

Research Article

What are the Effects of Demographic Structures on Housing Consumption?: Evidence from 31 Provinces in China

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Housing is closely related to population. The world's demographics have been changing greatly, like ageing, urbanization, and shrinking household. This paper takes China as the research object to study the effects of demographics on housing consumption. Demographics were considered from three aspects: natural structure, regional structure, and social structure. Based on Life Cycle Theory and Permanent Income Hypothesis, the models on housing consumption were constructed. Results show that demographic structures are important factors affecting housing consumption: (i) child-age dependency ratio (CDR), education level, and family size negatively affect housing consumption, while urbanization rate and old-age dependency ratio (ODR) have positive effects; (ii) CDR positively affects housing consumption through deposit and the indirect effect of ODR on housing consumption through deposit is negative; (iii) the influence of demographics on housing consumption is heterogeneous in different regions. It is relatively close between the central and the west to some extent but quite different in the east.

1. Introduction

Demographic changes lead to very heterogeneous demand responses for different housing attributes [1, 2]. According to the World Demographic Trends (<https://www.un.org/zh/development/population/conclusions.shtml>) reported by the UN Secretary-General, the global demographic trends by 2050 are as follows: ageing due to prolonged life, continued urbanization, declining fertility, and shrinking household size. Table 1 shows that all of these trends are strongly related to housing market. Demographic analysis can provide a good basis for housing demand assessment over the short term [3]. However, existing literature studies just focused on one or two aspects of demographic structures when investigating the relationship between demographic structures and housing (e.g., [4–6]). Thus, it is necessary to study housing consumption in combination with comprehensive demographics to make a better forecast of housing consumption from the perspective of population.

In 2017, China ranked first in the world with a population of 1.368 billion, accounting for 18.41% of the global population.

The large population base reduces the impact of accidental factors and makes the demographic trends more obvious, and these trends are consistent with the global population trends (which will be introduced in detail in Section 2). In addition, the reform of the housing system and housing marketization in 1998 is an important milestone in the Chinese housing market [4]. Before that, housing was allocated to people by the Chinese government. But after 1998, housing became a common commodity in China. The only way for residents to own a house is to make a purchase in the housing market. This means that residential housing consumption is more sensitive to demographic changes since 1998 because citizens are the decision makers of housing consumption. During housing consumption, the characteristics and preferences will affect their behaviour. In summary, China is a good object to study the relationship between demographics and housing consumption and can provide reference for most countries, especially for those where housing is marketized.

Taking Chinese housing system reform in 1998 as a starting point, this paper investigates the effects of demographic structures on housing consumption using the panel

TABLE 1: Studies of demographic factors affecting housing consumption.

Factor	Literature studies
Natural structure	
Population size	Thompson [7]; Kuchay et al. [8]; Choi et al. [5]
Age structure	Campbell [9]; Easterlin [10]; Carliner [11]; Mankiw and Weil [12]; McFadden [13]; Green and Hendershott [14]; Ermisch [15]; Holly and Jones [16]; Myers and Ryu [17]; Levin et al. [18]; Hiller and Lerbs [19]; Malmberg [20]; Choi et al. [5]
Regional structure	
Spatial structure	Long and Wu [21]; Lee and Huh [22]; Saiz [23]; Chen et al. [4]; Akbari and Aydede [24]; Gonzalez and Ortega [25]; Lu et al. [26]; Wang and Zhang [27]; Eliasson [28]; Lin [29]
Social structure	
Education structure	Green and Hendershottb [14]; Zhou [30]; Eichholtz and Lindenthal [2]; Chen and Zhang [31]
Family size	Horioka [32]; Hugo [33]; Lauf et al. [6]; Chen and Chen [34]

data of 31 provinces from 1999 to 2017 in China. The regional differences of these effects among eastern, central, and western China are also revealed. In particular, natural structure, spatial structure, and social structure of population are included in the model on housing consumption and the partial effect of age structure on housing consumption is studied in detail.

The remainder of the paper is organized as follows. Section 2 sorts out the trends of demographics and housing consumption in different regions of China and nationwide. Section 3 reviews existing studies on the effects of demographic structures on housing consumption from three aspects (e.g., natural structure, regional structure, and social structure). How to choose suitable indicators of demographic structures is also fully discussed in this part. Based on life cycle theory and permanent income hypothesis, Section 4 constructs a panel model containing the indicators selected in Section 3 and presents provincial data from 1999 to 2017 in China. In Section 5, we analyse the panel model using fixed effect regression, interpret the direct and partial effect of demographic variables, and test the robustness of the model using the 4 trillion investment plan in 2008 in China. Section 6 concludes with implications.

2. Demographic Trends and Housing Consumption in China

2.1. Nationwide Demographic Trends and Housing Consumption. China's housing consumption increased rapidly since the abolishment of welfare housing policy in 1998 (housing was allocated to the household by Chinese government before 1998). According to the National Bureau of Statistics of China, housing sales area in 2018 was 14 times that of 1998. The growth rates in different periods are different. From 1998 to 2010, the sales of commodity houses increased by 19.67% annually, while the annual growth rate fell to 5.92% from 2011 to 2018. This may be related to the decline in the share of working-age people from 2011 (shown in Figure 1(a)). From the perspective of human capital, working-age households, who have more housing desire and better affordability, tend to have greater housing consumption [2]. As people aged 45–59 retire gradually, people aged 0–14 step into working age (15–59). According to the

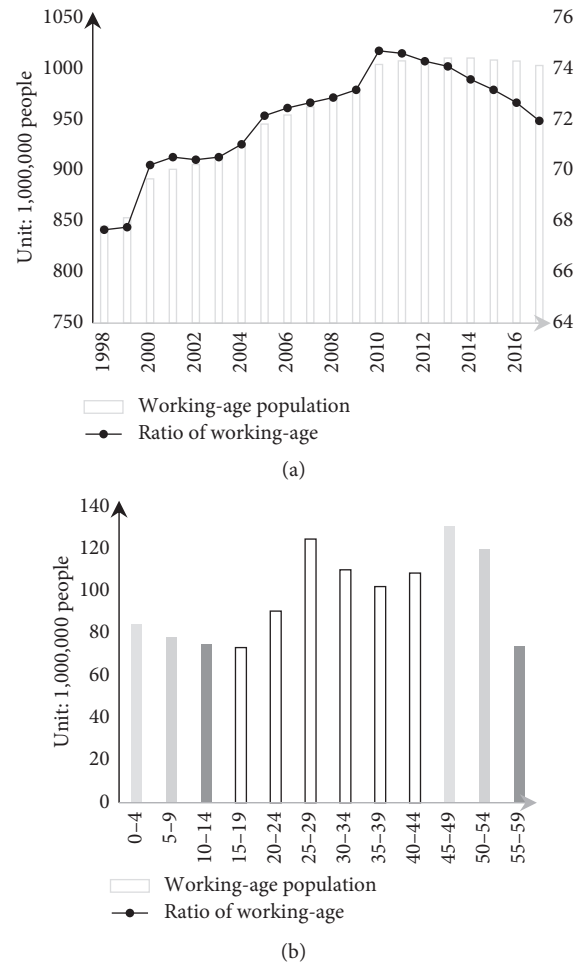


FIGURE 1: Trend of working-age population in China. (a) Working-age population in China, 1998–2017. (b) China's population aged 0–59 in 2017. Source: China Statistical Yearbook 2018.

Chinese population aged 0–59 in 2017 (Figure 1(b)) and the low birth rate in China, working population is forecasted to decline continually in the next 15 years and housing consumption will be affected directly.

China has entered the ageing society since 1999, and its ageing speed tends to be faster. Due to the age dependency of private demand for different forms of housing, population

ageing can unfold heterogeneous impacts across different housing markets [19]. Besides, family support for the elderly is the most common in China. The increased pressure on offspring to care for the elderly will curb the housing consumption of the younger generation. According to the WHO, China will become the most ageing country in the world with 35% ageing rate in 2050 (http://www.un.org/esa/socdev/aging/Vienna_intlpanofaction.html). China's ageing process is significantly faster than other countries. If other factors are not considered, the negative impact of ageing on housing consumption will stick out [34]. In addition, the spatial distribution of ageing is uneven in China. In Figure 2, Heihe-Tengchong Line is a significant demarcation line of ageing. Younger populations are mainly found in the northwest and the elderly are mainly in the southeast [35]. Depending on the degree of ageing, regional housing consumption will vary differently.

The social characteristics of population are also changing. The family size in China fell from 3.58 to 3.03 from 1999 to 2017, and the proportion of population with college degree or above education rose from 2.87% to 12.89% during this period. Also, some other structural changes of population have emerged in China, such as large-scale movements and regional unbalance distribution. Natural and socioeconomic conditions lead to extremely uneven distribution of population [36]. The Chinese Sixth National Census shows that the floating population was as high as 221 million (compared with 121 million in the Fifth National Census), which was almost 20% of the total population. Actually, the inflowing cities were mainly concentrated in eastern provinces and municipalities, like Guangdong, Zhejiang, Shanghai, and Beijing. The unbalanced distribution and different densities in population make regional housing consumption heterogeneous. Consequently, we will divide China into three parts to study the regional difference in the relationship between housing consumption and demographic structures.

2.2. Regional Demographic Trends and Housing Consumption. In the *2016 National Real Estate Development Investment and Sales Situation in China*, 31 provinces in China were divided into three parts: East, Central, and West (the East includes 8 provinces, such as Hebei, Liaoning, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan and 3 municipalities, such as Beijing, Tianjin, Shanghai; the Central includes 8 provinces, such as Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan; and the West includes 11 provinces, such as Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Ningxia, Tibet, Qinghai, Xinjiang, and 1 municipality which is Chongqing). Differences in geographical location have caused great inequalities in the macroeconomic environment. Development level of the East is the highest, the Central is the second, and the West is the last (the per capita GDP in 2017 was 81625, 47766, and 44717 yuan, respectively). Next, we choose Beijing, Hubei, and Sichuan as the representatives of the East, Central, and West, respectively (Figure 3) and roughly compare the demographic trends and housing consumption of these three regions.

To some extent, Beijing, Hubei, and Sichuan have different regional characteristics (Figure 4). Specifically, the demographic trends and housing consumption from 1999 to 2017 in Sichuan (West) and Hubei (Central) were in line with those in China. For example, the trends of housing consumption, urbanization rate, family size, old-age dependency rate, and child-age dependency rate in Hubei (Central) and Sichuan (West) were similar to those across the country. The circumstance may exist because the central and western parts become the majority of China, as Figure 3 shows. While in Beijing, except for the education level, the other demographic variables showed converse trends. Beijing has become a high urbanized city since 1999, and the urbanization rate was almost unchanged. Its strong economic conditions attracted labors, decreased the old-age dependency ratio, and increased the total population. However, the increasing population did not necessarily increase housing sales area, which may be because the income of inflowing labors was not enough to afford the expensive houses in Beijing.

There are significant differences in demographic factors and housing consumption among the eastern, central, and western regions. In the following, we will conduct a more in-depth analysis by using the macrodata to identify the relationships and regional differences between demographics and housing consumption.

3. Literature Review

Demographic structures can be classified into three categories: natural structure, regional structure, and social structure. Studies on how demographic factors affect housing consumption are sorted out accordingly and shown in Table 1. In particular, among demographic factors, population size, age structure, spatial structure, education structure, and family size have a more significant effect on housing consumption, and these factors are used in this paper to study how demographic structures affect housing consumption.

3.1. Natural Structure and Housing Consumption. Due to the global trend of declining birth rates and increasing life expectancies, the impacts of population size and age structure on the housing market have received a great deal of attention in the existing literature.

3.1.1. Population Size. Changes in population size will alter housing consumption. The general dependence of the housing market on the total growth of population is widely recognized, because the demand for housing must come from a population to be housed [7]. Although population growth does not necessarily translate into effective housing demand, an increase in population often stimulates housing consumption. Kuchay et al. [8] pointed out that rapid population growth is the major contributory factor for the housing expansion of Srinagar. Choi et al. [5] also found that population size affected housing market to a certain extent. Therefore, population size is adopted as an indicator.

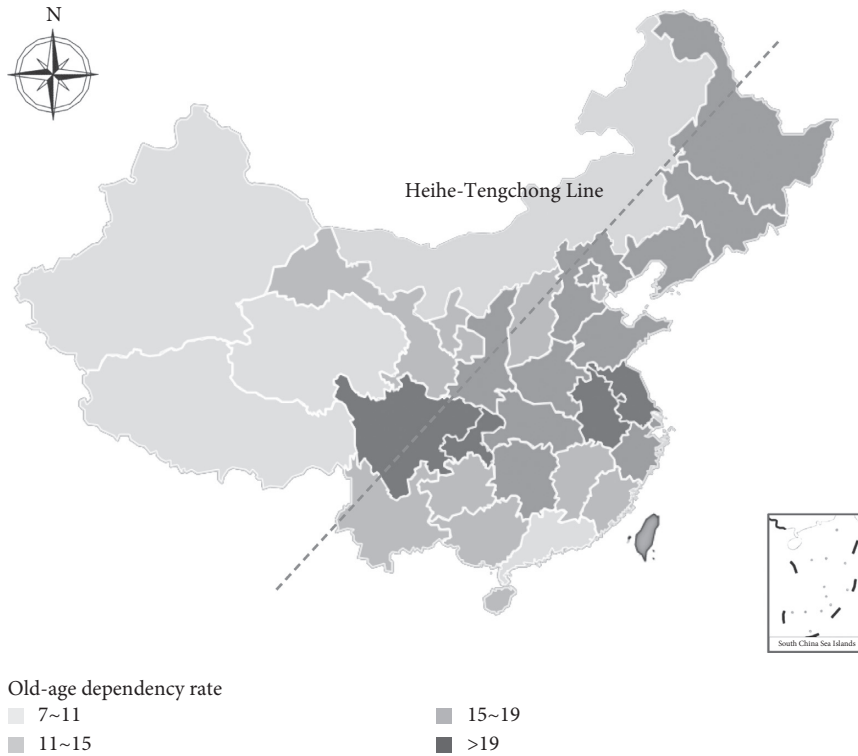


FIGURE 2: Old-age dependency rate of 31 provinces in China in 2017. Source: the figure is drawn by the author according to the data of the China Statistical Yearbook 2018.



FIGURE 3: Geographic locations of the East, Central, and West in China.

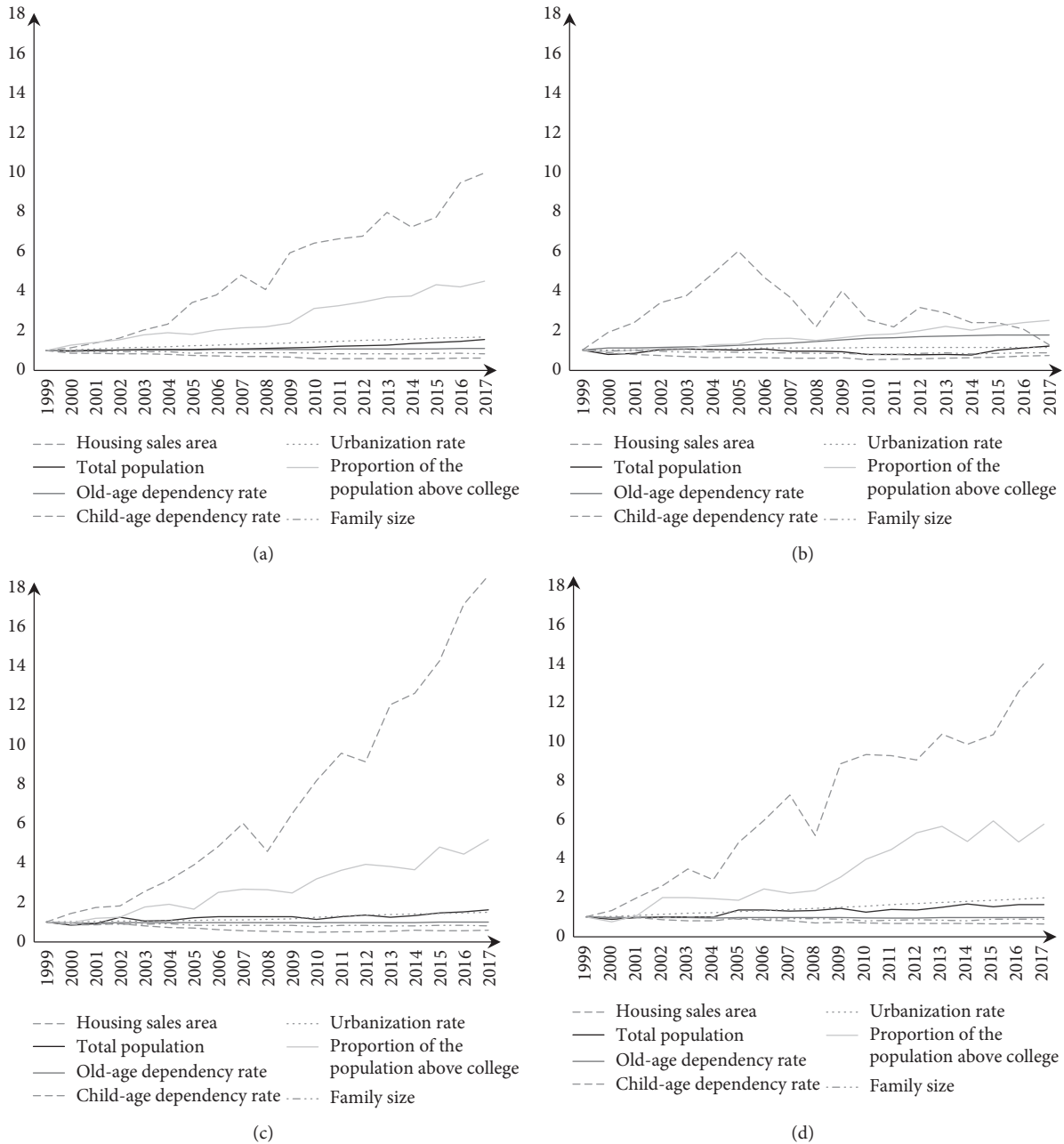


FIGURE 4: Examples of city-wide changes in housing consumption and demographics, 1999–2017. (a) China. (b) Beijing. (c) Hubei. (d) Sichuan. Note: all series are indexed to 1999=1. And all the data are from the National Bureau of Statistics of China.

3.1.2. Age Structure. Age structure is most closely related to housing consumption in the demographic structures. As early as 1954, Modigliani began to study the relationship between age and consumption and proposed Life Cycle Theory. Campbell [9] and Easterlin [10] focused on the relationship between age structure and housing consumption in the early time period. Carliner [11] believed that income elasticity of housing demand was discrepant during different ages, which resulted in different housing consumptions. Mankiw and Weil [12] first introduced the Life Cycle Theory into the housing market in 1989 and used US Census data in 1970 to estimate housing demand of different

ages. While Green and Hendershott [14] computed the partial effect of age on housing demand and suggested that keeping all else constant, the demand for housing tended to be flat or rising slightly with age. More scholars such as McFadden [13]; Holly and Jones [16]; Ermisch [15]; and Myers and Ryu [17] supported Mankiw and Weil’s opinions and found that age structure had a significant effect on housing demand, despite different estimation methods being adopted.

The main trend of age structure in China is ageing and declining birthrate (China’s total fertility rate was declining since 1991 and was 1.635 in 2018). Both ageing [18–20, 37]

and birth rate [5, 20, 37] have a close link with housing market. We choose child-age dependency rate (CDR) and old-age dependency rate (ODR) as indicators to reflect the change of age structure. Considering the partial effect mentioned by Green and Hendershott [14], the interactive items between CDR or ODR and deposit are also used to examine whether age structure has a partial effect on housing consumption through deposit.

3.2. Region Structure and Housing Consumption. Spatial migration may have an influence on the local housing market, by changing housing demand and housing consumption. In developed countries, such as Korea [22], America [23], Canada [24], Spain [25], and Iceland [28], immigrants affect housing market significantly and differently. In the United States, Saiz [23] used the IV (instrumental variable) method and concluded that a 1% increase in migration will result in a 1% increase in rents and housing prices. In Spain, immigration led to an average 2% annual increase in housing prices, for a 1.2%–1.5% increase in housing units between 2000 and 2010. In Iceland, 1% net immigration yielded a rise in housing prices as high as 4%–6%. There are differences in migration between China and developed countries. Migration in China mainly occurs between urban and rural areas or between regions. Many Chinese scholars, such as Long and Wu [21]; Chen et al. [4]; Lu et al. [26]; and Wang and Zhang [27], confirmed that there is a long-term and stable positive relationship between urbanization level and housing market. Urbanization process will generate a large number of rigid, investment, and speculative housing demand. Therefore, the urbanization rate is included as the indicator to respect the change of Chinese population spatial structure.

3.3. Social Structure and Housing Consumption. Family size, education level, and other sociodemographic factors play an increasingly important role in making housing purchase decision. Scholars usually study social structure of population from two aspects, that is, education structure based on the individual feature and family size based on the family feature.

3.3.1. Education Structure. High education levels would increase a household's housing consumption [2]. Green and Hendershott [14] used census data of 1980 and found that in 1980, the willingness to pay for a constant-quality house was about 50% lower for households in 70-year-olds than for those in 50-year-olds, owing to the surge in education after World War II. Zhou [30] pointed out that families with household heads of high educational level prefer to own private housing, and educational expenditure uncertainty negatively affects housing choice. Based on the micro-household data in China, Chen and Zhang [31] analyzed dynamic evolution of urban housing prices from the perspective of human capital. They found that every 1% increase in population of higher education rises urban housing prices by 4.6%–7.9%. Obviously, education is significantly related

to housing consumption. In this paper, the population share of people with college degree or above is used as the indicator to measure the change in educational structure.

3.3.2. Family Size. The consumption in housing is family-based. Horioka [32] proposed that the number of households, rather than the number of people, is the driving force of housing prices, and the expansion of household size would increase the demand for nonhousing assets, thereby weakening housing consumption. Hugo [33] used statistical methods to analyze the population and family changes in Australia, and results showed that the increase of households would increase total housing demand. Lauf et al. [6] also found that even if the total population showed a downward trend, the miniaturizing households had contributed to the rising demand for housing. The future housing demand in China will be affected by changes in household size. Chen and Chen [34] indicated that family miniaturization will boost urban housing consumption in China in the next 20 to 30 years. Thus, family size is used as another indicator.

Above all, population size, child-age dependency rate (CDR), old-age dependency rate (ODR), urbanization rate, the population share of people with college degree or above, and family size are adopted as indicators in this paper. Besides, the interactive items between CDR or ODR and deposit are also added to examine whether age structure has a partial effect on housing consumption through deposit.

4. Theoretical Framework and Data

4.1. Model Assumptions. Keynes proposed the Absolute Income Hypothesis in *The General Theory of Employment, Interest and Money*, arguing that people's consumption is determined by their current disposable income. On this basis, Friedman's Permanent Income Hypothesis believes that the main determinant of consumption is the persistent income of consumers rather than the current income. Modigliani's Life Cycle Theory, mainly analyzing the impact on consumption from income and deposit, holds that people plan their living expenses over a longer period to achieve the optimal allocation of consumption throughout the life cycle.

According to Life Cycle Theory and Permanent Income Hypothesis, the model of rational consumer pursuing maximization of intertemporal utility can be expressed as

$$\begin{aligned} \max \quad & E_t \left[\sum_{t=0}^T (1 + \delta)^{-t} u(C_t) \right], \\ \text{s.t.} \quad & S_{t+1} = (1 + r)(S_t + Y_t - C_t), \end{aligned} \quad (1)$$

where C_t , Y_t , and S_t denote the consumption, income, and deposit in the t -term, δ is the time preference rate, r is the return on assets, and T represents the life cycle stage, $T = \{0, 1, 2\}$, where "0" means childhood, "1" means labor period, and "2" means old age.

The utility function is a quadratic curve. When $\delta = r$, the optimal consumption path is

$$C_t = \frac{r}{1+r}S_t + \frac{r}{1+r} \sum_{i=0}^2 (1+r)^{-i} E_t Y_{t+i}. \quad (2)$$

It explains that the consumption level in the t -term depends on the current deposit and the discounted value of the current and expected future income. Further assuming that income follows first-order autoregression ($Y_{t+1} = aY_t + \varepsilon_t$), the simplified long-term consumption function can be obtained:

$$C_t = \beta_1 Y_t + \beta_2 S_t, \quad (3)$$

where β_1 and β_2 are the long-term influence coefficients of income and deposit on consumption.

Housing consumption is an important aspect of consumption. Based on the long-term consumption function, this paper considers the impact of housing supply on housing consumption and establishes the metrology models as follows (We tried to add housing price as a controlling variable, but the results showed that housing prices in all regions did not have a significant impact on housing consumption. In the traditional relationship between supply and demand, price is an important factor affecting demand. But house can not only be used for living but also a good investment. The rise in housing prices has stimulated investment behavior in the real estate industry and maintained the stability of housing consumption):

$$\begin{aligned} \ln HSA_{it} = & \alpha_0 + \alpha_1 \ln INCO_{it} + \alpha_3 \ln POPU_{it} + \alpha_4 \ln HCA_{it} \\ & + \alpha_5 CDR_{it} + \alpha_6 ODR_{it} + \alpha_7 URB_{it} + \alpha_8 FS_{it} \\ & + \alpha_9 EDU_{it} + u_i + \varepsilon_{it}, \end{aligned} \quad (4)$$

$$\begin{aligned} \ln HSA_{it} = & \alpha_0 + \alpha_1 \ln INCO_{it} + \alpha_2 \ln DEPO_{it} + \alpha_3 \ln POPU_{it} \\ & + \alpha_4 \ln HCA_{it} + \alpha_5 CDR_{it} + \alpha_6 ODR_{it} + \alpha_7 URB_{it} \\ & + \alpha_8 FS_{it} + \alpha_9 EDU_{it} + u_i + \varepsilon_{it}, \end{aligned} \quad (5)$$

where i denotes the province, t represents the year, HSA, HCA, INCO, DEPO, POPU, CDR, ODR, URB, FS, and EDU represent housing consumption, housing supply, income, deposit, total population, child-age dependency rate, old-age dependency rate, urbanization rate, family size, and education level, respectively, u_i is the unobservable interprovincial effect, and ε_{it} is the error term. And Model (4) does not consider the impact of deposit.

Besides, there may be a partial effect of population age structure on housing consumption through deposit. The squeezing effect of CDR and ODR on consumption will vary among households with different deposits. In households with higher deposit, increased support pressures will result in a reduction in consumption. However, due to its considerable economic foundation, the degree of squeezing effect will be smaller. For families with lower deposit, the sensitivity of consumption to support pressure will be greatly increased. Furthermore, children and deposit can be seen as two types of pension tools that have the same economic function and replace each other: (i) when a family has a multitude of

children, parents will reduce deposit that were originally for old-age security and increase consumption; (ii) when the number of children is smaller, parents increase their deposit to support their old age and the consumption decreases.

Above all, this paper introduces the interaction items of CDR and deposit and ODR and deposit into the model. The extended model is

$$\begin{aligned} \ln HSA_{it} = & \alpha_0 + \alpha_1 \ln INCO_{it} + \alpha_2 \ln DEPO_{it} + \alpha_3 \ln POPU_{it} \\ & + \alpha_4 \ln HCA_{it} + \alpha_5 CDR_{it} + \alpha_6 ODR_{it} + \alpha_7 URB_{it} \\ & + \alpha_8 FS_{it} + \alpha_9 EDU_{it} + \alpha_{10} \ln DEPO_{it} \times CDR_{it} \\ & + \alpha_{11} \ln DEPO_{it} \times ODR_{it} + u_i + \varepsilon_{it}. \end{aligned} \quad (6)$$

4.2. Selection of Variables and Data. This paper selects the panel data of 31 provinces and municipalities in China from 1999 to 2017 as the research sample. All data come from the China Statistical Yearbook, and the People's Bank of China. The specific descriptions of each variable are shown in Tables 2 and 3.

With 1999 as the base year, the income and deposit are adjusted by the Consume Price Index, and variables are processed by natural logarithm except the structural variables. Meanwhile, to ensure the robustness of the results, the panel data are checked for panel smoothness. The unit root test is used for the panel stationarity test commonly, mainly including LLC, IPS, Fisher-ADF, HT, and so on. In this paper, LLC, IPS, Fisher-ADF, and HT are all used for the unit root test. The results in Table 4 show that most variables are stationary at 99% levels in more than two tests, indicating the panel data in this paper have good stability.

5. Results of the Fixed Effect for Panel Data

5.1. Analysis of Regression Results. To reveal the effects of demographic structures on housing consumption and the regional differences in effects, we conduct an overall analysis of China at first and then divide 31 provinces and municipalities into East, Central, and West. Based on the panel data, fixed-effect models are established and estimated by Stata15.1.

In this paper, the F -test and Hausman test are carried out in the national and regional models. The F -test results show consistent rejection of the null hypothesis, which means that there are significant differences in the cross sections of the panel data. The results of Hausman test are shown in Table 5. Except for Model 2 in the Central, the other models consistently reject the null hypothesis of the random-effect model. Therefore, the static fixed-effect model is adopted for panel regression (although Model 2 in Central did not pass the Hausman Test, a fixed-effect regression was still performed on it for comparison). And robust cluster regression is used to avoid heteroscedasticity and cross-sectional dependence in the model.

In Model 1, we do not consider the impact of deposit and add income and housing completion area as controlled variables to examine the impact of demographic factors on

TABLE 2: Basic information of research variables.

Variable code	Variable name	Unit	Processing of variable	Definition	Purpose of introduce
HSA	Housing sales area	10000 sqm	Natural logarithm	Annual sales area of commercial housing	To represent housing consumption
HCA	Housing completed area	10000 sqm	Natural logarithm	Annual completed area of commercial housing	To represent housing supply
INCO	Income	Yuan	Natural logarithm	Annual per capita disposable income	Controlled variable
DEPO	Deposit	100 million yuan	Natural logarithm	Year-end balance of resident deposits	Controlled variable
POPU	Total population	10000 people	Natural logarithm	Total population	To represent population size
URBA	Urbanization rate	%	—	Urban population/total population	To represent spatial structure
CDR	Child-age dependency rate	%	—	Population aged 0–14 years/aged 15–64	To represent the age structure
ODR	Old-age dependency rate	%	—	Population aged 65 and above/aged 15–64	To represent the age structure
FS	Family size	Person	—	Number of members per household	To represent the family structure
EDU	Education level	%	—	College degree or above population/total population	To represent education structure
lnDEPO_CDR	Interaction items between CDR and lnDEPO	—	—	—	To study the partial effect of CDR on housing consumption
lnDEPO_ODR	Interaction items between ODR and lnDEPO	—	—	—	To study the partial effect of ODR on housing consumption

TABLE 3: Descriptive statistics of research variables.

Variable	Observed number	AVG	σ	Min	Max
INCO	589	16955.73	10480.38	4342.61	62595.74
DEPO	589	8812.215	9915.327	36.8	61890.08
HSA	589	2311.45	2393.532	0.9682	13522.51
HCA	589	1681.85	1530.225	0 ^a	7930.21
POPU	589	4247.2	2697.028	256	11169
URBA	589	0.4864	0.1590	0.1769	0.896
CDR	589	0.2604	0.0809	0.0964	0.5778
ODR	589	0.1221	0.0278	0.0627	0.2188
FS	589	3.2459	0.4610	2.33	6.79
EDU	589	0.0834	0.0631	0.0000532	0.4476

^aBecause China did not implement housing commercialization until December 1998, most provinces and municipalities did not have commercial housing completed in 1999.

TABLE 4: Unit root test of research variables.

Variable	LLC	IPS	Fisher-ADF	HT
lnINCO	-9.2190***	2.0186	14.1692***	4.7458
lnDEPO	-10.5586***	0.3699	-0.8486	4.4005
lnHSA	-9.1567***	-3.7837***	5.1203***	1.1136
lnPOPU	2.9264	-2.3749***	37.7105***	0.5170
URBA	-1.2787*	-1.7656**	5.6751***	2.1132
CDR	-9.4555***	-6.5755***	13.2810***	-1.6080*
ODR	-2.1383**	-4.7252***	2.8882***	-4.4565***
FS	-4.9431***	-4.3037***	5.1512***	-11.2796***
EDU	-3.6654***	-6.9857***	8.6770***	-8.8446***
lnDEPO_ODR	-1.7560**	-4.6702***	4.3962***	-4.2110***
lnDEPO_CDR	-4.0330***	-4.0898***	4.9772***	-3.1801***

Note. ***, **, and * indicate significance at 1%, 5%, and 10%.

TABLE 5: Estimation results of fixed-effect models for population structure and housing consumption across the country and across regions.

Variable	Nationwide			East			Central			West		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
lnINCO	1.1701*** (5.67)	0.8279*** (2.80)	1.2330*** (3.84)	1.2069** (2.86)	0.8916* (1.93)	0.8099* (1.89)	1.3331** (3.39)	1.3125** (2.64)	1.2705* (2.15)	1.0314** (2.93)	0.4070 (0.98)	0.3189 (0.64)
lnDEPO		0.3724** (2.46)	-0.0755 (-0.22)		0.3069 (1.28)	-0.0412 (-0.11)		0.0271 (0.07)	0.1404 (0.19)		0.5483*** (4.92)	0.6536 (1.47)
lnHCA	0.0697*** (6.23)	0.0700*** (6.26)	0.0682*** (5.39)	0.0502*** (3.27)	0.0515*** (3.30)	0.0344* (1.79)	0.0594*** (5.13)	0.0593*** (5.03)	0.0521** (3.38)	0.0932*** (3.58)	0.0887*** (3.27)	0.0843*** (3.10)
lnPOPU	-0.5859 (-1.14)	-0.8890* (-1.74)	-0.9261* (-1.78)	-0.8227 (-1.14)	-1.2282 (-1.21)	-1.0826 (-1.05)	-3.3678* (-2.03)	-3.3704* (-2.01)	-3.8925* (-2.35)	0.0315 (-0.03)	-0.2981 (-0.43)	-1.4655 (-1.51)
URBA	3.3291*** (4.88)	2.3342*** (3.30)	2.7319*** (3.81)	2.7401* (1.86)	2.0261 (1.26)	1.6826 (1.57)	5.5608*** (4.75)	5.4789*** (4.14)	5.5869*** (3.76)	3.1249** (2.67)	2.1776 (1.67)	4.7940** (2.74)
CDR	-3.7113*** (-3.14)	-3.4397*** (-3.23)	-10.5594*** (-3.42)	-4.6515*** (-3.25)	-4.5295*** (-3.29)	-23.5904*** (-5.72)	-0.2330 (-0.28)	-0.2204 (-0.24)	-5.7983 (-0.73)	-5.1090** (-2.92)	-4.4907** (-2.86)	-6.7572 (-1.76)
ODR	4.0423* (1.99)	3.9180* (1.92)	11.4679 (1.12)	4.3652 (1.74)	4.5328* (1.86)	12.5077 (0.87)	-1.0550 (-0.27)	-1.0963 (-0.27)	21.1717 (1.26)	4.2602 (1.65)	4.5068 (1.50)	31.5801*** (3.47)
FS	-0.2961*** (-3.12)	-0.2337*** (-2.19)	-0.1427 (-1.19)	-0.1314 (-0.59)	-0.1493 (-0.71)	-0.0362 (-0.19)	-0.7115*** (-4.71)	-0.7101*** (-4.67)	-0.6546*** (-5.17)	-0.2783* (-1.97)	-0.1980 (-1.55)	-0.1598 (-1.34)
EDU	-8.1761*** (-7.78)	-7.9662*** (-7.30)	-6.2861*** (-5.91)	-7.0396*** (-3.68)	-6.5297*** (-3.27)	-4.2519* (-2.08)	-8.2023** (-3.21)	-8.2357** (-3.21)	-6.3469* (-1.96)	-9.6970*** (-5.73)	-9.4814*** (-5.74)	-7.9119*** (-6.17)
lnDEPO_ODR			-1.0201 (-0.90)			-1.0410 (-0.58)			-2.5833 (-1.21)			-3.3660*** (-3.54)
lnDEPO_CDR			0.9831*** (2.84)			2.2712*** (5.30)			0.7503 (0.79)			0.5172 (0.92)
Constant	0.8902 (0.24)	3.6795 (0.93)	3.1870 (0.77)	2.3528 (0.41)	6.3589 (0.76)	8.7775 (1.06)	23.7416 (1.76)		27.1147 (1.88)	-2.4339 (-0.48)	1.6436 (0.52)	8.8187 (1.39)
Hausman	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1992	0.0006	0.0000	0.0000	0.0000
R ² within group	0.9017	0.9039	0.9132	0.8598	0.8610	0.8946	0.9549	0.9549	0.9563	0.9083	0.9137	0.9249
Sample size	589	589	589	209	209	209	152	152	152	228	228	228

Note. ***, **, and * indicate significance at the 1%, 5%, and 10%. Numbers in parentheses are T statistics. Hausman stands for the Hausman test *p* value.

housing consumption. Then, the deposit is added to test the impact of deposit on housing consumption and to make comparison with Model 3. Finally, in Model 3, we add the interaction items between age structure and deposit to test whether the partial effect of age structure on housing consumption exists.

The estimated results of Model 1, Model 2, and Model 3 are shown in Table 5. It displays that R^2 of all models reaches 85% and above, indicating the models explain the dependent variable very well, and the conclusions of this paper are highly reliable. Based on the estimated results, the empirical analysis is as follows:

- (1) Income has a positive effect on housing consumption in the Nationwide, East, and Central. In the West, only Model 1 shows a significant positive impact, reflecting that the influence of income on changes in housing consumption is less, and the impact of demographic factors on housing consumption is more significant. Comparatively, the impact of income in the Central is greater than that in the East, indicating that the increment of housing consumption caused by equal increase of income is larger in the Central than in the East. This can be explained from the perspective of housing affordability. In 2017, the housing price-to-income ratio in the East was 8.8, compared with 6.9 in Central (the data are calculated by the author based on data from the Statistical Yearbook of China 2018). The East has higher housing prices and less income elasticity of housing consumption, and then, the same increase of income causes less increment of housing consumption.
- (2) In Model 2 of the Nationwide and West, there is a positive impact of deposit on housing consumption. After adding the interaction items between deposit and age structure, the effect of interaction terms on housing consumption is significant, but the impact of deposit turns to be not significant. This shows that the impact of deposit on housing consumption is mainly realized through age structure.
- (3) Among all models, the completed area of commercial housing has a significant positive impact on housing consumption. It means that with the housing supply increase in China, more housing needs are met, which increases housing consumption. The increase range is higher in the West than in the Central, and the increase range in the Central is higher than in the East.
- (4) The total population has a negative impact on housing consumption Nationwide and in the Central, which is quite unexpected but reasonable. The dependent variable in the paper is essentially the annual housing consumption. After the rapid development of China's real estate in the past two decades, the per capita housing area of urban residents in 2017 increased to 36.9 m^2 . As the housing needs of residents are gradually met, the stock of housing demand is decreasing year by year. Furthermore, China's population growth slows down,

the number of new populations decrease every year, and then the new demand for housing decreases. The final result is that although total population increases, the housing consumption declines. This reflects that the total population is not the main factor determining housing consumption in China and improvement demands are the future of housing market.

- (5) Urbanization has a significant positive impact on housing consumption in the Central and West, as well as Nationwide. In the process of urbanization, a large number of rural people have entered the towns, resulting in the continuous expansion of the urban population and the increasing living demand and investment demand for urban housing. However, this effect is not significant in the East, in line with Chen et al. [4]. The stunning level of economic development in the East has attracted a large amount of floating population, which is included in the resident urban population (the urbanization rate in this paper is obtained from the China Statistical Yearbook, which is the proportion of resident urban population to the total population, not the urban registered population). While in the East, restrictions on the housing purchase of floating population are greater, curbing the housing consumption of floating population. In addition, many eastern provinces already have high urbanization levels in an earlier period. It would be difficult for ordinary rural-urban migrants to obtain local urban household registration status [4]. Some developed provinces, such as Beijing and Shanghai, set a high threshold for local urban household registration [38], further reducing the role of urbanization in promoting housing consumption.
- (6) ODR has a positive direct impact on housing consumption in the West. According to the Life Cycle Theory, the increase in ODR would reduce the housing consumption. The possible reason for the opposite situation is that China is still in the early stage of ageing, and the pressure to support the elderly is not serious enough to compress the housing consumption of younger generation. Furthermore, helping children purchase houses with "altruism" increases the elderly population's housing consumption [39]. But the further ageing will curb housing consumption, and the turning point is when the average pension burden of the working-age population equals to the house purchase support of the elderly population. Perhaps, the East and Central are at this point, ODR has no significant impact on housing consumption.

In the West, ODR has a negative impact on housing consumption through deposits. The higher the deposit of the elderly, the less they support purchasing their children's houses, and the promotion of ODR to housing consumption will reduce. If the deposit (after adjusting by Consume Price Index) reaches $1187.38 (=e^{31.5801/3.366}/10)$ billion yuan, ODR will affect

housing consumption negatively. At present, only Sichuan Province in the West has exceeded this threshold, and the ODR of the other 11 provinces in West is positively affecting housing consumption. Nationally, ODR has a direct positive impact on housing consumption and has no significant indirect impact.

- (7) CDR has a significant negative impact on housing consumption in the East and West and Nationwide. When CDR increases, the reduction caused by aggravated pressure to raise children is more than the increasing demand from newborns. With the decrease of CDR in China, the housing consumption will continue to increase.

After adding the interaction item between CDR and deposit, results show that in the East and Nationwide, the direct impact of CDR on housing consumption is more negative and CDR affects housing consumption through deposit positively. Only after deposit breaking through the bottleneck can the housing consumption of newborns be released. By then, CDR will have a positive impact on housing consumption. In the East, if the deposit (after adjusting by Consume Price Index) reaches 3242.73 ($=e^{23.5904/2.2712}/10$) billion yuan, CDR will affect housing consumption positively. At present, only Guangdong Province in the eastern region has exceeded this threshold, but the deposits in Jiangsu, Zhejiang, and Shandong are approaching. Perhaps, because the deposits in the West are not high, the indirect effect of CDR through deposit is not significant.

- (8) In the Central, family size has a significant negative impact on housing consumption, and the national trend is basically in line with the Central. With the shrinking of family size and the increasing number of households in China, the demand for housing will continue to increase.
- (9) All models show that the education level has a significant negative impact on housing consumption. This is inconsistent with Eichholtz and Lindenthal [2]. According to Chen and Zhang [31], talent gathering would bring housing prices up, which may curb housing consumption. However, housing prices have no significant impact on housing consumption in the result of this research. There are other reasons for the phenomenon that improvement in education level curbs housing consumption, like education spending squeezing housing consumption [30]. With the popularization of the concept of "Knowledge Change Fate" in China, more people choose to receive a higher education; what followed is an increase in social competitive pressures. The increasing pressure will lead to a surge in education investment in the family and even squeeze housing consumption. The crowding-out effects is greatest in the West, second in the Central, and smallest in the East. One interpretation is that the income in Central and West

regions is lower, and the education consumption accounts for a larger proportion, so the crowding-out effect is greater.

5.2. Robustness Test. Next, the paper examines the robustness of the effects of demographic changes on housing consumption. In response to the global financial crisis, China launched a 4 trillion investment plan and a series of policies to stimulate domestic demand in November 2008, mainly by building a large amount of infrastructure, including railways, highways, and others. The policy drove China's economic growth and caused a great shock to real estate market, resulting in great demand for real estate and rapid growth in housing prices. This paper uses this historical policy to test the robustness and effectiveness of the model and introduces the year 2009 as a dummy variable into Model 3, expanding Model 3 to Model 4. The estimated results are shown in Table 6. It shows that there is no large deviation between Model 3 and Model 4. The investment plan stimulated housing consumption at that time and had a significant positive impact on housing consumption, which was consistent with the fact. The degree of influence was deeper in the Central and West than in the East.

6. Conclusion

Like other countries, demographic variables affect housing consumption from several aspects in China, such as population size, age structure, spatial structure, education level, and family size. At present, China's annual housing consumption is decreasing. With the rapid development of the housing supply, China's housing demand is gradually being met, and the impact of population size on demand of new houses is weakened. What really affects the housing consumption is the changing housing demand brought about by the other demographic transition. Among them, child-age dependency ratio (CDR), education level, and family size negatively affect housing consumption, while urbanization rate and old-age dependency ratio (ODR) have positive effects.

Comparing the results of different regions, there do exist significant differences among the eastern, central, and western China (Table 7). The level of development in the East is much higher than that in the Central and West, and the differences between the latter two are not obvious to some extent. The stunning level of economic development in the East has attracted a large number of floating populations, which are included in the resident urban population. However, the stricter restrictions on purchases of them has curbed the housing consumption of the floating population and reduced the role of urbanization rate in promoting housing consumption. Therefore, the positive impact of urbanization on housing consumption is significant in the Central and West, not in the East. Moreover, the negative impact of educational level on housing consumption is greater in the Central and West, followed by the East. This is mainly because education expenditures crowd out housing

TABLE 6: Robustness test: 4 trillion investment plans in 2008.

Variable	Nationwide		East		Central		West	
	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4	Model 3	Model 4
lnINCO	1.2330*** (3.84)	1.2284*** (3.80)	0.8099* (1.89)	0.8305* (1.95)	1.2705* (2.15)	1.3056* (2.14)	0.3189 (0.64)	0.2666 (0.54)
lnDEPO	-0.0755 (-0.22)	-0.1125 (-0.33)	-0.0412 (-0.11)	-0.0952 (-0.25)	0.1404 (0.19)	-0.0427 (-0.06)	0.6536 (1.47)	0.6293 (1.44)
lnHCA	0.0682*** (5.39)	0.0688*** (5.40)	0.0344* (1.79)	0.0347* (1.77)	0.0521** (3.38)	0.0519** (3.50)	0.0843*** (3.10)	0.0853*** (3.13)
lnPOPU	-0.9261* (-1.78)	-0.9953* (-1.89)	-1.0826 (-1.05)	-1.0716 (-1.04)	-3.8925* (-2.35)	-3.7550* (-2.36)	-1.4655 (-1.51)	-1.5040 (-1.56)
URBA	2.7319*** (3.81)	3.0310*** (4.15)	1.6826 (1.57)	1.9710 (1.80)	5.5869*** (3.76)	5.6508*** (3.90)	4.7940** (2.74)	5.1952** (2.93)
CDR	-10.5594*** (-3.42)	-10.5101*** (-3.36)	-23.5904*** (-5.72)	-23.5732*** (-5.69)	-5.7983 (-0.73)	-7.5467 (-0.96)	-6.7572 (-1.76)	-6.6478 (-1.76)
ODR	11.4679 (1.12)	11.5835 (1.13)	12.5077 (0.87)	12.4564 (0.87)	21.1717 (1.26)	18.1994 (1.12)	31.5801*** (3.47)	31.2946*** (3.44)
FS	-0.1427 (-1.19)	-0.1687 (-1.34)	-0.0362 (-0.19)	-0.0651 (-0.33)	-0.6546*** (-5.17)	-0.7275*** (-4.69)	-0.1598 (-1.34)	-0.1795 (-1.46)
EDU	-6.2861*** (-5.91)	-5.7735*** (-5.24)	-4.2519* (-2.08)	-4.0562* (-1.91)	-6.3469* (-1.96)	-5.0787 (-1.59)	-7.9119*** (-6.17)	-7.0470*** (-5.40)
lnDEPO_ODR	-1.0201 (-0.90)	-1.0764 (-0.94)	-1.0410 (-0.58)	-1.0631 (-0.59)	-2.5833 (-1.21)	-2.2818 (-1.712)	-3.3660*** (-3.54)	-3.4093*** (-3.59)
lnDEPO_CDR	0.9831*** (2.84)	1.0132*** (2.88)	2.2712*** (5.30)	2.2943*** (5.26)	0.7503 (0.79)	1.0162 (1.08)	0.5172 (0.92)	0.5515 (1.00)
Stimulus policy		0.1523*** (5.28)		0.1105* (1.89)		0.1588*** (3.62)		0.1821*** (4.64)
Constant	3.1870 (0.77)	3.9465 (0.94)	8.7775 (1.06)	8.8353 (1.06)	27.1147 (1.88)	27.2106* (1.94)	8.8187 (1.39)	9.5831 (1.51)
Hausman	0.0000	0.0000	0.0000	0.0000	0.0006	0.0214	0.0000	0.0000
R ²	0.9132	0.9146	0.8946	0.8956	0.9563	0.9575	0.9249	0.9266
Sample size	589	589	209	209	152	152	228	228

Note. ***, **, and * indicate significance at the 1%, 5%, and 10%. Numbers in parentheses are *T* statistics. Hausman stands for Hausman test *p* value.

TABLE 7: Impact of demographics on housing consumption in different regions of China.

Variable	East	Central	West
URBA	/	+	+
EDU	-	--	--
CDR	-	/	/
DEPO_CDR	+	/	/
ODR	/	/	+
DEPO_ODR	/	/	-

Note. + indicates the positive impact on housing demand; / indicates the impact is not significant; - indicates the negative impact; -- means a deeper negative impact.

consumption. And in China, the difference in education expenditure is small, so the East with higher income has less impact.

Besides, inspired by Green and Hendershottb [14], this paper introduces the interaction items between age structure and deposit to analyze the partial effects of age structure. Results show that in the East, although the overall impact of CDR on housing consumption is negative at present, it can positively affect housing consumption through deposit. As CDR increases, increased support costs will crowd out housing consumption, but the household's demand for housing space increases at the same time. When deposit

reaches a high level, the housing demand of newborns will be released. In the East, if the deposit reaches 3242.73 billion yuan, CDR will affect housing consumption positively. Likewise, the interaction item between ODR and deposit has a significant negative impact on housing consumption in the West. Older people's support for their children's house purchases can increase housing consumption [39], but their preference for pension savings may weaken this help. When the deposit in the West exceeds 1187.38 billion yuan, the overall impact of ODR on housing consumption will become negative.

Using the 4 trillion investment plan in 2008 to conduct a robustness test, the results not only prove the robustness of the model but also confirm the feasibility of adjusting housing consumption through policies. At present, the growth rate of housing consumption in China is slowing down. For Chinese policymakers, it is a good choice to adjust the real estate market according to the trends of demographic structures, so as to realize housing consumption and maintain the stable development of real estate market. According to the findings of this article, we can draw some interesting policy implications: (i) nationally, further liberalization of free education or an improvement in the quality of public education may reduce the education expenditure of households, thereby releasing housing consumption; (ii) adjusting household deposit by changing bank

interest rates can alleviate the impact of changes in the age structure on the housing market; (iii) the harsh household registration system in the past severely restricted the housing demand of floating population, and liberalizing the household registration system gradually may help translate housing demand into housing consumption, especially in eastern China.

Data Availability

The data used in this paper were mainly derived from the China Statistical Yearbook and the People's Bank of China, which can be found at <http://www.stats.gov.cn/english/Statisticaldata/AnnualData/> and <http://www.pbc.gov.cn/en/3688006/index.html>, respectively.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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