013), in most cities in China there are certain degrees of housing bubbles, mainly in eastern and central metropolises, while the real estate bubble in western cities has been becoming increasingly obvious in recent years. Therefore, it is important to study real estate prices across various regions in China. Examining the duration and magnitude of housing price cycles in different regions can enhance knowledge of past trends, improve the accuracy of future predictions, and help the government to implement effective economic policies according to the different characteristics of the various regions.

Figure 2: House price growth rate of the representative provinces in three regions







Source: CEIC database.

The literature on the housing market cycle in China is extensive; most of it has focused on the factors influencing the real estate cycle (Gu and Zhang, 2014; Luo et al., 2012; Zhang and Zeng, 2013), estimations of the real estate cycle in regions (Li and Guo, 2011; Ma, 2007), the relationships between the real estate cycle and macroeconomics (Zhao, 2010), and the origins of the real estate cycle (Wang and Qiu, 2007). House prices are an important indicator of the housing market cycle (Li and Guo, 2011). Normally, the development of real estate has a positive effect on macroeconomics. However, in recent years, high house prices have inhibited the strong demand for housing from most ordinary workers, exacerbated the unfair distribution of wealth, and hindered the process of urbanisation. Therefore, when the real estate sector is overheating or sluggish, it will adversely affect economic development and the volatility of real estate prices, thus causing macroeconomic fluctuations. However, studies of house prices have mainly focused on the factors behind their fluctuations (Luan, 2016; Niu, 2011; Tang, 2013; C. Wang, 2015) , the fluctuation characteristics of house prices (Xia et al., 2012), and real estate price bubbles (Zhao, 2010). Little research has been conducted into the house price cycle in China; the house price cycle has remained confined to analyses of influencing factors (Zhao & Shi, 2015) and to cities. Thus, analyses of the house price cycle and of the factors determining house prices when in periods of rapid growth or recession are important for facilitating the sustained and stable development of the Chinese national economy.

This paper contributes to the existing literature in several ways. First, we focus on 30 provinces in China, rather than only one region or province, which can improve our understanding of the properties of the house price cycle across 30 provinces. Second, Markov-switching models are used in our study. There are several advantages of applying Markov Switching in examining housing price cycles. Such a model not only reveals the measures of uncertainty associated with the chronology of turning points, but also facilitates real-time detection of cycle transitions and offers a well-developed theory for predictions of the cycle (Clements and Krolzig, 2003). We can observe different growth patterns (rapid, normal, low growth rate) in different regions and compare the duration of regimes across regions and over time. In this paper, we applied a three-regime Markov-switching model to better suit our data, rather than a two-regime model, which is normally used in studying business cycles; this kind of research is relatively limited in China. Finally, the regime probabilities obtained from the Markov Switching model can be used to analyse the factors determining the smooth probability of rapid growth and recession regimes. Furthermore, we used a panel dataset of 30 provinces and conducted three panel model for east, central and west regions by considering the fixed effects of individual provinces.

The rest of the paper is organised as follows. Section 2 reviews the literature and introduces the background to this study. Section 3 explains the econometric methodology and data. Section 4 discusses the empirical results of the regime-switching models and fixed-effect panel models. The final section draws conclusions and policy implications.

2. Literature Review

Hansen (1964) used the term ‘fluctuation’ to describe irregular movements of macrovariables over time. However, the term ‘cycle’ denotes a sequence of events that is constantly repeated and not necessarily to the same degree or at the same period. Hansen also commented that the tendency to fluctuate is not a ‘pathological condition’, but an inherent characteristic of the market economy. Accordingly, to stabilise it not only requires structural adjustments, but also a deliberate and positive anti-cyclical program. Generally, the housing price cycle reflects the natural rise and fall of house prices that occurs over time. Wherever one starts in the cycle, the house price is observed to go through four periods: expansion, peak, contraction, and trough. They do not occur at regular intervals, but do have recognised indicators. Therefore, governments could incorporate the house price cycle as a factor when improving economic policies, by understanding when and why recession or inflation will occur and to predict future trends.

Within the literature concerning real estate cycles, Gu (2007) found that the analysis of securities investment theory in terms of fluctuations in price and volume was notably mature and advanced. Furthermore, house prices share the same features as the price of securities. Therefore, tools to analyse securities, for example, moving average forecasting methods and spectral, balance, and volume analyses can be applied to analyse housing market cycles. Li and Guo (2011) applied spectral analysis to investigate the house price cycle in Wuhan. Zhu and Zhang (2011), by applying principal component analysis to the composite index and comparing the real estate cycle fluctuation and amplitude among four municipal cities, found that a synthetic index method efficiently reflected turning points and amplitudes within the real estate cycle, although there was considerable subjectivity when determining the weight. Xu et al.,(2010) used time-series analysis and all-around Principal Component Analysis to study China’s real estate cycle because researchers employing this method can describe and analyse the dynamic trajectory of multi-index economic problems and it represents a more efficient and scientific quantitative analysis tool for examining real estate cycle research. He et al.,(1996) calculated the diffusion index to study the real estate cycle. However, Ma (2007) found that while the diffusion index can effectively predict changes in the economy and its turning points, this method cannot reflect the strength of changes in the economy. For this reason, Ma recommended using a synthetic index method. Subsequently, Hongchun Gu (2013) noted that a Hodrick–Prescott Filter method can effectively decompose the long-term trend components and short-term fluctuations in economic time series, and thus is widely used in economic cycle research. Zhao and Shi (2015) attempted to divide house price cycles into expansion, normal, and contraction periods by using a triangular diagram. Overall, current tools for researching real estate cycles have certain limitations, and most of them focus on how to calculate the composite indeces for real estate cycles.

The Markov-switching model of Hamilton (2016) is one of the most popular nonlinear time-series models in the business cycle literature (see, for example, Chang and Nelson 1999; Artis et al., 2017; Krolzig and Toro 2001; and Dijk and Franses 2017). House price cycles also share the characteristic of cyclical asymmetry, which means that the economy functions differently in high and low growth rate phases of the house price cycle. Currently, there are a limited number of studies on house price cycles using the Markov Switching model. Chowdhury and Maclennan (2014) noted that house price cycles in the United Kingdom can be divided into two regions based on magnitude, duration, and behaviour during recession, boom and sluggish periods by using Markov-switching autoregression methods. They found that the asymmetrical growth patterns of regional house prices at different points on the cycle can be observed effectively using this model. They also uncovered that uniform housing and monetary policies increased diversion between regions. Corradin and Fontana (2013) applied a Markov-switching error correction model to estimate house price returns in 13 European countries, with deviations between house prices and fundamentals feeding into the short-run. Their results show that growth rates within regimes differed largely across countries and displayed synchronisation with each other in European housing markets during some periods. Lee et al., (1997) identified the turning points of Taiwan's real estate cycle using a bivariate Markov-switching autoregressive model. They revealed that projecting the peak and trough in a real estate cycle could provide an important reference indicator for decision makers and investors. Overall, to the best of the authors' knowledge, there is no current research on the house price cycle for all provinces in China, while the abovementioned studies provide a basis for using a Markov-switching model to study China's house price cycle.

According to the work of Fu (2013), Liang and Gao (2007), Luo (2011), Sun et al., (2011) and C. Wang (2015) the exogenous factors that affect house price dynamics in China can be divided into four kinds. The first is economic factors, which include national income, the money supply and interest rates. The second involves cost factors, such as land price. The third comprises social factors including levels of urbanisation and population considerations (for example, the number and structure of populations and households). The fourth variable is policy factors, for instance, tax regimes and house prices. Tang(2013) noted that monetary policies are one of the most important factors influencing fluctuations in real estate prices. He explained that sufficient money supply in real estate will reduce the dependence of the real estate business on asset turnover and reduce the speed of real estate sales because property developers will increase prices in order to obtain excess profits. In terms of the endogenous factors that affect house prices, they concluded that these include the contradiction of supply and demand, price expectations, investment and real estate return rates.

3. Data

In China, the data on house prices and the underlying factors that are used in our panel model for 30 provinces is available from government sources: The National Bureau of Statistics (NBS) and the CEIC. We used seasonally adjusted real house prices in our empirical work, and the data frequency was drawn monthly from March 1998 to August 2016. However, some provinces did not have data for January and February each year. There are three explanations for this problem. First, there were no transactions in January and February (for example, in Jilin and Tibet). Second, the statistics always started from March each year. Third, the NBS has not released January and February data separately. Instead, the NBS releases February year-to-date data (which are the cumulative figures for both January and February) to better reflect statistics during the Chinese New Year period. Hence, we computed the missing data via linear and cubic interpolation and found that the result of cubic spline interpolation is closer to our original data. In the explanatory variable in the panel data model, consumer price indeces, floor space sold, real estate investment, and lending rates are available in quarterly data form. However, GDP, government expenditure, and population at the province level data is available only in yearly form. Hence, we transformed yearly data into quarterly data using a cubic method[2]. Above all, changes in housing prices is normally reported as quarterly indeces in China. Next, we calculated real house prices, GDP, government expenditure, and real estate investment and the growth rate of house prices, GDP, government expenditure, population, Consumer Price Indeces, floor space sold, and real estate investment on a year on year basis. Eventually, we used augmented Dickey–Fuller unit root tests to examine the stability of the data. The results show that all the series rejected the null of non-stationarity at the 10% level of significance (Table 1).

Table 1: Results of Augmented Dickey-Fuller unit root tests

Eastern		Central		Western	
Beijing	-2.58(0.10)	Anhui	-3.14(0.03)	Chongqing	-3.37(0.01)
Fujian	-3.72(0.01)	Heilongjiang	-6.21(0.00)	Gansu	-5.54(0.00)
Guangdong	-3.39(0.01)	Henan	-3.76(0.00)	Guangxi	-2.60(0.09)
Hainan	-3.82(0.00)	Hubei	-4.95(0.00)	Guizhou	-4.99(0.00)
Hebei	-2.72(0.07)	Hunan	-5.59(0.00)	Inner-Mongolia	-6.69(0.00)
Jiangsu	-3.77(0.00)	Jiangxi	-4.79(0.00)	Ningxia	-2.62(0.09)
Liaoning	-3.24(0.02)	Jilin	-3.98(0.00)	Qinghai	-5.08(0.00)
Shandong	-3.50(0.01)	Shanxi	-8.06(0.00)	Shaanxi	-3.49(0.01)
Shanghai	-3.48(0.01)			Sichuan	-2.55(0.11)
Tianjin	-4.94(0.00)			Xinjiang	-3.40(0.01)
Zhejiang	-2.64(0.09)			Yunnan	-4.11(0.00)

Note: The figures in parenthesis are p-values
Source: Authors' calculations.

4. Research Methodology

The Markov-swithing model of housing price cycles. We first estimate the Markov-switching model of housing price cycle to understand the nature of the housing price cycle in China. In the Markov-switching model proposed by Hamilton (1989), there are multiple structures (equations) for identifying the time-series behaviours of the economic variables in different regimes; this model can also deal with more complex dynamic patterns by permitting switching between these structures. The switching mechanism is controlled by an observable state variable, and a Markov-switching model allows frequent changes at random time points. Consequently, it is suitable for describing correlated data that exhibits distinct dynamic patterns during different time periods. As shown in Figure 1, house prices in China have fluctuated. The range of the house price growth rate was from -5% to 35%, althoughlargely it stood between 0% and 10%. The two regime Markov-switching model implied that following the trough of a growth recession, since output switches back to the normal-growth phase, the value will never regain the ground lost during the downturn. The effects of growth recessions on the level of output will thus be permanent. In addition to examining the two-regime model of business cycle in terms of key macroeconomic variables, several recent papers suggest applying three-regime models. In the three-regime model normal periods are

[2] The results the cubic method in interpolation of quarterly data from yearly data provide the most suitable results to explain movement of data in our study comaring to those of the alternative method, e.g. linear, quadratic curve fitting method.

classified as alternative regimes to the rapid growth (expansion) and recession regimes. The relevance of a third regime in growth-cycle dynamics has to be considered. Girardin (2005) applied the three regime business cycle model and showed that the three-regime model can explain the high growth rates found in emerging markets. Therefore, in this paper, we test 30 provinces' house price cycles in China to identify average house price growth (hp_t) and duration in different regimes using a three-regime Markov-switching model. Autoregressive models with up to three lags are used, such as:

$$hp_t = \alpha_{st} + \beta_1 hp_{t-1} + \beta_2 hp_{t-2} + \beta_3 hp_{t-3} + \varepsilon_t, \qquad s_t = 1,2,3 \tag{1}$$

where St= {1,2,3} represents an unobservable state variable that determines the switching between these three regimes; and α_0 (St=0), α_1 (St=1), and α_3 (St=2) denote the conditional house price growth rate in the expansion, normal, and contraction regimes, respectively. Suppose that St follows the first-order Markov chain as follows:

$P(St=0| St\text{-}1=0) = P_{00}$
$P(St=1| St\text{-}1=0) = P_{01}$
$P(St=2| St\text{-}1=0) = P_{02}$
$P(St=0| St\text{-}1=1) = P_{10}$
$P(St=1| St\text{-}1=1) = P_{11}$
$P(St=2| St\text{-}1=1) = P_{12}$
$P(St=0| St\text{-}1=2) = P_{20}$
$P(St=1| St\text{-}1=2) = P_{21}$
$P(St=2| St\text{-}1=2) = P_{22}$

$$P = \begin{bmatrix} P_{00} & P_{01} & P_{02} \\ P_{10} & P_{11} & P_{12} \\ P_{20} & P_{21} & P_{22} \end{bmatrix}$$

where $P_{00}+P_{01}+P_{02}=P_{10}+P_{11}+P_{12}=P_{20}+P_{21}+P_{22}=1$ and $0<Pij<1$, where i,j= 0,1,2, the probability denotes the transition probabilities of St=j given that St−1=i. The transition probability governs the random behaviour of the state variable and determines the persistence of each regime. The constant expected duration and smooth probability calculated from transition probability, respectively, are used for estimating how long the regime will last and the probability of staying in the current state without knowing the prior state. Equation (1) can be estimated by using a maximum likelihood estimator. Then, a likelihood ratio test and Wald test were undertaken to test whether the mean house price growth rates are different from each regime within the region or not.

i) The panel data model for determinants of regime-switching in housing price cycles

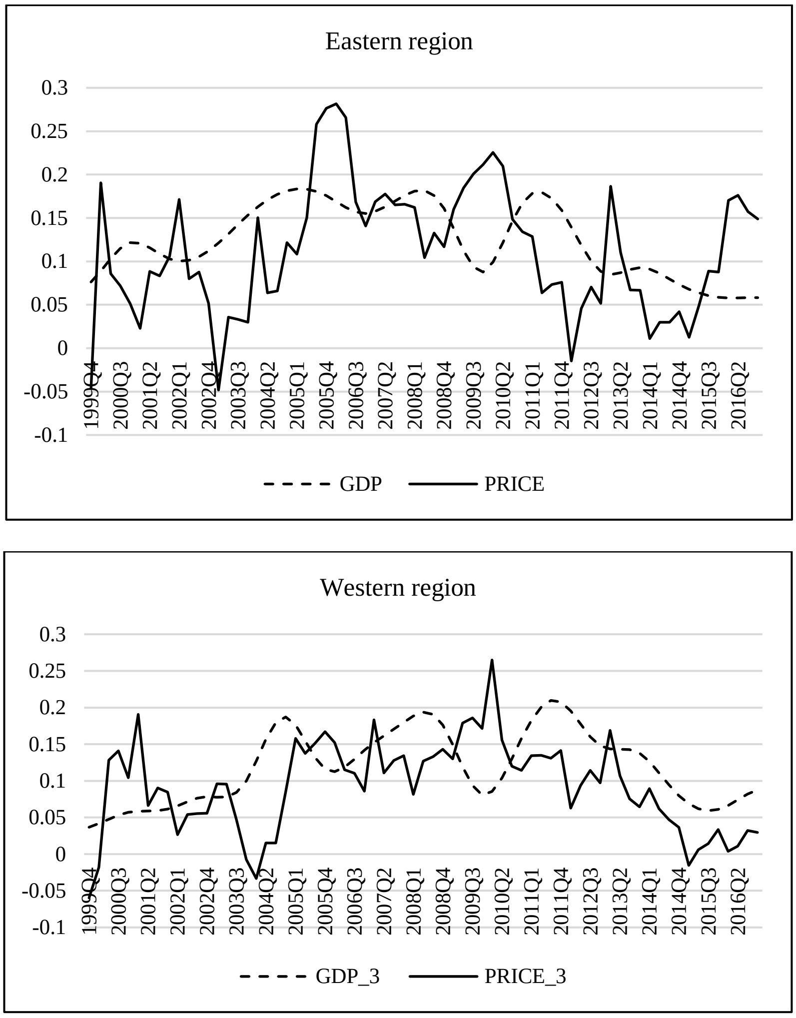
Next, we apply the panel model to evaluate the effects of factors that influence changes in the regime of the house price cycle. The results from this part will be helpful for policy recommendations on the role of government during boom or recession periods. As mentioned in the literature review, the determinant factors behind housing price cycles include the growth rate of real national income (GDP), population (POP), real estate investment (INV), real government expenditure (GOV), floor space sold (FSS), and real lending rates (LR). Real GDP growth and floor space sold is used to represent the demand for real estate. Lending rate and government expenditure are used to characterize policy factors. Social factors are proxied by the size of the population. Finally, real estate investment represents the variable related to the cost factor in our study. show that time of occurrence and duration is not complementary in high growth and growth–recession regimes; thus, we want to test the relationship between these factors and the smooth probability of the high growth and contraction regimes to see the effect on house price cycles for three regions using a panel data model. We assumed heterogeneity between the three regions. Consequently, we used a fixed-effect model by allowing its own intercept value. We also assumed that the slope of each factor was similar among cross sections. We condcut three panel model estimations for east, central and west regions by considering the fixed effects of individual province. Thus, our fixed-effect panel model is as follows:

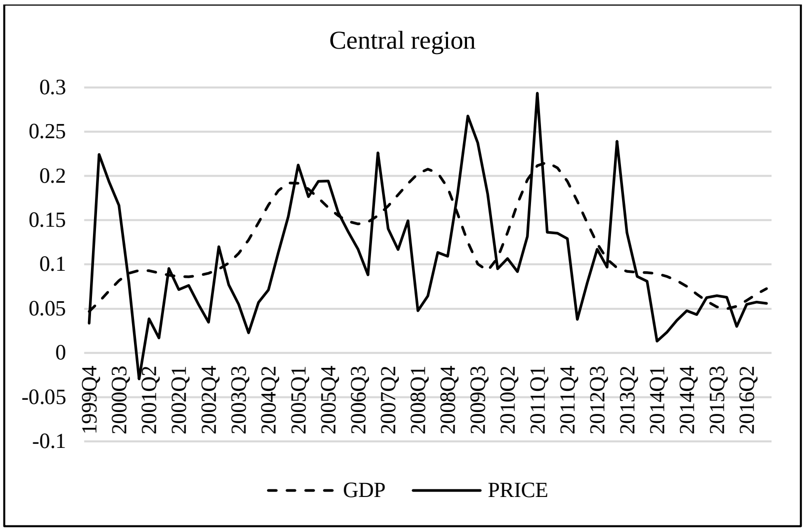
$$Y_{it} = \gamma_{0i} + \gamma_1(FSS_{it}) + \gamma_2(LR_{it}) + \gamma_3(POP_{it}) + \gamma_4(GOV_{it} + C\gamma_5\big(GDP_{i,t-8}\big) + \gamma_6(INV_{it}) + \mu_{it} \quad (2)$$

Where Y_{it} represents the smooth probability of high growth and growth–recession; I = {1, 2, 3} represent eastern region, central region, and western region, respectively; and t represents time. To test our assumption, we used Wald tests to identify this model.

We found that the growth rate of GDP fluctuated one or two years ahead of the fluctuation in house prices (see Figure 3). For this reason, we use the last two-year real GDP growth as a dependent variable in our model. The dating of regimes in our results

Figure 3: Fluctuations of house prices and GDP





Source: CEIC database.

5. Empirical Results

5.1 Descriptive Statistics

We first computed the descriptive statistics of house price growth in each province and compared growth cycles between the three regions. The results (Table 2, 3, and 4) show that, since 1999, house prices in each province showed a rising trend. Shanghai (11.7%), Jiangxi (11.4%), and Inner Mongolia (8.3%) grew fastest, while Liaoning (5.8%), Heilongjiang (7.1%), and Xinjiang (6.4%) exhibited the lowest growth rates in their region. In terms of economic stability, Jiangsu, Heilongjiang, and Guangxi reflected the lowest standard deviations in house price growth. When comparing the three regions, the average growth rate of the western provinces had a higher degree of similarity than those in the eastern and central provinces. Thus, there are high differences in house price growth among the eastern provinces.

Table 2: Descriptive statistics for growth rate of house prices in the eastern region

	Hainan	Shanghai	Beijing	Zhejiang	Jiangsu	Hebei
Mean	0.0844	0.1174	0.1036	0.1069	0.0987	0.0844
Median	0.0765	0.1159	0.0846	0.091	0.0763	0.0942
Maximum	1.1793	0.4878	0.513	0.4421	0.3485	0.4461
Minimum	-1.2689	-0.3165	-0.4219	-0.1312	-0.1039	-0.4203
Std. Dev.	0.3298	0.1463	0.1768	0.1103	0.0807	0.1236
Skewness	-0.9935	0.0378	-0.1044	0.654	0.4618	-0.8344
Kurtosis	6.7415	3.1726	2.9253	3.2929	3.2311	5.6771

	Tianjin	Fujian	Shandong	Guangdong	Liaoning
Mean	0.0964	0.0909	0.078	0.0642	0.0586
Median	0.089	0.0957	0.0699	0.0668	0.0625
Maximum	0.4138	0.3734	0.4416	0.3371	0.3991
Minimum	-0.6075	-0.1762	-0.2894	-0.2671	-0.2329
Std. Dev.	0.1089	0.1051	0.102	0.103	0.0918
Skewness	-0.9555	-0.0874	0.1071	-0.3429	-0.1681
Kurtosis	10.4741	3.2688	7.1941	3.4259	4.9351

Source: Authors’ calculations.

Table 3: Descriptive statistic for growth rate of house prices in the central region

	Jiangxi	Shanxi	Henan	Hunan	Hubei	Anhui
Mean	0.1144	0.1007	0.0832	0.0748	0.0822	0.0903
Median	0.1229	0.0975	0.0826	0.0843	0.0834	0.0798
Maximum	0.3898	0.8159	0.7592	0.4069	0.3124	0.5455
Minimum	-0.2134	-0.7051	-0.4292	-0.4906	-0.2326	-0.4491
Std. Dev.	0.1074	0.2098	0.1423	0.1261	0.1005	0.1274
Skewness	-0.1855	0.0114	0.4923	-0.9634	-0.5803	0.2321
Kurtosis	2.6865	6.49	7.3596	5.6885	3.9664	6.8996

	Jilin	Heilongjiang
Mean	0.0876	0.0708
Median	0.0882	0.0631
Maximum	1.0654	0.3784
Minimum	-1.0775	-0.2459
Std. Dev.	0.2877	0.0972
Skewness	-0.2985	0.1612
Kurtosis	7.3081	4.2772

Soure: Authors' calculations.

Table 4: Descriptive statistic for growth rate of house prices in the western region

	Gansu	Inner Mongolia	Qinghai	Shaanxi	Chongqing	Guangxi
Mean	0.0689	0.0831	0.0779	0.0785	0.0731	0.074
Median	0.0908	0.083	0.077	0.0858	0.072	0.0673
Maximum	0.9152	0.6814	0.7325	0.4673	0.4144	0.2774
Minimum	-1.0877	-0.4445	-0.7886	-0.3433	-0.3541	-0.1178
Std. Dev.	0.2509	0.1545	0.1923	0.1286	0.1283	0.0741
Skewness	-1.2687	0.1787	-0.412	-0.2988	-0.397	0.2373
Kurtosis	10.0793	5.7761	7.3383	3.989	3.9708	3.372

	Guizhou	Yunnan	Xinjiang	Ningxia	Sichuan
Mean	0.0713	0.065	0.0648	0.0692	0.0763
Median	0.0596	0.0638	0.0761	0.0723	0.0687
Maximum	0.3961	0.4342	0.5251	0.3682	0.4804
Minimum	-0.2258	-0.4386	-0.4884	-0.2512	-0.2755
Std. Dev.	0.1077	0.1101	0.1417	0.1078	0.1229
Skewness	0.2165	-0.5296	-0.493	0.251	0.4011
Kurtosis	3.1651	6.9217	5.8998	2.9675	4.155

Source: Authors' calculations.

5.2 Empirical results of the Markov-switching models

This section discusses the results obtained from the Markov switch model for each province. Tables 5, 6, and 7 present the average growth rates and duration of house prices in different regimes in each province. As shown, the results of the Likelihood Ratio test and Wald test (Tables 8, 9, and 10) suggest that the three house price growth regimes are indeed statistically different from each other in all provinces except Guangdong. In Guangdong, the three-regime model is strongly rejected, and the two-regime model gives a reasonable picture of the growth cycle. The optimum lag of autoregression depends on the partial autocorrelation function of each province.

Table 5: The results of the MSMs for each province in the eastern region

	Hainan	Shanghai	Beijing	Zhejiang	Jiangsu	Hebei
α1	0.909***	0.396***	0.133	0.107***	0.114***	0.146***
α2	0.094	0.21***	0.078	0.014	0.024	0.082**
α3	-0.822***	0.034	-0.223***	-0.05***	-0.052**	-0.134***
β1	0.861	0.947	0.928	1.048	0.987	0.86
	(-17.816)	(-39.508)	(-21.24)	(-12.483)	(-78.061)	(-8.04)
β2	-	-	-	-0.154	-	-0.149
	-	-	-	(-1.834)	-	(-1.152)
β3	-	-	-	-	-	0.028
	-	-	-	-	-	(-0.328)
σ	0.33	0.146	0.177	0.083	0.081	0.124
Log-likelihood	115.951	310.371	247.146	405.836	445.631	246.597
D1	1.992	11.445	2.215	9.059	6.202	21.932
D2	65.875	10.575	70.907	9.126	4.256	1
D3	10.814	15.068	10.855	7.57	16.573	4.257
LR test	49.605	18.937	3.075	8.229	41.544	7.48
prob.	0	0	0.079	0.004	0	0.006

	Tianjin	Fujian	Shandong	Guangdong	Liaoning	Median
α1	0.317***	0.208***	0.331***	0.331***	0.154***	0.181
α2	0.152***	0.087***	0.08***	0.08**	0.037**	0.08
α3	-0.033	0.027	-0.157***	-0.068*	-0.135***	-0.068
β1	0.85	1.294	0.816	0.772	1.144	
	(-13.362)	(-14.564)	(-10.906)	(-8.982)	(-15.547)	
β2	0.044	-0.353	-0.207	0.052	-0.285	
	(0.71909	(-3.941)	(-2.17)	(-0.439)	(-3.802)	
β3	-	-	0.15	0.116	-	
	-	-	(-1.885)	(-1.486)	-	
σ	0.096	0.105	0.102	0.103	0.092	
Log-likelihood	355.632	366.842	308.022	365.587	351.084	
D1	4.62	4.915	2.027		2.77	4.767
D2	44.94	7.598	32.969	15.867	21.316	15.867
D3	16.478	1.438	1.436	9.619	3.464	9.619
LR test	21.489	13.287	85.963	1.891	51.65	
prob.	0	0	0	0.169	0	

Note: *** represents a 1% level of significance; ** represents a 5% level of significance; * represents a 1% level of significance. The figure in parenthesis is a t-statistic. D1, D2 and D3 are denoted as the duration of rapid growth, normal growth and growth-recession regimes, respectively. LR is the likelihood ratio test statistic for linearity.

Source: Authors' estimation.

Table 6: The result of the MSMs for each province in the central region

	Jiangxi	Shanxi	Henan	Hunan	Hubei	Anhui
α1	0.217***	0.505***	0.116**	0.222***	0.188***	0.489***
α2	0.089***	0.091***	-0.047	0.009	0.04	0.142***
α3	-0.03	-0.514***	-0.278***	-0.228***	-0.136***	-0.166***
β1	1.017	0.986	0.927	0.841	0.891	0.945
	(-10.561	(-14.086)	(-29.326)	(-11.798)	(-11.852)	(-40.497)
β2	-0.127	-0.211	-	0.105	0.144	-
	(-1.275)	(-2.079)	-	(-1.348)	(-1.436)	-
β3	-	-0.211	-	-	-0.131	-
	-	(-2.911)	-	-	(-1.677)	-
σ	0.107	0.21	0.142	0.126	0.101	0.127
Log-likelihood	327.26	161.491	249.313	308.041	335.251	348.748
D1	7.167	2.437	29.711	1.499	3.12	1.496
D2	6.516	24.726	1.251	21.684	15.353	46.188
D3	2.391	1.496	8.361	1.996	1.368	15.996
LR test	41.835	85.34	2.095	59.085	34.784	123.716
prob.	0	0	0	0	0	0

	Jilin	Heilongjiang	Median
α1	0.126***	0.258***	0.22
α2	-0.197***	0.064***	0.052
α3	-0.587***	-0.068**	-0.197
β1	1.213	0.808	
	(-18.127)	(-10.239)	
β2	-0.433	0.089	
	(-6.493)	(-1.109)	
β3	-	-	
	-	-	
σ	0.288	0.097	
Log-likelihood	91.706	305.466	
D1	19.679	3.453	3.287
D2	1	13.319	14.336
D3	1.383	3.608	2.193
LR test	16.586	26.032	
prob.	0	0	

Note: *** represents a 1% level of significance; ** represents a 5% level of significance; * represents a 1% level of significance. The figure in parenthesis is a t-statistic. D1, D2 and D3 are denoted as the duration of rapid growth, normal growth and growth-recession regimes, respectively. LR is the likelihood ratio test statistic for linearity.
Source: Authors' estimation.

Table 7: The result of the MSMs for each province in western region

	Gansu	Inner	Qinghai	Shaanxi	Chongqing	Guangxi
α1	0.488***	0.292***	0.313***	0.131*	0.118***	0.196***
α2	0.11**	0.111***	0.06	-0.019	-0.021***	0.073***
α3	-0.297***	-0.111**	-0.155	-0.217***	-0.184***	-0.026
β1	1.114	1.234	1.157	0.909	-	0.839
	(-15.241)	(-14.902)	(-12.76)	(-11.001)	-	(-10.744)
β2	-0.207	-0.317	-0.377	0.074	-	-0.167
	(-2.764)	(-3.914)	(-4.01)	(-0.872)	-	(-1.739)
β3	-	-	-	-	-	0.202
	-	-	-	-	-	(-2.53)
σ	0.251	0.155	0.192	0.129	0.106	0.074
Log-likelihood	146.478	199.504	183.437	251.06	274.851	399.724
D1	1.845	2.884	2.716	2.03	9.39	3.589
D2	13.61	6.843	40.493	1.316	20.122	7.781
D3	6.493	4.863	5.72	24.056	8.585	27.247
LR test	60.85	47.4	16.467	23.986	104.874	28.23
prob.	0	0	0	0	0	0

	Guizhou	Yunnan	Xinjiang	Ningxia	Sichuan	Median
α1	0.172***	0.232***	0.335***	0.135***	0.184***	0.196
α2	0.056	0.034	0.039	0.034	-0.016	0.039
α3	-0.053	-0.153***	-0.157***	-0.086***	-0.22***	-0.155
β1	0.953	0.865	0.912	0.904	0.975	
	(-38.426)	(-10.782)	(-29.99)	(-26.183)	(-10.292)	
β2	-	-0.079	-	-	-0.134	
	-	(-0.72)	-	-	(-1.475)	
β3	-	0.125	-	-	-	
	-	(-1.57)	-	-	-	
σ	0.108	0.11	0.142	0.105	0.105	
Log-likelihood	308.21	280.744	266.905	321.881	332.947	
D1	10.638	4.475	8.562	1.493	4.608	3.589
D2	5.261	15.129	27.219	13.376	25.103	13.61
D3	2.486	1.568	1.872	4.52	1.797	4.863
LR test	15.349	58.692	68.922	16.967	77.034	
prob.	0	0	0	0	0	

Note: *** represents a 1% level of significance; ** represents a 5% level of significance; * represents a 1% level of significance. The figure in parenthesis is a t-statistic. D1, D2 and D3 are denoted as the duration of rapid growth, normal growth and growth- recession regimes, respectively. LR is the likelihood ratio test statistic for linearity.

Source: Authors' estimation.

Table 8: Probabilities of transition between regimes in the eastern area

Province	Initial regime	Regime1	Regime2	Regime3
Hainan	Regime1	0.498	0.502	0.000
	Regime2	0.000	0.985	0.015
	Regime3	0.031	0.062	0.908
Shanghai	Regime1	0.913	0.000	0.087
	Regime2	0.000	0.905	0.095
	Regime3	0.008	0.058	0.934
Beijing	Regime1	0.549	0.356	0.096
	Regime2	0.000	0.986	0.014
	Regime3	0.092	0.000	0.908
Zhejiang	Regime1	0.890	0.000	0.110
	Regime2	0.009	0.890	0.100
	Regime3	0.038	0.094	0.868
Jiangsu	Regime1	0.839	0.085	0.076
	Regime2	0.169	0.765	0.066
	Regime3	0.009	0.051	0.94
Hebei	Regime1	0.954	0.000	0.046
	Regime2	1.000	0.000	0.000
	Regime3	0.041	0.194	0.765
Tianjin	Regime1	0.784	0.216	0.000
	Regime2	0.006	0.978	0.017
	Regime3	0.02	0.041	0.939
Fujian	Regime1	0.797	0.075	0.129
	Regime2	0.047	0.868	0.085
	Regime3	0.000	0.696	0.304
Shandong	Regime1	0.507	0.340	0.153
	Regime2	0.011	0.970	0.019
	Regime3	0.140	0.556	0.304
Guangdong	Regime1			
	Regime2		0.937	0.063
	Regime3		0.104	0.896
Liaoning	Regime1	0.639	0.266	0.095
	Regime2	0.041	0.953	0.006
	Regime3	0.289	0.000	0.711

Source: Authors' calculations from the regression results of the three-regime MSMs specified in equation (1)

Table 9: Probabilities of transition between regimes in the central area

	Initial regime	Regime1	Regime2	Regime3
Jiangxi	Regime1	0.860	0.118	0.021
	Regime2	0.099	0.847	0.055
	Regime3	0.057	0.361	0.582
Shanxi	Regime1	0.590	0.339	0.071
	Regime2	0.024	0.960	0.016
	Regime3	0.190	0.478	0.332
Henan	Regime1	0.966	0.027	0.006
	Regime2	0.418	0.201	0.381
	Regime3	0.074	0.046	0.880
Hunan	Regime1	0.333	0.558	0.110
	Regime2	0.026	0.954	0.020
	Regime3	0.100	0.402	0.499
Hubei	Regime1	0.680	0.320	0.000
	Regime2	0.049	0.935	0.017
	Regime3	0.000	0.731	0.269
Anhui	Regime1	0.332	0.279	0.390
	Regime2	0.014	0.978	0.008
	Regime3	0.000	0.063	0.937
Jilin	Regime1	0.949	0.035	0.016
	Regime2	0.670	0.000	0.330
	Regime3	0.332	0.391	0.277
Heilongjiang	Regime1	0.710	0.235	0.055
	Regime2	0.030	0.925	0.045
	Regime3	0.035	0.242	0.723

Source: Authors' calculations from the regression results of the three-regime MSMs specified in equation (1)

Table 10: Probabilities of transition between regimes in the western area

Province	Initial regime	Regime1	Regime2	Regime3
Gansu	Regime1	0.458	0.457	0.085
	Regime2	0.028	0.927	0.045
	Regime3	0.038	0.116	0.846
Inner Mongolia	Regime1	0.653	0.270	0.077
	Regime2	0.103	0.854	0.043
	Regime3	0.121	0.085	0.794
Qinghai	Regime1	0.632	0.191	0.177
	Regime2	0.025	0.975	0.000
	Regime3	0.11	0.065	0.825
Shaanxi	Regime1	0.507	0.384	0.108
	Regime2	0.467	0.240	0.292
	Regime3	0.000	0.042	0.958
Chongqing	Regime1	0.894	0.106	0.000
	Regime2	0.028	0.950	0.022
	Regime3	0.049	0.067	0.884
Guangxi	Regime1	0.721	0.279	0.000
	Regime2	0.000	0.963	0.037
	Regime3	0.062	0.066	0.871
Guizhou	Regime1	0.906	0.052	0.042
	Regime2	0.090	0.810	0.100
	Regime3	0.084	0.318	0.598
Yunnan	Regime1	0.777	0.140	0.084
	Regime2	0.041	0.934	0.025
	Regime3	0.103	0.534	0.362
Xinjiang	Regime1	0.883	0.058	0.059
	Regime2	0.007	0.963	0.030
	Regime3	0.209	0.325	0.466
Ningxia	Regime1	0.330	0.345	0.324
	Regime2	0.027	0.925	0.047
	Regime3	0.034	0.188	0.779
Sichuan	Regime1	0.783	0.169	0.048
	Regime2	0.019	0.960	0.021
	Regime3	0.110	0.446	0.444

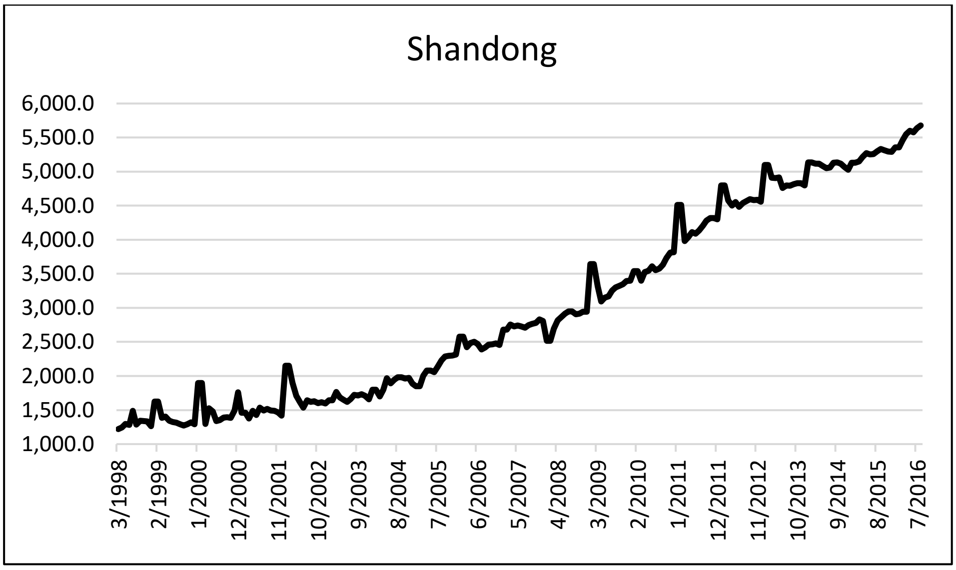
Source: Authors' calculations from the regression results of the three-regime MSMs specified in equation (1)

The growth–recession regime corresponds to negative house price growth in all provinces, except for two eastern provinces – Shanghai (3.4%) and Fujian (2.7%) – and falls in house prices were faster in the central region than other regions. Additionally, when comparing the growth rate of house prices in high growth regimes, provinces in the central region also grew at a faster rate than the eastern and western regions. In the central region, the drop was highest in Jilin (58.7%), followed by Shanxi and Henan. But in terms of rapid growth rate, the average growth rate was highest in Shanxi (50.5%), followed by Anhui and Heilongjiang. House price growth in the normal growth regime was between 1% and 10%, other than for Shanghai (21%), Tianjin (15.2%), and Anhui (14.2%), while some provinces in the central region showed negative growth rates in the case of Henan (-5%) and Jilin (-19.7%). Moreover, provinces in the eastern region grew faster than those in other regions. Otherwise, Zhejiang showed the lowest growth rate, both in high (10.7%) and middle growth rate regimes. Moreover, Hainan had the highest growth rate both in high (90.8%) and low growth rate regimes. Hainan is special compared to other provinces in the east. In 1988 Hainan gained independence from Guangdong province and became the only provincial-level special economic zone in China. A large amount of capital flowed into Hainan province and boosted local house prices. In 1993, the housing bubble burst and the government spent eight years attemting to deal with keep-long-in- stock real estate in Hainan Province. Until 2000, Hainan's house prices rose gradually. Due to the weak macro economy and the structural imbalance of product supply and demand, the Hainanese real estate market suffered a decline for five consecutive years from 2011 to

2015. Therefore, Hainan is much more volatile compared to other provinces in the eastern region. Thus, there was a big difference among eastern provinces. Hence, we calculated the mean growth rate, rather than the average growth rate of each regime in each region, and the results are similar, as discussed above.

The average duration of the low growth regime was shortest in the central region. Additionally, the low growth regime was very short-lived in Hubei, followed by Jilin and Shanxi. Taking Shandong as an example, the expected duration of being in the contraction regime is 1.436 months. We observe that the house prices of Shandong had only two short periods of experiencing contraction regimes (see figure 4), early 2005 and 2008. The reason for those recession periods lies in the high frequency of introducing macro-control policies affecting real estate in 2004 and the financial crisis of 2007. Conversely, the average duration of low growth regime was the longest in Guangxi and Sichuan, about seven quarters. However, the average duration of the high and normal growth rate regime in all regions was similar. The probabilities of transition between regimes, reported in Tables 8, 9 and 10, indicate that, when starting from a growth–recession regime, most central provinces had lower probabilities of staying in such a condition compared with eastern and western. By contrast, most eastern provinces were stable in a growth–recession regime. Furthermore, all regions were relatively constant in a normal growth regime, except for Hebei, Shaanxi, Henan, and Jilin, which showed normal growth exclusively, followed by rapid growth. In some provinces, a rapid growth regime, with some likelihood, led to growth recessions, such as in Zhejiang, Ningxia, and Anhui.

Figure 4: House prices in Shandong



Source: CEIC database.

Table 11 presents contemporaneous correlations of the smoothed probabilities of growth–recession and rapid growth regimes between the three regions. Rapid growth in the central region is substantially correlated both with the eastern and western regions, while correlation with the eastern region is much larger than with the western. In a growth–recession regime, in almost all cases, correlations with each other are much stronger than for rapid growth regimes, but correlations of the central region with the western region are larger than with the eastern region. Furthermore, correlations of the eastern region with the western were significant.

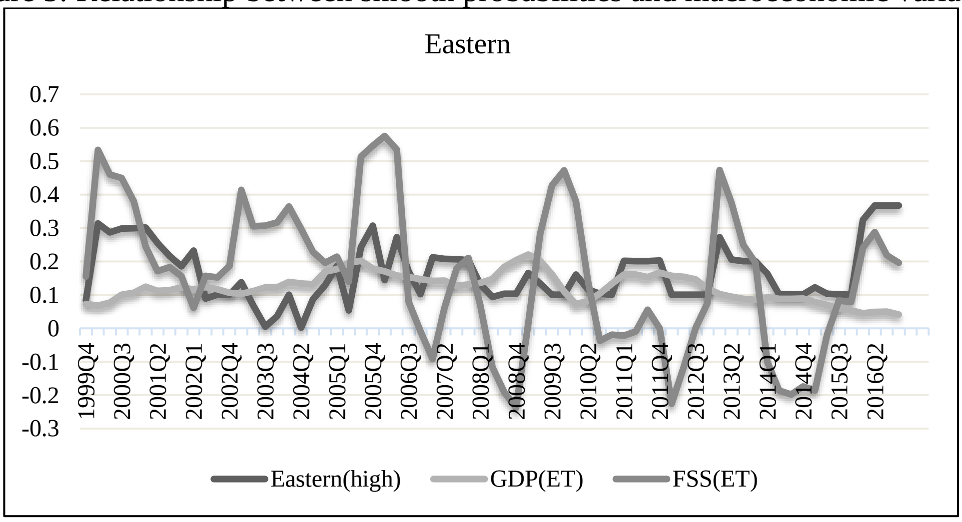
Table 11: Cross-correlations of smoothed probabilities among regions

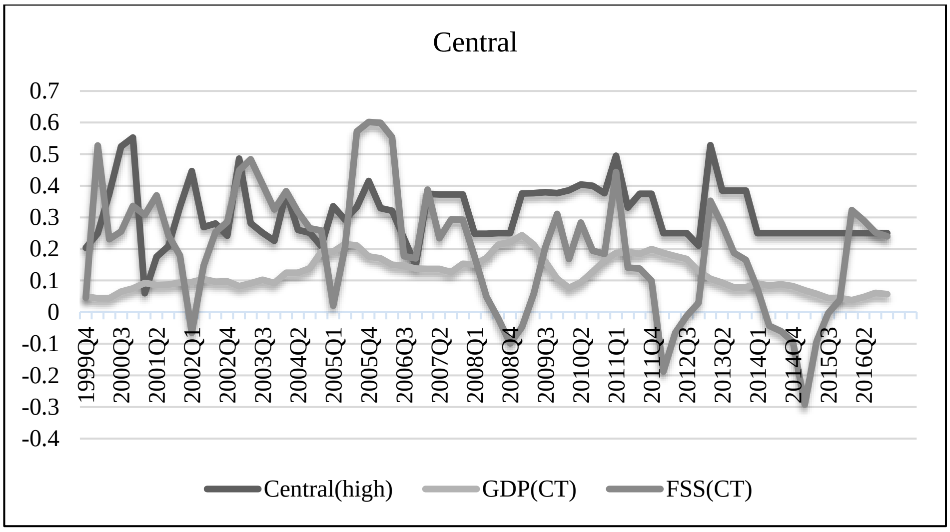
	ES	CT	WS
Rapid growth regime			
ES	1	0.21***	-0.06
CT	0.21***	1	0.13**
WS	-0.06	0.13**	1
Growth recession regime			
ES	1	0.42***	0.43***
CT	0.42***	1	0.74***
WS	0.43***	0.74***	1

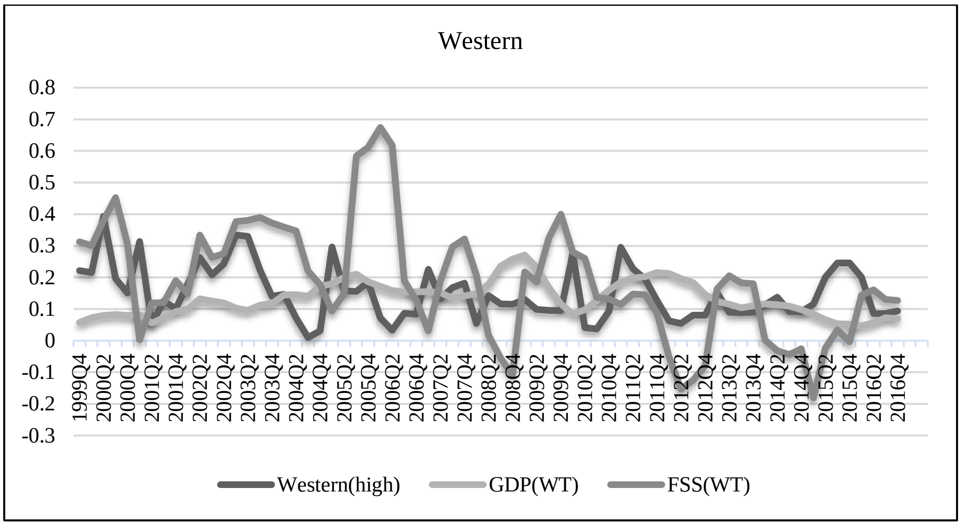
Note: ES, Eastern region; CT, Central region; WS, Western region. Likelihood ratio. Significant at the 10%, **5% and ***1% levels.
Source: Authors'calculations using data from the smooth probabilities of being in rapid growth and contraction regimes.
Source: Authors' estimation.

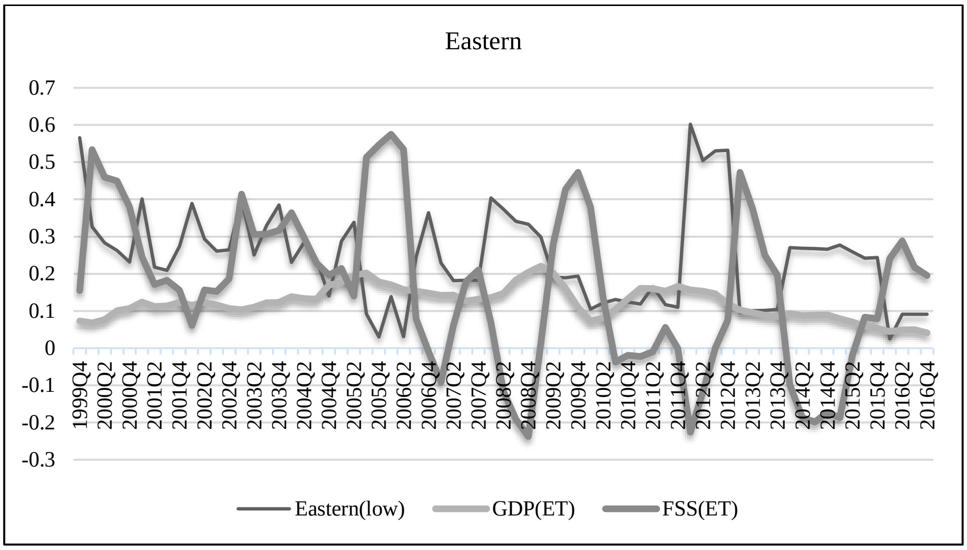
Next, we plot the relationship between smooth probabilities and macroeconomic variables in Figure 5. In case of smooth probabilities i9n relationship to high regimes, Figure 5 shows that the movement of smooth prabablities correspondes to changes in floor space sold. GDP growth seems to have lagged in relationship with smooth probabilities, which are similar to those of the housing price series in Figure 3. For the smooth probabilities of transition to low regimes, the correlations between smooth probabilities, GDP growth and floor space sold are less obvious compared to those of high regime probabilities. However, the data still shows a pattern of movement in the different direction. Therefore, in the next section, we further investigate the relationship between smooth probabilities and the explanatory varaibles using the panel data regression

Figure 5: Relationship between smooth probabilities and macroeconomic variables




Central
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
1999Q4
2000Q3
2001Q2
2002Q1
2002Q4
2003Q3
2004Q2
2005Q1
2005Q4
2006Q3
2007Q2
2008Q1
2008Q4
2009Q3
2010Q2
2011Q1
2011Q4
2012Q3
2013Q2
2014Q1
2014Q4
2015Q3
2016Q2
Central(high)
GDP(CT)
FSS(CT)


Western
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1999Q4
2000Q2
2000Q4
2001Q2
2001Q4
2002Q2
2002Q4
2003Q2
2003Q4
2004Q2
2004Q4
2005Q2
2005Q4
2006Q2
2006Q4
2007Q2
2007Q4
2008Q2
2008Q4
2009Q2
2009Q4
2010Q2
2010Q4
2011Q2
2011Q4
2012Q2
2012Q4
2013Q2
2013Q4
2014Q2
2014Q4
2015Q2
2015Q4
2016Q2
2016Q4
Western(high)
GDP(WT)
FSS(WT)


Eastern
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
1999Q4
2000Q2
2000Q4
2001Q2
2001Q4
2002Q2
2002Q4
2003Q2
2003Q4
2004Q2
2004Q4
2005Q2
2005Q4
2006Q2
2006Q4
2007Q2
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2010Q4
2011Q2
2011Q4
2012Q2
2012Q4
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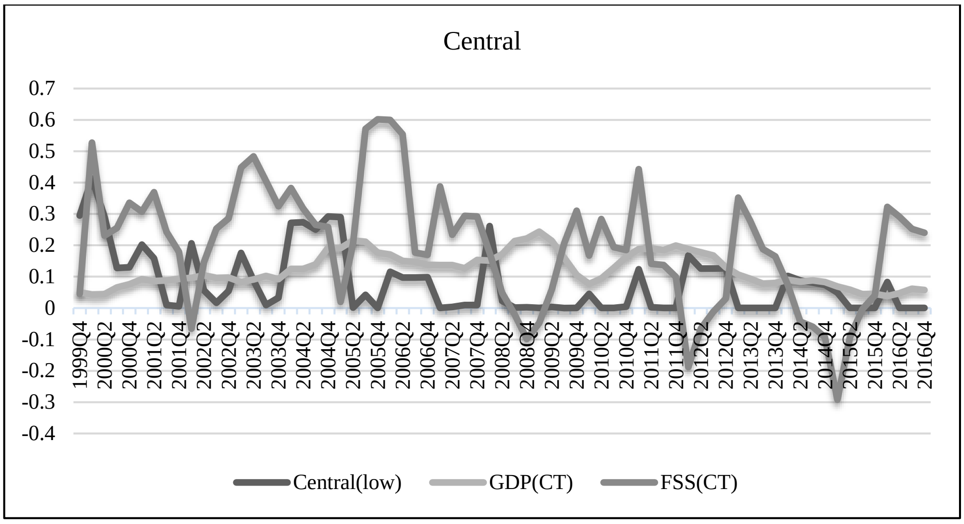
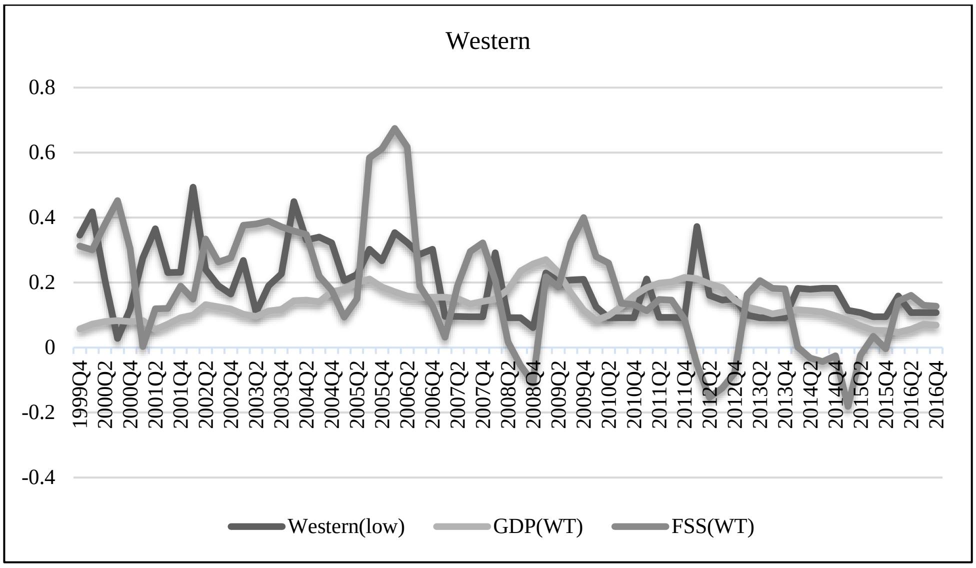
2015Q4
2016Q2
2016Q4
Eastern(low)
GDP(ET)
FSS(ET)





Source: CEIC

5.3 Empirical results of panel data models

The results of the Wald test (Table 12) suggest that growth rate of floor space sold, real estate investment, last two years' real GDP, and real government expenditure are indeed statistically significantly different from each other between the three regions in terms of the smooth probability of rapid growth. Additionally, for the smooth probability of growth–recession, growth rate of floor space sold, and real estate investment are significantly different between each region.

Table 12: Wald test results of panel data model (P values reported)

	FSS	GDP (-8)	INV	LR	GOV	POP
Rapid growth regime						
East-middle, middle-west	0.0117	0.0997	0.0019	0.3674	0.0450	0.1917
Low growth regime						
East-middle, middle-west	0.0001	0.5325	0.0702	0.4693	0.1707	0.1970

Note: H0: Eastern-Central =0, Central- Western=0; H1: Eastern-Central ≠0, Central-Western≠0
Source: Authors' calculations.

Consequently, in our estimation framework, the results of the two fixed-effect panel data models are given in Tables 13 and 14. We found that a 10% increase in the growth of floor space sold in the eastern region will increase the probability of staying in a rapid growth regime by about 1.12% , while it will significantly decrease the probability of staying in a recession regime by 2.77%. Moreover, as the growth rate of real estate investment increases by 10%, the probability that house prices will stay in a rapid growth regime seems to decrease by 3.88%, but the probability that they will stay in recession increases by 2.65%. For the central region, growth rate of floor space sold, last two-year GDP, government expenditure, and population have a significant, positive relationship with the smooth probability of rapid growth. In a recession regime, in terms of an increase in the growth rate of the last two-year GDP, the probability of staying in a recession regime decreases by 0.95% for the whole country. Lending rate has a positive relationship with the smooth probability of a recession regime in all three regions. Moreover, a higher growth rate of floor space sold will increase the likelihood of being in a recession regime in the western region.

Table 13: Determinant factors of the smooth probability of rapid growth and growth-recession

Variable	boom	recession
	Coefficient	Coefficient
C	0.188 (3.094)	0.077 (1.104)
Lending rate	-0.005 (-0.448)	0.037*** (2.732)
The growth rate of floor space sold(eastern)	0.121** (2.426)	-0.277*** (-4.631)
The growth rate of floor space sold(central)	0.252*** (3.452)	-0.009 (-0.112)
The growth rate of floor space sold(western)	-0.003 (-0.053)	0.213*** (3.179)
The growth rate of real estate investment(eastern)	-0.388*** (-2.909)	0.265* (1.713)
The growth rate of real estate investment(central)	-0.138 (-1.374)	0.072 (0.615)
The growth rate of real estate investment(western)	0.117 (1.307)	-0.128 (-1.199)
The growth rate of GDP (-8) (eastern)	0.414 (0.801)	-0.946*** (-5.221)
The growth rate of GDP (-8) (central)	0.576*** (2.775)	-0.946*** (-5.221)
The growth rate of GDP (-8) (western)	-0.385 (-1.604)	-0.946*** (-5.221)
The growth rate of government expenditure(eastern)	0.074 (0.276)	-0.047 (-0.441)
The growth rate of government expenditure(central)	0.461*** (2.861)	-0.047 (-0.441)
The growth rate of government expenditure(western)	-0.08 (-0.65)	-0.047 (-0.441)
Population growth(eastern)	0.074 (0.276)	-2.492 (-1.274)
Population growth(central)	0.461** (2.861)	-2.492 (-1.274)
Population growth(western)	-0.08 (-0.650)	-2.492 (-1.274)

Fixed Effects (Cross)		
_1--C	-0.009	0.084
_2--C	-0.034	-0.113
_3--C	0.042	0.028
R-squared	0.608	0.516
Adjusted R-squared	0.565	0.482
Log likelihood	227.298	183.513
S.E. of regression	0.074	0.092
S.D. dependent var	0.112	0.128

Note: ***p<0.01, **p<0.05, *p<0.1. The figure in parenthesis is a t-statistic
Source: Author's estimation.

6. Conclusions and Recommendations

In this paper, we have used a three-regime Markov-switching model of growth cycles to analyse regional house price cycles in China from 1999 to 2016. There are four important findings. First, we find that the rapid-growth regime, which had apparently disappeared, re-emerged a few years later for some substantial time in Xinjiang, Chongqing and Jiangsu. This contradicts the popular interpretation of structural changes in terms of a secular slowdown in growth corresponding to a 'permanent' switch to a slower growth path. Second, during economic downturns and rapid economic growth, house prices in the central region fell and grew faster than those in other regions. However, during normal growth regimes, house price growth rates in the eastern region were higher than those in the central and western regions. The durations of normal and rapid growth regimes were clearly similar between the three regions, while the central region had short-lived growth–recession regimes. Moreover, when starting from a recession regime, most central provinces were less likely to stay in the recession regime. Third, we wanted to establish whether house price cycles in the eastern region are more closely related to the central or western region. When in a recession regime, house prices in the three regions were likely to decrease simultaneously, but when in a rapid growth regime, house prices change across the three regions differently. We attribute these significant variations in growth rates and average regime durations to the existence of regional heterogeneity. As one of the polar industries, the real estate market is being confronted with new challenges as well as opportunities. Meanwhile, the regional differences are becoming more prominent. China's real estate market has a relatively serious regional imbalance and, mainly in the real estate market, investment in first-tier cities such as Beijing, Shanghai and Shenzhen is overheated and house prices have risen so fast, while in some areas development has lagged. Large gaps of consumption levels, imbalances in the supply and flow of population and capital are all major factors causing regional differences. Finally, from the results of the fixed-effect panel data model, we found that the most common factors affecting house prices when in recession among the three regions were the last two-year GDP growth and the real lending rate. For the eastern region, the growth of floor space sold, and real estate investment affected house price significantly, both in recession and boom periods. Four factors affect the smooth probability of rapid growth in the central region – the growth rate of floor space sold, last two-year GDP, government expenditure, and population size – while for the western region, only the growth rate of floor space sold is significant.

Given these points, some policy implications can be drawn. It should be possible for the Chinese government to use a uniform housing policy for the entire country when house prices are in recession because of the common shared factors: the last two-year GDP growth and the real lending rate. However, in a boom period, a uniform housing policy may increase diversion between the regions because the determinant factors are significantly different between regions. Therefore, the government should implement different policies according to the house price cycle and the determinant factors of each region. Moreover, the People's Bank of China should change the demand for real estate by controlling the payment of loans and lending rates. However, lending rates are not significantly related to the smooth probability of rapid growth. Hence, we recommend that, in boom periods, the government of China should control the payment of loans in the eastern and central regions to stabilise house prices.

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