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Population Ageing, Asset Prices and Paying Ability: A Study Based on Urban Private Housing Prices in China

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Abstract: Population ageing and asset price issues, especially with regard to housing, exert a major impact on sustainable development. Since China entered the remit of an ageing society in 2001, the proportion of its elderly population has been rising. In the same period, the country's real estate market experienced a rapid rise in house prices following the monetisation reform. Many large cities have experienced waiting lists for the purchase of private housing, and working-class groups not being able to afford it. This has become a social phenomenon in China. This study takes the social reality of China as the main research object, investigates the influencing mechanism of the ageing population structure on the residential commercial housing market, and locates paying ability, ageing, and private housing prices within the same framework. The study found that paying ability can be regarded as a regulating variable between ageing and private housing prices; consequently, a panel threshold effect model was constructed empirically to analyse the non-linear effects of ageing on private housing prices. The results show that when residents' payment levels differ, the effect of ageing on the price of private housing also varies. Finally, by combining the 17-year panel data of 30 provinces and cities in China, it was found that all of the eastern regions of China crossed the threshold in 2010, and that all of the central and western regions crossed the threshold in 2011. At present, therefore, ageing can be said to be exerting an active impact on housing prices in China. To effectively curb the excessive rise in housing prices, the corresponding housing supply policy should be formulated from the perspective of improving the supply of housing to meet demand and the intergenerational transfer of the elderly population.

Keywords: Population Ageing, Asset Prices, Paying Ability, Panel Threshold Effect Model, Non-linear Effects

1. Introduction

China officially entered an ageing population in 2001, in which year the percentage of the population aged 65 and over reached 7.1%. According to the latest data from the National Bureau of Statistics, in 2017 the population aged 65 and over accounted for 11.39%, then making China the most ageing country in the developing world [1]. In the past 17 years, the degree of ageing has been increasing at an average annual rate of 3.6%, and has been pursuing the rate of economic growth. Therefore, ageing has become a substantial challenge to the Chinese economy and society. At the same time, the real estate market in China has developed rapidly, and house prices have risen from 2,170 yuan/m^2 to 7,892 yuan/m^2, with an average annual growth rate of 15.5%. Increasing ageing and rising house prices have become two major social problems in China. The price of real estate is an important economic variable affecting economic development and social livelihood in China, and is known to be a major hub linking an ageing society with sustainable development. The demographic effect is the main channel whereby an ageing population affects the supply and demand of real estate, through which ageing directly affects housing prices. Moreover, an ageing population can also indirectly affect housing prices through other socio-economic variables [2, 3], such as paying ability, monetary policies, and expectations pertaining to house prices. Therefore, studying the relationship between ageing and housing prices may be seen as beneficial for aiding the coping mechanisms with the challenges wrought by ageing

population. Furthermore, locating the adjustment factors between the two may be seen as helpful to understanding the impact of population ageing on the macro economy.

The major objectives of this paper are as follows: (1) to reveal the non-linear relationship between an ageing population and housing prices; (2) to examine paying ability as an adjustment variable between an ageing population and housing prices; (3) to analyse the specific years in which the provinces and cities in different regions of China crossed the threshold; and (4) in order to make the results more persuasive, to discuss the empirical analysis of the 30 provincial and 16-year panel data from China, which is suitable and practical for this study.

The remainder of this paper is structured as follows. Section 2 introduces the previous research and background to the internal differentiation within the ageing population and house prices. Section 3 presents the relevant influencing mechanisms that may exert an impact on the latter two factors. Section 4 elaborates the data processing algorithm used and data sources. Section 5 outlines the experimental process and discusses the analytical results. Finally, the major conclusions are summarized in Section 6, based on which corresponding policy suggestions are provided.

2. Literature Review

From the perspective of Housing Economics, there are four main reasons why housing differs from other commodities. Firstly, houses are diverse in size and have different architectural, location and traffic characteristics. From this perspective, it can be seen that housing cannot be considered as a homogeneous commodity for the purposes of analysis. Secondly, compared to other goods and services, the transaction costs of houses are huge. Therefore, financial services form an important part of purchasing behaviour. Thirdly, when a house is transferred, this generates high transaction costs, thus greatly affecting the circulation, and supply and demand of the house. Fourth, housing is immovable and durable, so the price of housing will be affected by changes in the regional economy and policies.

Many scholars have analysed house prices based on the above understanding. Goukasian and Majbouri [4], Taylor [5], Del Negro and Marco, Campbell [6] and Vargas Silva [7] all believe that the change in interest rates is the main factor causing fluctuations in US real estate prices. Li et al. [8] found that the visual quality of a community is directly proportional to house prices, and that noise pollution is inversely proportional to the same. Gower et al. [9] studied private schools from the perspective of school districts, finding that such schools had a strong positive impact on surrounding housing prices. Wu et al. [10] believe that land prices are not a factor in driving house prices, and that the latter are mainly affected by demand, such as income and housing costs. Lee et al. [11] found that property rights restrictions and lack of liquidity in housing could curb the rise in house prices. Liang et al. [12] found that in cities with a limited supply of land, land supply policies will lead to rapid growth in housing prices and wages. Michael et al. [13] conducted an empirical analysis using a two-stage least squares method. The results showed that household income and construction costs are the most important factors leading to changes in house prices, rents, and land prices. Ziwen et al. [14] studied the impact of the top three hospitals on surrounding housing prices and found that, within 0.713km, as the weighted distance from the hospital increases, house prices grow progressively higher; in the range of 0.713-2.048km, house prices decrease with the increase of the weighted distance, and increase with the weighted distance to the hospital of 2.048km.

The above ideas, put forward by scholars working in particular research fields, have a certain significance in explaining the rise in house prices. However, land scarcity, monetary policy and speculative psychology are three factors that stable and long-term existence. After the real estate industry initiated its monetisation reform in 1998, the structural rise in housing prices occurred after 2003, meaning that the above concepts cannot explain the jumps in housing prices after 2003. Therefore, since the 1980s and 1990s, scholars have tried to interpret the changes in housing prices from a demographic perspective.

Literature on demographics and housing demand began to be published in the 1960s, including works by Burnham Campbell [15] and Richard Easterlin [16], which involved research on the age structure of the population. Carliner [17] argues that different age groups in a population have different income elasticity in terms of housing demand. Ying [18] studied the development of the real estate industry in the United States after the Second World War, finding that the population age structure, family structure and spatial distribution structure had the most significant impact on real estate. Wei and Jianhua [19] studied the influence of the population age structure on real estate demand based on grey theory, finding that the influence of different age groups on housing demand varies, whereby people aged 20-23 and 36-40 had the greatest impact on housing demand. The former is due to this group entering the legal age for marriage, when the demand for housing is high; the latter emerges from the increasing demand for housing as this group's paying ability increases. However, most previous studies have been based on qualitative analysis, with no further empirical analysis.

2.1. The Linear Effect of an Ageing Population on Housing Demand

The study of housing demand with regard to ageing has become a focus of scholars' attention in the 20th century. Many scholars have explained the role of ageing in housing demand from the perspective of the residential preferences of the elderly, the differences in the impact of different types of private housing, and the intergenerational transfer of savings. Lauf et al. [20] found that population shrinkage accelerated population ageing and had a great impact on land consumption. Due to the residential preferences of the elderly, this effect was found to be particularly pronounced in the outer city, thus reducing urban shrinkage. Population ageing has produced synergies in urban growth and landscape fragmentation,

creating trade-offs between urban shrinkage and compactness. Hiller et al. [21] combined urban demographic information and detailed house price data from 87 German cities between 1995 and 2014, finding that house prices and major demographic variables showed strong cross-sectional dependence. The actual appreciation of housing prices in ageing cities is weak. Population ageing exerts different effects in different housing sectors: the sale price of apartments and villas is negatively correlated with ageing, while the latter is positively correlated with actual rental growth. Wang et al. [22] studied how population ageing and mobility affect urban housing prices. Their results showed that a 1% increase in the dependency ratio of the elderly led to a 0.368% increase in house prices At the same time, a 1% increase in urbanisation was found to increase house prices by about 0.139%, while a 1% increase in inter-regional mobility increased house prices by about 1.038%. A study by Broxterman et al. [23] found that a 1% decline in the middle-aged population drove the transfer of intergenerational wealth to the younger generation, in turn driving house prices up by 0.391%. Similarly, a 1% increase in the elderly population led to a 0.072% increase in housing prices.

2.2. The Non-linear Effect of an Ageing Population on Housing Demand

When some scholars combined ageing with paying ability, inflation, economic growth, urbanisation and other variables to interpret the impact on housing prices, ageing was found to have an inhibitory effect on the latter. For example, Bandopadhyaya et al. [24] studied the relationship between house prices and demographics in the United States, finding a significant negative correlation between house prices and relative ageing in the period 1991-2010. If economic growth accelerates and the population ages faster, house prices may rise sharply. Park et al. [25] studied the impact of ageing on the Korean housing market and found that paying ability and dependency ratios did, indeed, exert an impact on housing prices. A 1.0% increase in the dependency ratio led to a 0.7% decline in house price, while a 1.0% increase in income led to an average price increase of 0.3%. Inoue et al. [26] used panel data from 23 major developed countries, including major Asian countries, to estimate various models and found that younger dependency ratios had positive, statistically significant effects on inflation and housing prices. The old-age dependency ratio was found to be negative and statistically significant. Jäger et al. [27] used cross-country datasets from 13 developed economies spanning the period 1950-2012, and found that the proportion of individuals between the ages of 60 and 65 was negatively correlated with house prices, while the larger proportion of younger residents was positively correlated with housing prices; furthermore, the increase in the life expectancy of the population was found to have no significant relationship with housing prices. Therefore, the demographic transition can be said mainly to bring about a downward pressure on housing prices.

Saita et al. [28] compared the impact of ageing on housing prices in Japan and the United States, finding that the impact of population factors on Japanese real estate prices was greater than that of the United States. For Japan, the impact of population on land prices in 2012-2040 is forecast be -2.4% per year. Wang [29] used the overlapping age model to demonstrate that population ageing inhibits housing demand, while urbanisation can increase housing demand and offset some of the negative effects of ageing. Takáts [30] took the prices of 22 developed economies between 1970 and 2009 to determine the impact of ageing. Over the past 40 years, real housing prices in developed countries have increased by about 30 basis points per year, with aging predicted to reduce house prices by an average of about 80 basis points per year over the next 40 years. Carter et al. [31] found that when house prices fell, older people were more likely to avoid investing in housing for two reasons: life expectancy and neighborhood familiarity. Zheng's results [32] also support this conclusion.

2.3. No Relationship Between an Ageing Population and Housing Demand

In contrast to the previous analyses, numerous scholars have found that an ageing population has no significant impact on housing demand. For example, Poterba [33] used data from the United States, Canada and the United Kingdom to study the historical relationship between demographics and national debt, long-term government bonds, and actual returns on company stocks. Although the theoretical model usually shows that the equilibrium return on financial assets will change with an ageing population, financial assets and an ageing population do not have statistically significant effects in the empirical analysis of time series; thus, it is not possible to predict changes in the value of future assets based on demographic changes. Dieleman [34] depicts the overall situation of housing consumption by income and age, finding that the age structure has little effect on housing consumption. Chen et al. [35] simulated a micro-family in Scotland and found that population ageing is not the main determinant of housing prices. Xiang et al. [36] used macro data from 1995 to 2009 to examine the impact of the age structure of China's population on housing demand, finding that mothers 25-29-year olds and the 50-64-year old population at the peak payment level had a greater demand for housing, while the demand for housing among people aged 65 and over was low. Yanbin [37] posits that the main driving force for the rapid increase in housing demand is urbanisation, and that the negative impact of ageing on housing demand is small. Yajing [38] argues that the degree of urbanisation and population size are the two forces driving the growth of residential demand. The contribution of the above factors to housing demand is as high as 73%, and the impact of population ageing on housing demand is becoming increasingly apparent.

From the studies analysed in this literature review, it can be determined that most of them have aimed to reveal how demographic characteristics determine the price of housing; however, current research in this area contains the following shortcomings and research gaps. Firstly, the age structure of the population and the non-linear effects on housing demand

are ignored. The impact of the population age structure on housing demand is translated to housing prices by examining the impact of elderly housing preferences, rigid housing demand and improved housing demand, causing housing prices to fluctuate and meaning that the impact of ageing on housing demand is affected by other factors. This impact may be expressed as promotion or inhibition, short-term or long-term, and current research does not explicitly state the non-linear effects of the population age structure on housing demand. Secondly, the regional differences in the impact of demographic changes on residential demand are ignored. Due to differences in environmental characteristics, lifestyle concepts and habits, and housing preferences, there exist regional differences in the impact of population on housing demand, which the existing research has made little mention of.

3. Mechanism Analysis

An Ageing population represents the ageing of the entire population structure. The size of the elderly population and its proportion in an ageing society will increase significantly, the proportion of the working population will decline, and the family structure will change accordingly. Changes in population structure and family structure brought about by ageing will affect real estate prices through the following channels:

3.1. Demographic Effect

A decline in the proportion of people in the age appropriate bracket for buying houses, and changes in family structure caused by an ageing population, directly affect housing prices. Moreover, housing demands will vary with families in different life cycles [39, 40], which will also directly affect housing prices [41]. Both of the above can be considered to be the impact factors of demographic effects on real estate prices. With regard to the demand for house purchases, the former affects the quantity of such purchases while the latter affects the preference of the same. The third impact factor of demographic effects on real estate prices is the intergenerational transfer of wealth. With the intensification of the ageing society, the elderly population has become the actual purchaser of some housing through the intergenerational transfer of wealth, which has promoted the rise of housing prices and alleviated the decline in house prices caused by the reduction in the number of house purchases, to some extent [42].

3.2. Social Liability Effect

The social liability effect measures the indirect impact of ageing on real estate prices. In the context of ageing, the decline in the proportion of the working population leads to changes in the level of social wealth accumulation, which has a negative impact on economic development. Changes in the payment and debt levels of across society have an impact on real estate supply and demand [43, 44], which, in turn, drives real estate price volatility.

In short, the impact of the above two channels may be said to affect housing prices through paying ability. Therefore, the current paper adopts paying ability as the adjustment variable of the two within the overall analysis framework, analysing the situation of when housing affordability is not the same, and asking the question: are there different impacts of aging on housing prices?

4. Research Methods and Collected Data

4.1. Panel Threshold Model

The panel threshold regression model can examine the effect of different variables on the dependent variable at different stages. This model was adopted for the current study to analyze the non-linear effects of population ageing on housing prices.

The fixed-effect panel threshold regression model $\{ y_{it}, q_{it}, x_{it}: I \le i \le n, I \le t \le T \}$ can be expressed as follows:

$$y_{it}=\begin{cases} u_i + \beta_1 x_{it} + e_{it}, q_{it} \le \gamma \\ u_i + \beta_2 x_{it} + e_{it}, q_{it} > \gamma \end{cases} \quad (1)$$

Where y_{it} is the explained variable; x_{it} is the explanatory variable; q_{it} is the threshold variable; γ is the threshold value; e_{it} is the random disturbance, and $\varepsilon_{it} \sim N(0, \sigma^2)$.

If the argument x_{it} is exogenous, this means that x_{it} does not include the hysteresis value of the dependent variable, which is a static panel. The intercept term, u_i, indicates that the model is a fixed effect model. The explicit function was used to change the model to vector form, as follows:

$$y_{it} = \mu_i + \beta_1 x_{it} I(q_{it} \le \gamma) + \beta_2 x_{it} I(q_{it} > \gamma) + e_{it} \quad (2)$$

Using short panel data with large cross-sectional data and small time data, $\beta = (\beta_1\ \beta_2)$ and $x_{it}(\gamma) = \begin{pmatrix} x_{it} I(q_{it} \le \gamma) \\ x_{it} I(q_{it} > \gamma) \end{pmatrix}$ were defined. Equation (2) can be abbreviated as:

$$y_{it} = \mu_i + \beta' x_{it}(\gamma) + e_{it} \quad (3)$$

The above equations were then time averaged to obtain:

$$\bar{y_i} = \mu_i + \beta' \bar{x_i}(\gamma) + \bar{e_i} \quad (4)$$

Where $\bar{y_i} = T^{-1} \sum_{t=1}^{T} y_{it}$, $\bar{e_i} = T^{-1} \sum_{t=1}^{T} e_{it}$, $\bar{x}(\gamma) = T^{-1} \sum_{t=1}^{T} x_{it}(\gamma) = \begin{pmatrix} \frac{1}{T} \sum_{t=1}^{T} x_{it} I(q_{it} \le \gamma) \\ \frac{1}{T} \sum_{t=1}^{T} x_{it} I(q_{it} > \gamma) \end{pmatrix}$.

Then, equation (3) minus equation (4) was applied, following which the model's dispersion form emerged as:

$$y_{it}^* = \beta' x_{it}^*(\gamma) + e_{it}^* \quad (5)$$

Where $y_{it}^* = y_{it} - \bar{y_i}$, $x_{it}^*(\gamma) = x_{it}(\gamma) - \bar{x_i}(\gamma)$, and $e_{it}^* = e_{it} - \bar{e_i}$. Bringing the previous formula into equation (5), the stacking matrix was then used to represent equation (5) as:

$$Y^* = X^*(\gamma)\beta + e^* \quad (6)$$

Where $X^*(\gamma) = \begin{bmatrix} x_1^*(\gamma) \\ \vdots \\ x_i^*(\gamma) \\ \vdots \\ x_n^*(\gamma) \end{bmatrix}$, and the remainder of the variables are similar.

For a given γ, the OLS was used to estimate the consistency of the equation (6). The formulas obtained are as follows:

$$\hat{\beta}(\gamma) = (X^*(\gamma)'X^*(\gamma))^{-1}X^*(\gamma)'Y^* \tag{7}$$

$$S_1(\gamma) = \widehat{e^*}(\gamma)'\widehat{e^*}(\gamma) = Y^{*'}\{I - X^*(\gamma)'\left(X^*(\gamma)'X^*(\gamma)\right)^{-1}X^*(\gamma)'\}Y^* \tag{8}$$

By selecting a different γ, the sum of the squared residuals, $S_1(\gamma)$, was minimised. Finally, the estimated coefficient, $\hat{\beta} = \hat{\beta}(\gamma)$, corresponding to the final threshold value, could be obtained. The presence or absence of the threshold effect was tested by the LR statistic. The standard was as follows:

$$\mathrm{LR}_1 = (S_0 - S_1)/\hat{\sigma}_1^2 \tag{9}$$

The original hypothesis was $H_0^1: \beta_1 = \beta_2$, with which there was no threshold effect. The LR statistic is not a standard distribution, and the conventional test method cannot obtain a list of its critical values. Help was thus sought from the Bootstrap method. If the null hypothesis was rejected, the model could be considered to have a threshold effect. The confidence interval of γ was calculated by the LR statistic.

4.2. Variable Selection and Model Construction

4.2.1. Variable Selection

Attention was paid to the effect of an ageing population on asset prices at different payment levels. Therefore, asset price was the dependent variable, ageing population the independent variable, and paying ability the threshold variable. The control variables included industrial structure, financial progress, openness and household size.

a. Aging population. The old-age dependency ratio was applied to represent the level of the ageing population. The old-age dependency ratio refers to the ratio of the middle-aged population to the working-age population in the population as a whole, which is used to indicate how many elderly people there are for every 100 individuals of working-age in the population. The calculation method is such that the proportion of the elderly population over 65 years old accounts for the proportion of the labour force. In order to prevent heteroscedasticity, the data were processed in the group.
b. Asset price. Actual housing prices were used to represent asset prices. The actual value was transformed from the nominal value through a fixed asset price index, with a fixed basement of 2000.
c. Paying ability. Per capita disposable income was used to measure the value of regional labour. Similarly, this was selected to represent paying ability. The latter is often linked to rapid economic development, higher levels of education, improved infrastructure, and a higher quality of life for residents, which are conducive to the accumulation of skilled people in a particular area and the promotion of sustainable development.
d. Control variables. (i) Industrial structure. Industrial structure was here defined here in terms of an advanced industrial structure. The latter refers to the process and trend of the adjustment and transformation of the industrial structure of a country's national economy, from a low-level structure dominated by labour-intensive industries to a high-level structure dominated by knowledge- and technology-intensive industries. An advanced industrial structure and the rationalisation of the existing industrial structure may be seen as the main paths towards, and important goals for, achieving rapid and sustainable development. Therefore, industrial structure was adopted as a control variable. (ii) Financial progress. The percentage of the added value of the financial industry to the added value of the tertiary industry represents financial progress, and the value was logarithmically processed. Accelerating financial progress is an important measure of supporting economic development and structural adjustment. The financial industry represents the direction and potential of economic development. Therefore, financial progress was adopted as a control variable. (iii) Openness. A high degree of openness means that a particular region is more accepting and inclusive of new concepts, the accompanying talents, knowledge and resources, and communicates more with the outside world. Such openness is a good platform for the start-up and development of emerging industries, which can promote employment and accelerate development. Therefore, openness was also adopted as a control variable. (iv) Household size. As a sociodemographic characteristic, the smaller the size of a household, the greater the demand for housing, thus promoting an increase in housing prices. Therefore, household size was taken as a control variable.

4.2.2. Model Construction

30 provincial-level panel data from 2001 to 2017 across China (with the exception of Tibet, owing to the lack of data) were used to analyse the non-linear effects of an ageing population on real estate prices. A panel threshold model was constructed as follows:

$$lnp_{i,t} = \alpha_1 age_{it} \cdot I(lnpy \le \gamma_1) + \alpha_2 age_{it} \cdot I(lnpy > \gamma_2) + \cdots + \alpha_n age_{it} \cdot I(lnp \le \gamma_n)$$
$$+\alpha_{n+1} age_{it} \cdot I(lnp > \gamma_{n+1}) + \theta x_{it} + \mu_i + \varepsilon_{it} \tag{10}$$

Where *i* represents each province and city, *t* is the year, *lnp* denotes the real estate price, *age* signifies the ageing population, *lnpy* is the paying ability threshold, and *x* is the control variable combination. I(·) is an indication function whereby, when the content in the brackets is valid, the value of 1 is adopted, otherwise being 0. μ_i is the fixed effect matrix of the individual and ε_{it} denotes a stochastic disturbance. The statistical description of the variables is shown in Table 1. The statistical software used was Stata15.0.

Table 1. *Descriptive statistics of variables.*

Characteristics	Variables	Sample size	Mean	SD	Min.	Max.
lnp	Estate price	510	3.5809	0.6519	2.2852	5.7268
age	Ageing population	510	2.1261	1.5918	0.0148	9.2948
lnpy	Paying ability	510	9.6562	0.5728	8.5693	11.0445
lnopen	Openness	510	3.0984	0.9419	0.7164	5.1972
lnts	Industrial structure	510	-0.0726	0.3481	-0.6991	1.4469
hs	Household size	510	3.1879	0.3608	2.3309	4.3274
lnf	Financial progress	510	2.3353	0.4234	0.6344	3.2250

Source: Author's own elaboration.

5. Empirical Analysis

5.1. Empirical Analysis of Threshold Effect

5.1.1. Hausman Test

The panel fixed effect and panel random effect are the two regression methods used in panel data analysis, with the difference of random interference. The Hausman test, proposed by Jerry Hausman of the Massachusetts Institute of Technology, is typically used to choose the correct regression method. The core idea of this test is to transform the validity of the original hypothesis into the test of whether the difference between the two estimates is significant or not. Upon undertaking a panel data regression, the hypothesis suggests that the random interference would comply with the characteristics of panel random effects, otherwise the fixed effects.

Table 2. *Hausman test.*

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Random cross-section	86.42	15	0.000

Source: Author's own elaboration.

The Hausman test was performed using Stata15.0 software. The test results in table 2 show that the *chi-square statistic* value emerged as 86.42 and the *P* value as 0.000, indicating that the null hypothesis was significantly rejected, and that the panel fixed effect could be adopted.

5.1.2. Empirical Results

When taking paying ability as the threshold variable, although the single threshold and double threshold test were passed at the significance level of 1%, since the P value in the double threshold regression was not as significant as the single threshold, the single threshold effect was ultimately applied for the purposes of the analysis. The results are shown in Table 3. The threshold effect is shown in Figure 1.

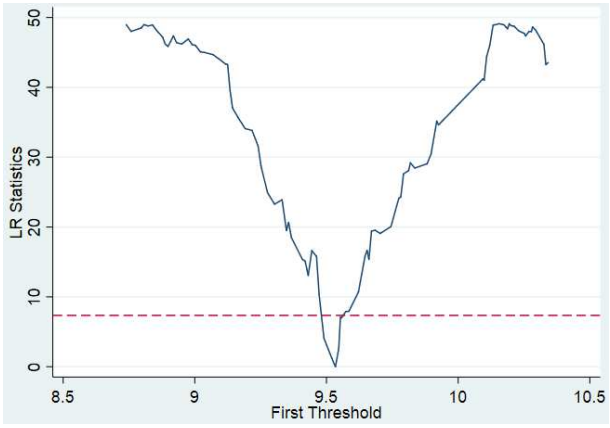

Figure 1. *Threshold rendering.*

Table 3. *Threshold Number Selection.*

Threshold variable	Threshold number	F	1%	5%	10%	P	Threshold value	Confidence interval
Paying ability	Single	365.13***	62.1588	45.9719	37.1246	0.0000	9.5340	[9.5199, 9.5466]
Paying ability	Double	346.87**	32.5000	22.2683	17.8161	0.0200	10.1557	[10.0986, 10.1737]

Note: Dependent variable: lnp; Independent variables: age, lnpy, lnstr, lnopen, lnf, hs. ***p<0.01, **p<0.05, *p<0.1. Both the P value and the critical value are the results of a 1000-iteration Bootstrap.

As evident from the threshold effect diagram, when the threshold value is less than 9.5340, the ageing population has a negative impact on house prices. When the threshold value is greater than 9.5340, the ageing population has a positive effect on the same.

The estimated results of the threshold effect of ageing on housing prices are shown in Table 4. Based on the parameter estimation results of the control variables, the impact of openness (lnopen) on house prices can be seen to be significantly positive at the 1% level, indicating that the level of import and export trade has promoted regional economic development, which, in turn led to the rise in house prices. The

industrial structure (lnts) can be seen to be positive at the 1% significance level. The value here continues to tilt towards the tertiary industry, indicating that the industrial structure tends to be rationalised. The results here show that an industrial structure mainly comprised of the service and financial industries can significantly promote housing prices. Household size (hs) was found to be negative at the 1% significance level, indicating that the expansion of household size has curbed the rise in housing prices, and that a reduction in household size will promote housing prices. A shrinking household size is the main change trend with regard to family structure in China. Young people's preferences for space and freedom have increased the demand for housing, which has, in turn, boosted housing prices. The financial industry's development level (lnf) emerged as positive at the 1% significance level, indicating that China's current level of financial development is in line with the development of the real estate market, and that the financial policies implemented by developers and homebuyers can effectively promote housing prices.

Table 4. *Threshold Estimation Result.*

Characteristics	Intercept	SD	T Value	P Value
lnopen	0. 1118***	0. 0336	3.32	0.001
lnstr	0.3102***	0.0584	5.31	0.000
hs	-1.1230***	0.0732	-15.35	0.000
lnf	0.6247***	0.0445	14.03	0.000
lnpy <9.5340	-0.0515***	0.0119	-4.31	0.000
lnpy ≥9.5340	0.0528***	0.0087	6.10	0.000
Constant	5.3496***	0.3078	17.38	0.000
R^2	0.9832			

Source: Author's own elaboration.

Based on the change range of the threshold (lnpy), the effect of the ageing population on house prices was significant at the 1% level. The impact of an ageing population on housing prices is not a simple linear relationship, but a complex, nonlinear one. Moreover, this relationship is also affected by changes in payments. With the rise of paying ability, there was seen to be a significant increase in the marginal efficiency of the impact of ageing on housing prices. The coefficients of the two interval segments are -0.0515 and 0.0528, respectively. The results indicate that when the payment level is low (lnpy<9.5340), house prices will drop by 0.0515% for every 1% increase in the proportion of the elderly population. A lower payment level means lower savings, so the effect of the intergenerational transfer of savings is not very apparent; low payment levels, on the other hand, mean a lower demand for improved housing for the elderly. Therefore, ageing can be said to have curbed the increase in housing prices. When the payment level is high (lnpy ≥ 9.5340), the results show that the price of housing will increase by 0.0528% for every 1% increase in the elderly population. High payment levels mean strong solvency; China's existing financial policies and the increase in savings brought about by the increase in the elderly population have spurred the demand for housing among young people of the right age, and promoted the rise in housing prices.

5.1.3. Robustness Test

In order to verify the applicability of the model and the scientific nature of the method, and to prevent the threshold effect from being accidental or one-time, the actual house price (lnp) of the explanatory variable was replaced by the nominal house price, (lnp0). The model then passed a single threshold test, whereby the effect of the explanatory variables on the interpreted variables was found to be significant. The rationality of the panel threshold effect model and the reliability of the empirical results were verified. The results are shown in Tables 5 and 6.

Table 5. *Threshold Number Selection for Robustness Test.*

Threshold variable	Threshold number	F	1%	5%	10%	P	Threshold value	Confidence interval
Paying ability	Single	359.08***	48.3971	35.3358	29.3975	0.0000	10.0986	[10.0942, 10.1082]

Note: Dependent variable: lnp; Independent variables: age, lnpy, lnstr, lnopen, lnf, hs. ***p<0.01, **p<0.05, *p<0.1. Both the P value and the critical value are the results of a 1000-iteration Bootstrap.

Table 6. *Threshold Estimation Result for Robustness Test.*

Characteristics	Intercept	SD	T Value	P Value
lnpy <10.0986	-0.0203**	0.0097	-2.10	0.036
lnpy ≥10.0986	0.0823***	0.0100	8.22	0.000
Constant	10.0896***	0.3016	33.45	0.000
R^2	0.8769			

Source: Author's own elaboration.

5.2. Threshold Area Distribution

The data of 30 provinces in China from 2001 to 2017 were selected for the empirical analysis. The empirical results of the whole sample show that when the payment level is higher than the threshold value, the impact of ageing on housing prices is enhanced; conversely, when the payment level is lower than the threshold value, the impact of ageing on housing prices is restrained. However, due to China's large territory, the regional differences in resource endowments lead to different modes of economic growth and levels of development. Therefore, in order to undertake an in-depth study of the impact of ageing on housing prices, it was necessary to consider the regional characteristics of China. In line with its geographical characteristics, the country was divided into three regions: eastern, central and western. The annual payment levels of the three regional provinces and cities were distinguished according to the threshold value; the detailed distribution is shown in Figures 2 to 4, respectively.

From 2010, the payment level of all provinces and cities in the eastern region can be seen to be higher than the threshold

of 9.5340, indicating that after 2010, the impact of ageing on housing prices in all areas of the eastern region was enhanced. The earliest threshold crossing in the eastern region occurred in Shanghai (2003), followed by Beijing (2003), Zhejiang (2004), Guangdong (2005), Tianjin (2006), Fujian Province (2006), Jiangsu Province (2007), Shandong Province (2007), Liaoning Province (2008), Hebei Province (2009), and Hainan Province (2010).

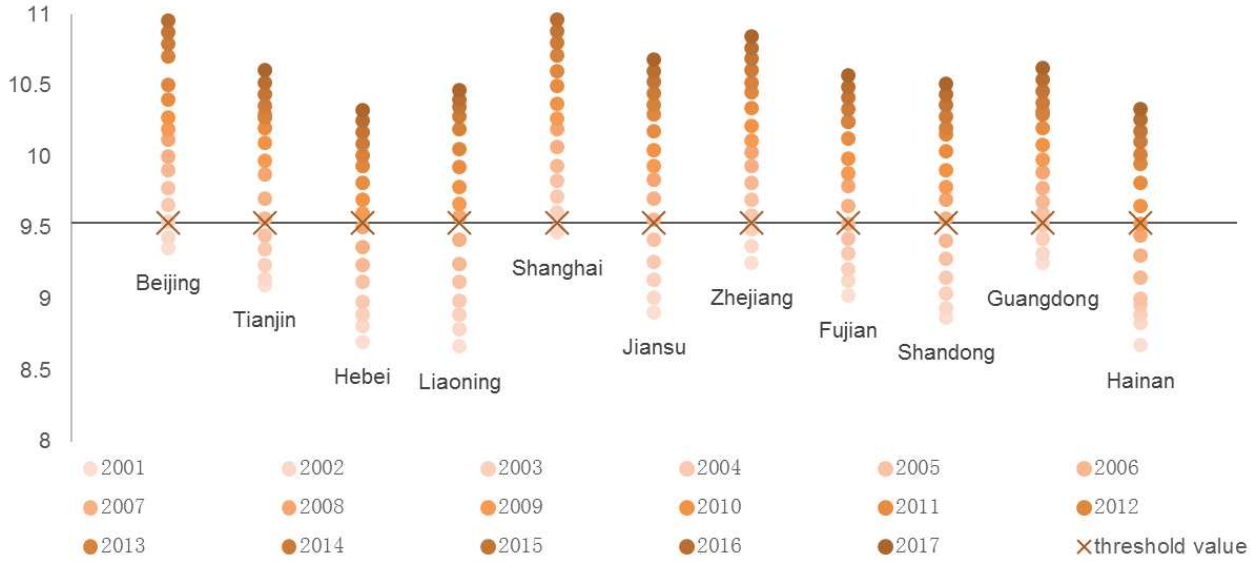

Figure 2. *Distribution of thresholds in the eastern region.*

As of 2011, the payment level of all provinces and cities in the central region was found to be higher than the threshold of 9.5340, indicating that after 2011, the impact of ageing on housing prices in all areas of the central region was enhanced. The per capita disposable payment level in the central region emerged as relatively balanced. Eight provinces and cities crossed the threshold around 2010, with Hunan, Hubei and Henan provinces crossing the threshold in 2009, Jiangxi, Anhui and Shanxi provinces crossing the threshold in 2010, Jilin Province crossing the threshold in 2010, and Heilongjiang Province in 2011.

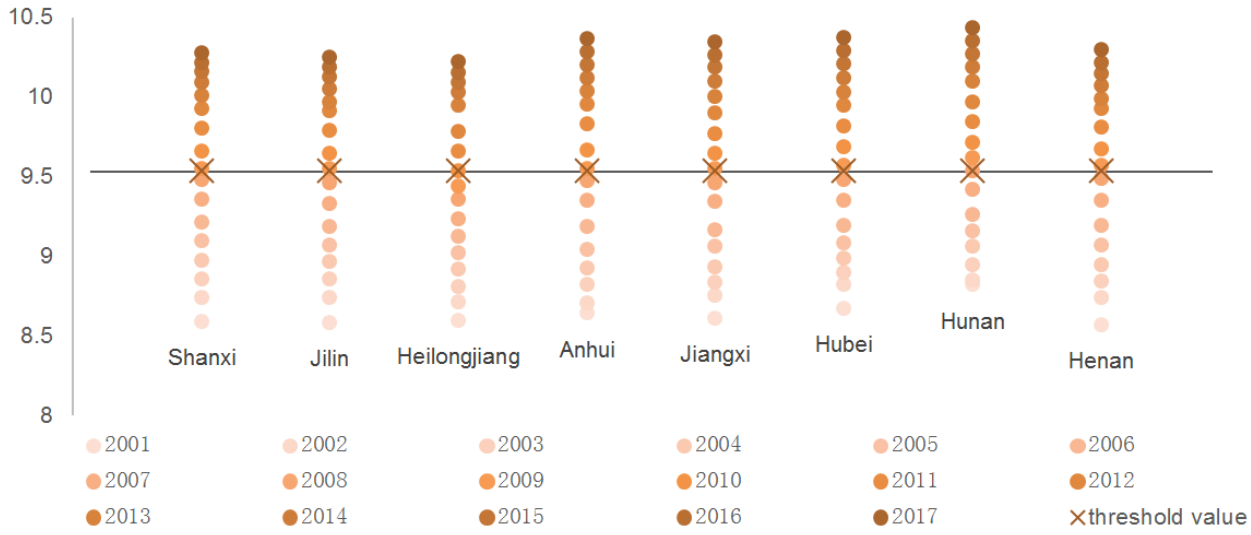

Figure 3. *Distribution of thresholds in the central region.*

From 2011, the payment level of all provinces and cities in the western region was found to be higher than the threshold of 9.5340, indicating that after 2011, the impact of ageing on housing prices in all areas of China's western region was enhanced. The earliest threshold crossing in the western region was realised by the provinces and cities of Inner Mongolia Autonomous Region, Guangxi Zhuang Autonomous Region and Chongqing Municipality, in 2008. These were followed by Yunnan Province (2009), Shanxi Province (2009), Sichuan Province (2010), Ningxia Hui Autonomous Region (2010), Guizhou Province (2010), Qinghai Province (2011), Gansu Province (2011), and Xinjiang Uygur Autonomous Region (2011).

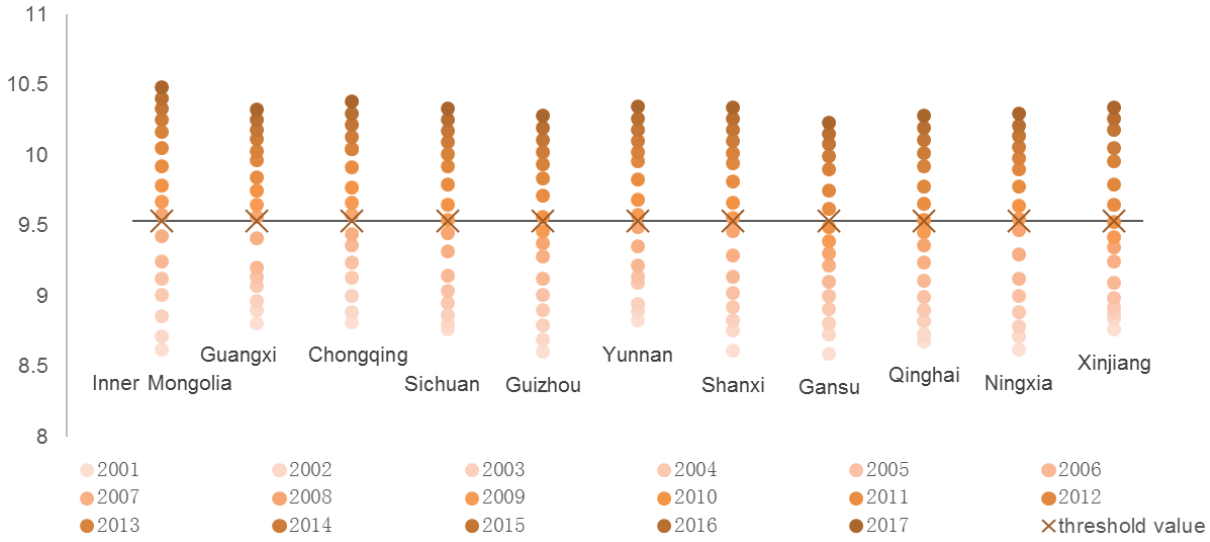

Figure 4. *Distribution of thresholds in the western region.*

In summary, as far as the national sample is concerned, since 2011 the paying ability of all provinces and cities in China exceeded the threshold, implying that ageing exerted an impact on housing prices. In terms of individual regions, due to the geographical environment and political characteristics of the eastern region, its pace of economic development level is relatively fast. The eastern region thus crossed the threshold earlier than the central and western regions. This further shows that in the eastern region, the inflection point of the impact of ageing on housing prices appears earlier. The development level of the central region is relatively balanced owing to its geographical advantages and the radiation effect from the eastern region. Conversely, most provinces in the western region lie on the border with 13 countries, including Inner Mongolia and Russia, and the regional economy is underdeveloped. However, the construction of transportation networks such as airports and high-speed railways has helped to drive the economic development of the western region, and the development gap between the central and western regions has continued to narrow.

6. Conclusions

In summary, there exist many factors that have a significant impact on the rise of private housing prices. According to the order of influence from largest to smallest, these factors are: payment levels, financial development, an advanced industrial structure, household size, regional openness, and an ageing population.

In the current study, while ageing was found to have a significant impact on house prices at the 1% level, this was not a simple linear relationship. The two exhibit more complex, nonlinear relationships, and there is also a threshold effect exerted by payment levels. With an increase in the latter, there was also found to be a significant increase in the marginal efficiency of the impact of ageing on housing prices. When the payment level was low ($lnpy$<9.5340), both ageing and housing prices changed in the opposite direction; that is, the rise in the old-age dependency ratio curbed the growth in housing prices, while the decline in the old-age dependency ratio was set to promote this.

When residents' payment level was high ($lnpy$≥9.5340), both ageing and housing prices changed in the same direction; that is, the rise in the old-age dependency ratio was seen to promote housing prices, while the decline in this ratio would curb the increase in housing prices. From the regional distribution of the threshold, it could be seen that the paying ability of the 30 provinces across the country exceeded the threshold. The eastern region crossed the threshold value in 2010, and the central and western regions crossed this in 2011. Thus, for the current time period under study, the impact of ageing on housing prices can be seen to be active. To effectively curb the excessive rise in housing prices, the corresponding housing supply policy should be formulated from the perspective of the demand for improved housing among the ageing population, and the intergenerational transfer of wealth from the elderly population to the younger age groups.

Due to China's vast territory and numerous ethnic groups, the population is affected by family, environment, traditional customs and other factors, and their preference for housing demand is quite different. Future research will be more inclined to the housing demand of individuals at the micro level.

Author Contributions

W. R. (Wei Ren), l. W. C. (liWen Chen) designed the study and wrote the paper. All authors read and approved the manuscript.

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Conflicts of Interest

All the authors do not have any possible conflicts of interest.

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