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The Impact of Aging on Urban Housing Demand Based on CGE

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Abstract. The population of China has been aging quickly in recent years, which will profoundly affect the housing market. This paper aims to analyze the effect of aging on urban housing demand. First, a general equilibrium model with an overlapping generation structure is established to analyze theoretically the effect of aging. Then, this paper uses GAMS software to simulate and forecast the change trend in urban housing demand. Finally, based on the research sample of 287 large and medium-sized cities in China in 2010, this paper uses ArcGis9.3 software to study empirically the influence of aging on urban housing demand and concludes that aging can increase urban housing demand.

1. Introduction

According to the demographic dictionary for population, which is compiled by the United Nations International Society, when the proportion of population aged 60 and over is greater than 10% or the proportion of people aged 65 and over is greater than 7% in a country or a region, it is considered an aging country or region. According to the fifth census at the end of November 2000, the population over 60 years old has reached 130 million, which accounts for 10.2% of the total population, and the number of people aged 65 and above have reached 88.11 million, which accounts for 6.96% of the total population. Therefore, our country has become an aging society. Housing demand is the demand for residential space and public services provided by residential locations (Zheng Siqi etc., 2012) [1]. It is the most important consumption demand by residents. Because housing supply generally lacks flexibility in large and medium cities (Glaeser, 2005) [2], the change in housing demand is the dominant factor determining the trend of the residential market. It also significantly affects the macro-economy (Iacoviello, 2005; Davis, 2005; Tsai, 2013; Chen and Jin, 2014) [3–6]. In addition, housing sales in large and medium cities account for a large proportion of the national housing market and have an important effect on the development of the national housing market and on macroeconomic fluctuation. Because aging is directly related to the change in demanders in the housing market, aging also has extensive and far-reaching influence on the housing market (Lu and Shih, 2013) [7]. The CGE model is often used to simulate the effectiveness of a policy, such as trade policy, tax policy, income distribution policy, population policy, tariffs policy, import and export policy, and so on. The CGE model is built according to economic transactions among different economic subjects. It is a helpful tool to analyze the effect of a tiny adjustment in a section of the macro-economy.

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2. Literature Review

Housing demand is directly derived from residential consumption demand and investment demand, and it is influenced by demographic factors. At present, most domestic and foreign scholars have recognized that aging will affect the housing market (Lu and Shih, 2013; Li and Shen, 2013) [8]. Mankiw and Weil (1989) believe that people's housing demand through the life cycle presents a "hump" tendency. Housing demand is quite low before the age of 20 and then increases rapidly, reaching its peak at between 20 and 30 years of age; finally, it begins to decline after the age of 40 [9]. Hamilton (1991), Hendershott (1991), Holland (1991) and Swan (1995) believe that income level and change in wealth also affect the housing market [10–13]. Thus, scholars have studied the effect of aging on housing demand and housing prices, and they find that aging will indeed lead to the decline of housing demand and housing prices. However, some control variables such as economic growth and urbanization have the opposite effects with respect to aging; thus, the negative effect of aging on housing demand and housing prices is not apparent in the short term, in comparison to its long-term effect. Some scholars abroad have tried to use a computable general equilibrium model to study the effect of demographic factors on the real estate industry. Luk (1993) used CGE models to study the effect of changes in housing prices, urban population density and land rent on the real estate market and the macro-economy [14]. Kim (2003) employed South Korea as a research object to construct a computable general equilibrium model and study the effect of the change in real estate supply on the growth of regional economic and income distribution [15].

At present, most domestic scholars use the CGE model to study the effect of the real estate tax, demand and supply on the real estate market; however, no one has used this model to study the effect of aging on the Chinese real estate market. In addition, domestic scholars have not reached an agreement on the study of how the aging process affects housing demand. Some people think that declining population and the negative economic effect of aging on the housing market will cause urban housing demand to decrease sharply, leading to a large surplus of housing in our country. Chen Binkai (2012) shows that aging will cause China's housing demand to present negative. growth after 2013 [16]. Mao Yushi (2012) argues that with the intensification of aging, the "4-2-1" family pattern which has resulted from family planning policy will lead to every young family inheriting 4 houses in the future, which may result in a large number of housing surpluses in our country [17]. Gan Li et al. (2013) argue that urban families' housing shortfall in China is 24.13 million and that the current production capacity will satisfy the existing rigid demand in less than two years. In the long term, new supply largely meets the new demand for housing, whereas new demand only accounts for 1/3 of the current production capability; therefore, a decline in housing prices is inevitable [18].

Another view is that although our country has already become an aging society, factors such as rapid development of the economy, rapid urbanization and the miniaturization of family size will cause the number of China's housing demanders to remain at a highlevel for a long time; thus, urban housing demand may not fall due to the aging process. Yang Hongxu (2013) argues that if the urbanization rate increased by 0.8 every year, China's annual urban housing demand would remain at approximately $245 million in 2015-2027; therefore, urban housing demand in the next 15 years will continue to be strong [19]. Chen Yanbin and Chen xiaoliang (2013) believe that aging will not lead to a large surplus in China's urban housing in the short or medium term; urbanization and the miniaturization of family size will not reveal the negative effect of aging on urban housing until 2045 [20].

3. Research on the Influence Mechanism

Research on the theory mechanism of the change in urban housing demand caused by the aging process aims to identify the key factors that influence urban housing demand, clarify the theory mechanism of the change in housing demand, and construct a computable general equilibrium model to provide a theoretical framework for empirical analysis and advancing policies. Residential demand changes include the change in demand, in demand structure and in the housing consumption behavior of residents. Residents' housing consumption decisions indicate whether they own houses (rent-purchase choice) and make decisions concerning housing consumption and housing types. It is the microcosmic basis of deciding residential demand amount and demand structure. Residents' housing consumption behavior depends on the residents' housing consumption preferences and budget constraints. Therefore, following bottom-up analysis logic, this chapter summarizes the internal and external factors that influence housing demand in the aging process in the context of three aspects: housing consumption preference, budget constraints and other institutional and policy factors. Then, this paper analyzes the mechanism of action of these factors.

In terms of housing consumption preference, residential characteristics and household characteristics are the main factors influencing residents' housing consumption preferences. Residential characteristics include building location, regional characteristics, neighborhood characteristics, functional characteristics, and so on. Household characteristics consist of personality characteristics, age, gender, family structure, social interaction and so on.

In addition to the individual behavior preference, housing demand largely depends on the ability to pay, that is, a budget constraint. In addition, financing ability and housing costs are the two main factors influencing the residents' budget constraint. Financing ability includes, for example, income and savings, credit, intergenerational transfer and raising burden. In terms of housing costs such as housing prices, interest rates and taxes, housing prices influence housing demand largely through risk and arbitrage effects; the increase of price volatility risk can decrease housing demand, and arbitrage motivation can increase housing demand. The raising of credit interest rates and tax costs will decrease housing demand. Other factors consist of economic growth, price expectations, urbanization and other related policies including credit policy, affordable housing policy and restrictions. These factors affect the budget constraint through housing prices, interest rates, taxes and so on. In addition, house price expectations affect the residents' housing consumption decisions through a risk effect and a capital gains effect. A risk effect causes people to postpone or stop purchasing houses, whereas a capital gains effect causes people to focus on potential investment income. Urbanization, which influences economic growth, also has significant effects on housing demand.

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These institutional factors and policies combine with economic growth, price expectations and urbanization to affect residents' housing consumption behavior and bring about changes in housing demand. At the same time, housing demand also affects housing characteristics and housing costs. The mechanism is shown in figure 1.

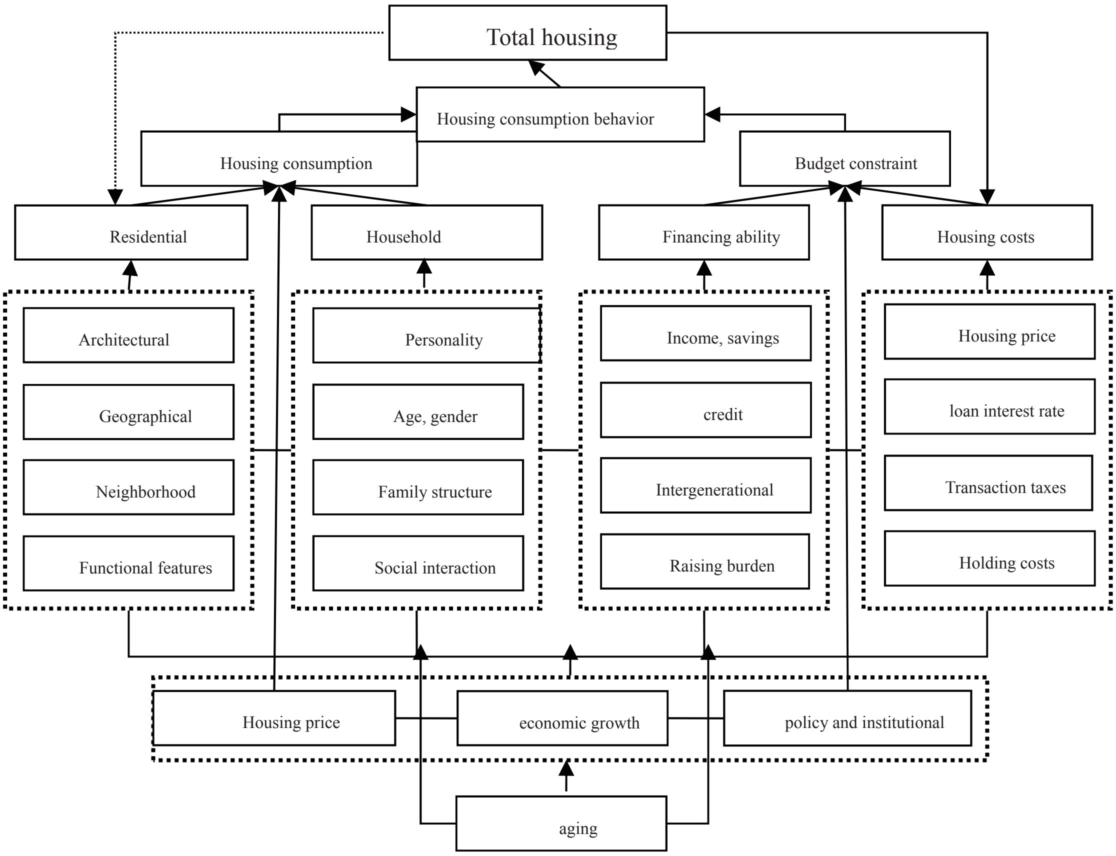

Figure 1: The mechanism of aging on urban housing demand in China

4. Constructing a Theoretical Model

4.1. Overlapping-generations model

The overlapping-generations model was described by Samuelson (1958). Diamond (1965) then improved it to be a classic inter-temporal dynamic model. This model fully considers the differences of each economic object and divides people into different age groups. Therefore, economic activities not only appear among the people in the same generation but also among those in different generations [21].

Combining the connotations and characteristics of aging, this paper fully considers the mechanism of aging on urban housing demand. The paper assumes the following: 1) there are 12 generations alive in each period. 2) Each generation has 12 survival periods and each period has 5 years. 3) In each period, the oldest generation dies and the new generation is born. 4) The age of new labor is 20, the retirement age is 60, and people live no longer than 79 years.

The life cycle is divided into three periods: the young, middle-aged people and the old. The 1st-4th generations are the young, the 5th-8th generations are middle-aged people, and the 9th-12th generations are the old.

(1) Young people use their labor income and housing funds from middle-aged people to purchase houses.

(2) The elderly use savings and interest to purchase goods, give middle-aged people their houses and spend all of their money before death.

(3) People in different generations have their own savings and consumption characteristics, which affect urban housing demand.

In addition to age, the main differences among each generation include ability to work, income, consumption and savings. Furthermore, the market is perfectly competitive, consumers are rational and they consider utility maximization the target (as shown in figure 2).

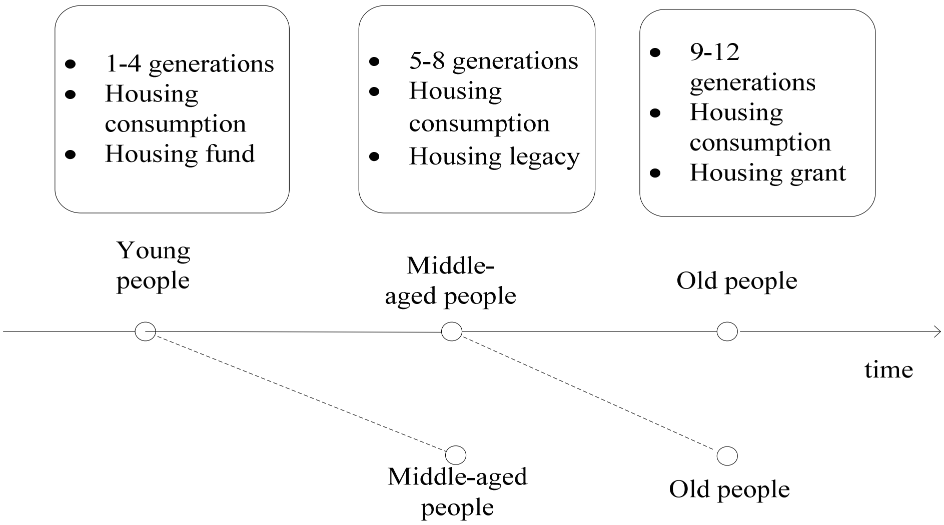

Figure 2: Overlapping-generations model structure

4.2. *Computable general equilibrium*

As a powerful tool for policy simulation, the Computable General Equilibrium model has been widely used worldwide after 30 years of development [22]. The CGE model is often used to analyze the effect of policy changes, technology changes and environmental changes on a country's or region's (domestic or international) welfare, industrial structure, labor market, environmental conditions and income distribution. The CGE model builds quantitative relationships among all of the components of an economy, enabling us to study the effect of a disturbance in one part of the economy on another. The input and output model emphasizes the connection or associated effect of industry. However, the CGE model relates all sectors of the economy and industries within the overall economic constraints, so it goes beyond the functions of a simple input-output model. These constraints include constraints on the size of the government budget deficit, on the trade deficit, on labor, capital and land, on the environment, and so on.

In this paper, the CGE model is divided into four modules: production, trading, institutions and system. The production module includes production functions and demand and output functions, which are derived from profit maximization. The institutions module describes the economic activities of resident, enterprise, government and foreign sectors. System modules include, for example, balance of supply and demand of the elements market and product market, balance of financial revenues and expenditures and balance of international payments.

The model in this paper describes an open economic system in which the market is a perfectly competitive market, companies pursue profit maximization, and consumers are rational and pursue utility maximization (as shown in figure 3).

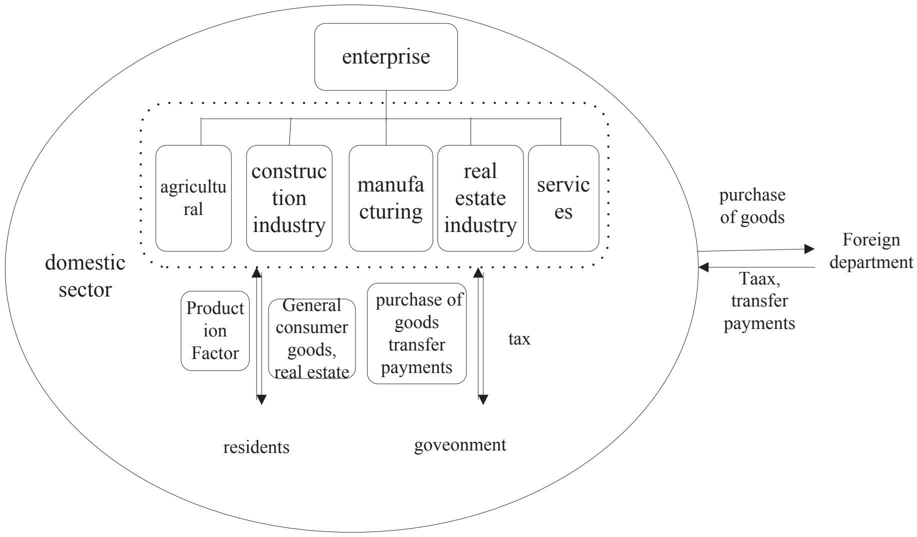

Figure 3: General equilibrium model of open economy

(1) Trading module

In an open economy, all of the commodities that are produced by China domestically Y_t^a can be divided into two parts. One part is produced and consumed in the domestic market, whereas the other part is produced in the domestic market and consumed in the foreign market. The former part is named OD_t^a; the latter part is named OE_t^a. The distribution of the two parts depends on the relative levels of domestic prices and international prices, and the relationship between them is similar to a production possibilities frontier. That relationship is generally described with the CET function: $Y_t^a = \partial_a^p[\delta_a^p QD_t^{a\rho_a^p} + (1-\delta_a^p)QE_t^{a\rho_a^p}]^{\frac{1}{\rho_a^p}}$, $\rho_a^p > 1$. The enterprise will choose a combination of QD_t^a and QE_t^a to achieve income maximization. The optimal combination satisfies the first-order condition: $\frac{PD_t^a}{PE_t^a} = \frac{\delta_a^p}{1-\delta_a^p}(\frac{QE_t^a}{QA_t^a})^{1-\rho_a^p}$. Similarly, the commodities in the domestic market (QS_t^c) include imports (QM_t^c) and the commodities which are produced and consumed in the domestic market (QD_t^c, $QD_t^c = QD_t^a$). The CES function is used to describe the relationship between them: $QS_t^c = \partial_c^q[\delta_c^q QD_t^{c\rho_c^q} + (1-\delta_c^q)QM_t^{c\rho_c^q}]^{\frac{1}{\rho_c^q}}$, $0 < \rho_c^q < 1$. To maximize utility, residents determine the consumption of import commodities and export commodities by their relative prices. The optimal allocation is determined by the first-order condition: $\frac{PD_t^c}{PM_t^c} = \frac{\delta_c^q}{1-\delta_c^q}(\frac{QM_t^c}{QD_t^c})^{1-\rho_c^q}$. In addition, the price of domestic product (PD_t^a) is considered the benchmark price: $PD_t^a = 1$. The price of products produced and consumed domestically is $PD_t^c = PD_t^a$. The weighted price of products in the domestic market is $PQ_t^c = PD_t^a \cdot \frac{QD_t^a}{QS_t^c} + PM_t^c \cdot \frac{QM_t^c}{QS_t^c}$. The price of products produced domestically is $PA_t^a = PD_t^a \cdot \frac{QD_t^a}{Y_t^a} + PE_t^a \cdot \frac{QE_t^a}{Y_t^a}$.

(2) Production module

The production module includes intermediate input ($QINT_t^a$), land (R_t^a), capital except land (K_t^a) and labor (L_t^a). A three-layer CES production function is used to describe production activities.

1) Agriculture sector

Assume that R_t^1 represents land capital, K_t^1 represents capital except land, L_t^1 represents labor, and Y_t^1 represents total output. The highest layer of nested function includes the added value (VA_t^1) and intermediate input ($QINT_t^1$) : $Y_t^1 = \partial_1^a[\delta_1^a VA_t^{1\rho_1^a} + (1-\delta_1^a)QINT_t^{1\rho_1^a}]^{\frac{1}{\rho_1^a}}$. Its first-order condition of cost minimization is $\frac{PVA_t^1}{PINT_t^1} = \frac{\delta_1^a}{1-\delta_1^a} \cdot (\frac{QINT_t^1}{VA_t^1})^{1-\rho_1^a}$. PVA_t^1 and $PINT_t^1$ are the weighted prices of added value and intermediate input, respectively, and satisfy the price relationship equations: $PA_t^1 \cdot Y_t^1 = PVA_t^1 \cdot VA_t^1 + PINT_t^1 \cdot QINT_t^1$.

The second floor of the nested function is the inputs of the added value, such as labor (L_t^1), capital (C_t^1)

and the intermediate input of each sector. The former is represented by the CES function, whereas the latter is represented by the Leontief function. The added value is $VA_t^1 = \partial_1^v[\delta_1^v C_t^{1^{\rho_1^f}} + (1-\delta_1^v)L_t^{1^{\rho_1^f}}]^{\frac{1}{\rho_1^f}}$, $0 < \rho_1^f < 1$. The first-order condition of cost minimization is $\frac{w_t^1}{\mu_t^1} = \frac{\delta_1^v}{1-\delta_1^v} \cdot (\frac{C_t^1}{L_t^1})^{1-\rho_1^f}$. w_t^1 and μ_t^1 represent labor and capital, respectively, and they meet the relationship equation: $VA_t^1 = w_t^1 \cdot L_t^1 + C_t^1 \cdot \mu_t^1$.

Intermediate input includes intermediate input of all sections. The production function of intermediate input is decided by Leontief direct consumption coefficients $(ia_1^1, ia_1^2, ia_1^3, ia_1^4, ia_1^5)$: $QINT_t^1 = ia_1^1 \cdot QINT_{t1}^1 + ia_1^2 \cdot QINT_{t1}^2 + ia_1^3 \cdot QINT_{t1}^3 + ia_1^4 \cdot QINT_{t1}^4 + ia_1^5 \cdot QINT_{t1}^5$. The price relationship equation is

$$PINT_t^1 \cdot QINT_t^1 = PD_t^1 \cdot QINT_{t1}^1 + PD_t^2 \cdot QINT_{t1}^2 + PD_t^3 \cdot QINT_{t1}^3 + PD_t^4 \cdot QINT_{t1}^4 + PD_t^5 \cdot QINT_{t1}^5.$$

The third layer of nested function describes capital, which includes land capital (R_t^1) and the capital except land (K_t^1). The relationship of these factors can be described as $C_t^1 = \partial_1^k[\delta_1^k k_t^{1^{\rho_1^k}} + (1-\delta_1^k)R_t^{1^{\rho_1^k}}]^{\frac{1}{\rho_1^k}}$, $0 < \rho_1^k < 1$; the first-order condition of cost minimization is $\frac{r_t^1}{\tau_t^1} = \frac{\delta_1^k}{1-\delta_1^k} \cdot (\frac{R_t^1}{K_t^1})^{1-\rho_1^k}$. r_t is return on capital, and τ_t is land yield. The first-order condition of profit maximization is described by the price relationship equation $w_t^1 L_t^1 + r_t^1 K_t^1 + \tau_t^1 R_t^1 = PA_t^1 \cdot Y_t^1$.

2) Construction sector

Assume that K_t^2 represents capital except land, L_t^2 represents labor, and Y_t^2 represents total output. The highest layer of nested function includes the added value (VA_t^2) and intermediate input, $(QINT_t^2) Y_t^2 = \partial_2^a[\delta_2^a VA_t^{2^{\rho_2^a}} + (1-\delta_2^a)QINT_t^{2^{\rho_2^a}}]^{\frac{1}{\rho_2^a}}$. Its first-order condition of cost minimization is $\frac{PVA_t^2}{PINT_t^2} = \frac{\delta_2^a}{1-\delta_2^a} \cdot (\frac{QINT_t^2}{VA_t^2})^{1-\rho_2^a}$. PVA_t^2 and $PINT_t^2$ are the weighted prices of added value and intermediate input, respectively, and satisfy the price relationship equations: $PA_t^2 \cdot Y_t^2 = PVA_t^2 \cdot VA_t^2 + PINT_t^2 \cdot QINT_t^2$.

The second floor of the nested function is the inputs of the added value, such as labor (L_t^2) and capital except land (K_t^2) and the intermediate input of each sector. The former is represented by the CES function, whereas the latter is represented by the Leontief function. The added value is $VA_t^2 = \partial_2^v[\delta_2^v K_t^{2^{\rho_2^f}} + (1-\delta_2^v)L_t^{2^{\rho_2^f}}]^{\frac{1}{\rho_2^f}}$, $0 < \rho_2^f < 1$. The first-order condition of cost minimization is $\frac{w_t^2}{r_t^2} = \frac{\delta_2^v}{1-\delta_2^v} \cdot (\frac{K_t^2}{L_t^2})^{1-\rho_2^f}$. w_t^2 and r_t^2 represent the price of labor and capital, respectively, and satisfy the relationship equation: $PVA_t^2 \cdot VA_t^2 = w_t^2 \cdot L_t^2 + K_t^2 \cdot r_t^2$. Intermediate input includes intermediate input of all sections. The production function of intermediate input is decided by Leontief direct consumption coefficients: $(ia_2^1, ia_2^2, ia_2^3, ia_2^4, ia_2^5) : QINT_t^2 = ia_2^1 \cdot QINT_{t2}^1 + ia_2^2 \cdot QINT_{t2}^2 + ia_2^3 \cdot QINT_{t2}^3 + ia_2^4 \cdot QINT_{t2}^4 + ia_2^5 \cdot QINT_{t2}^5$. The price relationship equation is $PINT_t^2 \cdot QINT_t^2 = PA_t^1 \cdot QINT_{t2}^1 + PA_t^2 \cdot QINT_{t2}^2 + PA_t^3 \cdot QINT_{t2}^3 + PA_t^4 \cdot QINT_{t2}^4 + PA_t^5 \cdot QINT_{t2}^5$. The first-order condition of profit maximization is $w_t^2 L_t^2 + r_t^2 K_t^2 = PA_t^2 \cdot Y_t^2$.

3) Manufacturing sector

Assume that K_t^3 represents capital except land, L_t^3 represents labor, and Y_t^3 represents total output. The highest layer of nested function includes the added value (VA_t^3) and intermediate input $(QINT_t^3) Y_t^3 = \partial_3^a[\delta_3^a VA_t^{3^{\rho_3^a}} + (1-\delta_3^a)QINT_t^{3^{\rho_3^a}}]^{\frac{1}{\rho_3^a}}$. Its first-order condition of cost minimization is $\frac{PVA_t^3}{PINT_t^3} = \frac{\delta_3^a}{1-\delta_3^a} \cdot (\frac{QINT_t^3}{VA_t^3})^{1-\rho_3^a}$. PVA_t^3 and $PINT_t^3$ are the weighted prices of added value and intermediate input, respectively, and satisfy the price relationship equations: $PA_t^3 \cdot Y_t^3 = PVA_t^3 \cdot VA_t^3 + PINT_t^3 \cdot QINT_t^3$.

The second floor of the nested function is the inputs of the added value, such as labor (L_t^3) and capital except land (K_t^3) and the intermediate input of each sector. The former is represented by the CES function, whereas the latter is represented by the Leontief function. The added-value part is $VA_t^3 = \partial_3^v[\delta_3^v K_t^{3^{\rho_3^f}} + (1-\delta_3^v)L_t^{3^{\rho_3^f}}]^{\frac{1}{\rho_3^f}}$, $0 < \rho_3^f < 1$. The first-order condition of cost minimization is $\frac{w_t^3}{r_t^3} = \frac{\delta_3^v}{1-\delta_3^v} \cdot (\frac{K_t^3}{L_t^3})^{1-\rho_3^f}$. w_t^3 and r_t^3 represent the price of labor and capital, respectively, and satisfy the relationship equation: $PVA_t^3 \cdot VA_t^3 = w_t^3 \cdot L_t^3 + K_t^3 \cdot r_t^3$. Intermediate input includes the intermediate input of all sections. The production function of intermediate input is decided by Leontief direct consumption coefficients $(ia_3^1, ia_3^2, ia_3^3, ia_3^4, ia_3^5)$:

$QINT_t^3 = ia_3^1 \cdot QINT_{t3}^1 + ia_3^2 \cdot QINT_{t3}^2 + ia_3^3 \cdot QINT_{t3}^3 + ia_3^4 \cdot QINT_{t3}^4 + ia_3^5 \cdot QINT_{t3}^5$. The price relationship equation is $PINT_t^3 \cdot QINT_t^3 = PA_t^1 \cdot QINT_{t3}^1 + PA_t^2 \cdot QINT_{t3}^2 + PA_t^3 \cdot QINT_{t3}^3 + PA_t^4 \cdot QINT_{t3}^4 + PA_t^5 \cdot QINT_{t3}^5$. The first-order condition of profit maximization is $w_t^3 L_t^3 + r_t^3 K_t^3 = PA_t^3 \cdot Y_t^3$.

4) Real estate sector

Assume that K_t^4 represents capital except land, L_t^4 represents labor, and Y_t^4 represents total output. The highest layer of nested function includes the added value (VA_t^4) and intermediate input ($QINT_t^4$) : $Y_t^4 = \partial_4^a[\delta_4^a VA_t^{4\rho_4^a} + (1-\delta_4^a) QINT_t^{4\rho_4^a}]^{\frac{1}{\rho_4^a}}$. Its first-order condition of cost minimization is $\frac{PVA_t^4}{PINT_t^4} = \frac{\delta_4^a}{1-\delta_4^a} \cdot (\frac{QINT_t^4}{VA_t^4})^{1-\rho_4^a}$. PVA_t^4 and $PINT_t^4$ are the weighted prices of added value and intermediate input, respectively, and satisfy the price relationship equations: $\frac{PVA_t^4}{PINT_t^4} = \frac{\delta_4^a}{1-\delta_4^a} \cdot (\frac{QINT_t^4}{VA_t^4})^{1-\rho_4^a}$.

The second floor of the nested function is the inputs of the added value, such as labor (L_t^4) and capital except land (K_t^4) and the intermediate input of each sector. The former is represented by the CES function, whereas the latter is represented by the Leontief function. The added value is $VA_t^4 = \partial_4^v[\delta_4^v K_t^{4\rho_4^f} + (1-\delta_4^v) L_t^{4\rho_4^f}]^{\frac{1}{\rho_4^f}}$, $0 < \rho_4^f < 1$. The first-order condition of cost minimization is $\frac{w_t^4}{r_t^4} = \frac{\delta_4^v}{1-\delta_4^v} \cdot (\frac{K_t^4}{L_t^4})^{1-\rho_4^f}$. w_t^4 and r_t^4 represent the prices of labor and capital, respectively, and satisfy the relationship equation: $PVA_t^4 \cdot VA_t^4 = w_t^4 \cdot L_t^4 + K_t^4 \cdot r_t^4$. Intermediate input includes intermediate input of all sections. The production function of intermediate input is decided by Leontief direct consumption coefficients ($ia_4^1, ia_4^2, ia_4^3, ia_4^4, ia_4^5$): $QINT_t^4 = ia_4^1 \cdot QINT_{t4}^1 + ia_4^2 \cdot QINT_{t4}^2 + ia_4^3 \cdot QINT_{t4}^3 + ia_4^4 \cdot QINT_{t4}^4 + ia_4^5 \cdot QINT_{t4}^5$. The price relationship equation is $PINT_t^4 \cdot QINT_t^4 = PA_t^1 \cdot QINT_{t4}^1 + PA_t^2 \cdot QINT_{t4}^2 + PA_t^3 \cdot QINT_{t4}^3 + PA_t^4 \cdot QINT_{t4}^4 + PA_t^5 \cdot QINT_{t4}^5$. The first-order condition of profit maximization is $w_t^4 L_t^4 + r_t^4 K_t^4 = PA_t^4 \cdot Y_t^4$.

5) Service sector

Assume that K_t^5 represents capital except land, L_t^5 represents labor, and Y_t^5 represents total output. The highest layer of nested function includes the added value (VA_t^5) and intermediate input ($QINT_t^5$)$Y_t^5 = \partial_5^a[\delta_5^a VA_t^{5\rho_5^a} + (1-\delta_5^a) QINT_t^{5\rho_5^a}]^{\frac{1}{\rho_5^a}}$. Its first-order condition of cost minimization is $\frac{PVA_t^5}{PINT_t^5} = \frac{\delta_5^a}{1-\delta_5^a} \cdot (\frac{QINT_t^5}{VA_t^5})^{1-\rho_5^a}$. PVA_t^5 and $PINT_t^5$ are the weighted prices of added value and intermediate input, respectively, and satisfy the price relationship equations: $PA_t^5 \cdot Y_t^5 = PVA_t^5 \cdot VA_t^5 + PINT_t^5 \cdot QINT_t^5$.

The second floor of the nested function is the inputs of the added value, such as labor (L_t^5) and capital except land (K_t^5) and the intermediate input of each sector. The former is represented by the CES function, whereas the latter is represented by the Leontief function. The added value is $VA_t^5 = \partial_5^v[\delta_5^v K_t^{5\rho_5^f} + (1-\delta_5^v) L_t^{5\rho_5^f}]^{\frac{1}{\rho_5^f}}$, $0 < \rho_5^f < 1$. The first-order condition of cost minimization is $\frac{w_t^5}{r_t^5} = \frac{\delta_5^v}{1-\delta_5^v} \cdot (\frac{K_t^5}{L_t^5})^{1-\rho_5^f}$. w_t^5 and r_t^5 represent the prices of labor and capital, respectively, and satisfy the relationship equation: $PVA_t^5 \cdot VA_t^5 = w_t^5 \cdot L_t^5 + K_t^5 \cdot r_t^5$. Intermediate input includes intermediate input of all sections; the production function of intermediate input is decided by Leontief direct consumption coefficients ($ia_5^1, ia_5^2, ia_5^3, ia_5^4, ia_5^5$): $QINT_t^5 = ia_5^1 \cdot QINT_{t5}^1 + ia_5^2 \cdot QINT_{t5}^2 + ia_5^3 \cdot QINT_{t5}^3 + ia_5^4 \cdot QINT_{t5}^4 + ia_5^5 \cdot QINT_{t5}^5$. The price relationship equation is $PINT_t^5 \cdot QINT_t^5 = PA_t^1 \cdot QINT_{t5}^1 + PA_t^2 \cdot QINT_{t5}^2 + PA_t^3 \cdot QINT_{t5}^3 + PA_t^4 \cdot QINT_{t5}^4 + PA_t^5 \cdot QINT_{t5}^5$. The first-order condition of profit maximization is $w_t^5 L_t^5 + r_t^5 K_t^5 = PA_t^5 \cdot Y_t^5$.

(4) institutions module

1) residents module

A. Decision model of the young

Assume that $C_{t,1}$ and $h_{t,1}$ represent how much young consumers spend on general consumer goods and housing at time t. $HF_{t,1}$ represents the housing fund of the young that comes from middle-aged people. This paper uses a constant elasticity of substitution utility function: $U_1 = \frac{1}{1-\theta} C_{t,1}^{1-\theta}$, $\theta > 0$. The largest consumer decision-making equation is established under the budget constraint:Max: $U_1 = \frac{1}{1-\theta} C_{t,1}^{1-\theta} h_{t,1}^{\theta}$

s.t.$C_{t,1} + h_{t,1} + s_{t,1} W_t L_{t,1} + ti_h W_t L_{t,1} + \mu h_{t,1} = W_t L_{t,1} + \varphi_{1,t}\varphi_{2,t} HF_{t,1}, HF_{t,1} = \varepsilon W_t L_{t,2}$. ε represents the housing fund rate.

To make the age structure consistent with the actual situation of our country, this model assumes that the size of the first generation population is 1 and that the fertility rate of generation g in period t is $\varphi_{g,t}(0 < \varphi_{1,t} < \varphi_{2,t} < \varphi_{g,t} < \varphi_{i,t} < \cdots)$. Therefore, the size of the second generation is $\varphi_{1,t}$, and the size of the third generation is $\varphi_{1,t}\varphi_{2,t}$. t and μ represent personal income tax rate and the property tax rate, respectively. This paper defines two equations: $C_{t,1} = \frac{1-\theta}{1+\mu\theta} \cdot (W_t L_{t,1} + \varphi_{1,t}\varphi_{2,t}HF_{t,1} - s_{t,1}W_t L_{t,1} - ti_h W_t L_{t,1})$ and $h_{t,1} = \frac{\theta}{1+\mu\theta}(W_t L_{t,1} + \varphi_{1,t}\varphi_{2,t}HF_{t,1} - s_{t,1}W_t L_{t,1} - ti_h W_t L_{t,1})$.

B. Decision model of middle-aged people

Assume that $C_{t,2}$ and $h^{\theta}_{t,2}$ represent the average consumer goods consumption and housing consumption of middle-aged people at time t. $HL_{t,2}$ represents the housing legacy of middle-aged people that comes from old people. This paper uses a "constant elasticity of substitution" utility function: $U_2 = \frac{1}{1+\rho}(\frac{1}{1-\theta}C^{1-\theta}_{t,2}h^{\theta}_{t,2} + HL_{t,2})$. The maximum consumption decision equations are established under the budget constraint: Max: $U_2 = \frac{1}{1+\rho}(\frac{1}{1-\theta}C^{1-\theta}_{t,2}h^{\theta}_{t,2} + HL_{t,2})$

s. t. $C_{t,2} + h_{t,2} + \varphi_{1,t}\varphi_{2,t}HF_{t,1} + s_{t,2}W_t L_{t,1} + ti_h W_t L_{t,2} + \mu h_{t,2} = W_t L_{t,2} + (1+r)s_{t-1,1}W_{t-1}L_{t-1,1} + HL_{t,2}$

$HL_{t,2} = \Re_1 + \Re_2(h_{t,1} + h_{t,2} + h_{t,3} + \varphi_{1,t}\varphi_{2,t}HF_{t,1})$

$HL_{t,2}$ represents the property value of housing legacy that comes from old people. $\Re_1$ and $\Re_2$ represent the degree of the housing bequest motive; when $\Re_2 = 0$, there is no bequest motive [32]. Then, the nonlinear equations under the first-order condition can be described as

$$C_{t,2} = \frac{1-\theta}{1+\mu\theta}[W_t L_{t,2} + (1+r)s_{t-1,1}W_{t-1}L_{t-1,1} + HL_{t,2} - \varphi_{1,t}\varphi_{2,t}HF_{t,1} - s_{t,2}W_t L_{t,1} - ti_h W_t L_{t,2}] \text{ and}$$

$$h_{t,2} = \frac{\theta}{1+\mu\theta}[W_t L_{t,2} + (1+r)s_{t-1,1}W_{t-1}L_{t-1,1} + HL_{t,2} - \varphi_{1,t}\varphi_{2,t}HF_{t,1} - s_{t,2}W_t L_{t,1} - ti_h W_t L_{t,2}]$$

C. Decision model of old people

Assume that $C_{t,3}$ and $h^{\theta}_{t,3}$ represent the average consumer goods consumption and housing consumption of old people at t times. $U_3 = \frac{1}{(1+\rho)^2}\frac{1}{1-\theta}C^{1-\theta}_{t,3}h^{\theta}_{t,3}$. The maximum consumption decision equation established under the budget constraint is Max: $U_3 = \frac{1}{(1+\rho)^2}\frac{1}{1-\theta}C^{1-\theta}_{t,3}h^{\theta}_{t,3}$, s. t. $C_{t,3} + h_{t,3} + \mu h_{t,3} = (1+r)s_{t-1,2}W_{t-1}L_{t-1,2}$.

Then, the nonlinear equations under the first-order condition can be described as

$$C_{t,3} = \frac{1-\theta}{1+\mu\theta}(1+r)s_{t-1,2}W_{t-1}L_{t-1,2} = \frac{1-\theta}{1+\mu\theta}(1+r)s_{t,2}W_t L_{t,2}$$

$$h_{t,3} = \frac{\theta}{1+\mu\theta}(1+r)s_{t-1,2}W_{t-1}L_{t-1,2} = \frac{\theta}{1+\mu\theta}(1+r)s_{t,2}W_t L_{t,2}$$

Assume that YH_t represents residents' income,

$YH_t = w^1_t L^1_t + w^2_t L^2_t + w^3_t L^3_t + w^4_t L^4_t + w^5_t L^5_t + shif_{hk} \cdot (r^1_t K^1_t + r^2_t K^2_t + r^3_t K^3_t + r^4_t K^4_t + r^5_t K^5_t) + tf_{hg}$. $shif_{hk}$ is the capital factor income of the residents, which comes from the enterprises; tf_{hg} is transfer payments of the residents, which come from government. Residents' expenditure includes consumer spending and income tax expenditure: $HE_t = h_{t,1} + h_{t,2} + h_{t,3} + C_{t,1} + C_{t,2} + C_{t,3} + \varphi_{1,t}\varphi_{2,t}HF_{t,1} + ti_h \cdot YH$. The balance of residents' income and expenditure can be described as $YH_t = HE_t + s_{t,g} \cdot YH$.

2) Enterprise module

Assume that $YENT^1_t$, $YENT^2_t$, $YENT^3_t$, $YENT^4_t$ and $YENT^5_t$ represent the incomes of the agriculture sector, manufacturing sector, construction sector, service sector and the real estate industry; tf_{eg} is transfer payments of the enterprises, which come from government: $YENT^1_t = shif_{ck} \cdot r^1_t K^1_t$, $YENT^2_t = shif_{ck} \cdot r^2_t K^2_t$, $YENT^3_t = shif_{ck} \cdot r^3_t K^3_t$, $YENT^4_t = shif_{ck} \cdot r^4_t K^4_t$, $YENT^5_t = shif_{ck} \cdot r^5_t K^5_t$. The total income of the corporate sector is $YE_t = YENT^1_t + YENT^2_t + YENT^3_t + YENT^4_t + YENT^5_t + tf_{eg}$. tr_t represents enterprise income tax, and tf_{he} is transfer payments of the residents, which comes from enterprises. Therefore, enterprises spending includes their direct tax and transfer payments they pay for residents: $EE_t = ti_c \cdot (Y^1_t + Y^2_t + Y^3_t + Y^4_t + Y^5_t) + tf_{he}$. Government savings can be described as $ENTSAV_t = YE_t - EE_t$.

3) Government sector

Suppose that government income includes land income, tax income from the real estate market and revenues from laborers' individual income tax. Government's expenditure is decided by the budget, which is an exogenous variable. μ is the house property tax rate, ti_h is personal income tax rate, ti_c is production tax rate, te is export tariff rate, and tm is import tariff rate. Government revenue can be described as $G_t = ti_h \cdot YH + \mu(h_{t,1} + h_{t,2} + h_{t,3}) + ti_c \cdot (Y_t^1 + Y_t^2 + Y_t^3 + Y_t^4 + Y_t^5) + \sum_c pwe_t^c \cdot te + \sum_c tm \cdot pwm_t^c \cdot QM_t^c \cdot EXR$. Government's expenditure includes government consumption, transfer payments to the residents and payments to the foreign sector: $OG_t = \sum_C QG_t^c \cdot PQ_t^c + tf_{hg} + tf_{eg} + tf_{rg}$; tf_{rg} is transfer payments to the foreign sector.

4) Foreign sector Assume that the foreign sector provides capital to the domestic real estate sector, obtains capital gains, and purchases houses in China. $OE_t = \sum_a pwe_t^a \cdot QE_t^a$, $YE_t = \sum_c QM_t^c \cdot pwm_t^c + tf_{rg}$, $PE_t^a = pwe_t^a \cdot (1 + te) \cdot EXR$, $PM_t^c = pwm_t^c \cdot (1 + tm) \cdot EXR$. pwe_t^a is the international price of domestic houses; pwm_t^c is the international market price of imported goods; EXR is the exchange rate; PE_t^a is the price of houses that are purchased by the foreign sector, and PM_t^c the price of houses that are produced by the foreign sector.

(5) General equilibrium module

1) Equilibrium of the factor market

Labor market equilibrium means that the labor supply is equal to the labor demand in the labor market: $\sum_{a=1}^5 L_t^a = \sum_g l_{t,g} \cdot POP_{t,g}$. $l_{t,g}$ is the effective coefficient of Labor of age group g in period t. Capital market equilibrium means that capital supply is equal to the capital demand in the capital market: $\sum_{a=1}^5 K_t^a = \sum_g (1 + r_t) s_t W_t L_{t,g}$. Land market equilibrium means that land supply is equal to the land demand in the land market: $LS = \sum_{a=1}^3 R_t^a$. LS is an exogenous variable and represents the land supply.

2) Commodity market equilibrium

Commodity market equilibrium means that the goods supply is equal to the goods demand in the commodity market: $QS_t^c = C_{t,1} + C_{t,2} + C_{t,3} + h_{t,1} + h_{t,2} + h_{t,3} + \varphi_{1,t}\varphi_{2,t}HF_{t,1} + \sum_a QINT_t^a + OG_t + OE_t + EINV_t$

3) Government revenue and expenditure equilibrium

Assume that $GSAV_t$ represents government savings and that government savings means government revenue minus government spending: $GSAV_t = G_t - OG_t$.

4) Balance of international revenue and expenditure: $FSAV_t = YE_t - OE_t$

5) Capital market equilibrium

Capital market equilibrium means that total investment is equal to total savings. To solve the model, this paper adds a dummy variable (VBIS):

$EINV_t = (1 - ti_h) \cdot YH - (h_{t,1} + h_{t,2} + h_{t,3} + \varphi_{1,t}\varphi_{2,t}HF_{t,1} + C_{t,1} + C_{t,2} + C_{t,3}) + GSAV_t + EXR \cdot FSAV_t + VBIS_t$

(6) Macroscopic closing condition

This model uses the Keynesian macro closed in which the factor price is fixed and employment is endogenous and determined by labor demand: $w_t^4 = \overline{w_t^4}$, $r_t^4 = \overline{r_t^4}$. This model adds two important macroeconomic variables: GDP and GDP price index:

$$GDP_t = \sum_c (QH_t^c + QM_t^c + QG_t^c + \overline{QINV_t^c} - \sum_a OE_t^a$$

$$PGDP_t \cdot GDP_t = \sum_c (QH_t^c + \overline{QINV_t^c} + QG_t^c) \cdot PD_t^c + \sum_a QE_t^a \cdot PE_t^a - \sum_c QM_t^c \cdot PM_t^c + \sum_c QM_t^c \cdot tm \cdot pwm_t^c \cdot EXR.$$

Based on the Walras law, this article considers the housing price of the domestic real estate market a benchmark price; this would reduce an endogenous variable. Therefore, this paper adds a dummy variable (walras) to the model:

$$QS_t^c = C_{t,1} + C_{t,2} + C_{t,3} + h_{t,1} + h_{t,2} + h_{t,3} + \varphi_{1,t}\varphi_{2,t}HF_{t,1} + \sum_a QINT_t^a + OG_t + OE_t \cdot +EINV_t + walras$$

4.3. Data processing and parameter estimation

Based on the 2007 input-output table compiled by the national bureau of statistics, this paper takes 2007 as its benchmark year and employs the social accounting matrix as the initial state of the general equilibrium model.

There are three main methods to estimate the parameters in the CGE model. The first method is to calibrate the consistency of data for the benchmark year. This method is applicable to estimate all parameters but the elastic parameters. Second, if there is sufficient data, then the parameters can be estimated by econometrics methods. Third, based on the existing research of others and the economic characteristics of the research object, we can also revise our estimation of the parameters [23]. In the calibration phase of the model, we must find all of the production functions, the CET production function and elasticity of the Armington condition function in the existing literature.

Seftonet and Weale (1997) noted that to reflect better the reality of the heritage distribution in English, it is necessary to assume a small bequest motive. They found that smaller bequest motives are associated with smaller heritage distributions. If the bequest motive is set at a high level, more families will give their children legacy assets [24]. Therefore, we set the legacy motivation at an appropriate level: $\mathfrak{R}_1 = 0.1$, $\mathfrak{R}_2 = 1$. Based on the literature, we set θ equal to 2 (Wang Tongsan, the frontiers of quantity economics, social sciences academic press, 2001). Solow suggested that the value of ρ should be between 0.01 and 0.02 (Solow, essays on the economic growth, Beijing institute of economic press) [25]. We use savings in SAM form divided by residents' disposable income in SAM form to obtain the Savings rate (s); the result is 0.3794. We use individual income tax divided by laborer income to obtain personal income tax rate (ti_h); the result is 0.0198. We use land capital gains in SAM form divided by capital gains to obtain land return rate (τ); the result is 0.0415. The results are shown in table 1.

Table 1: calibration results of variables and parameters of the CGE model

	consumption	
θ	alternative elastic constants	2
ρ	consumers timing parameters	0.015
s	the saving rate	37.94%
$\mathfrak{R}_1$	legacy motivation	0.1
$\mathfrak{R}_2$	legacy motivation	1
	Foreign markets	
te	export tariff rates	0.0895
tm	import tariff rate	0.076
EXR	the exchange rate	7.6071
	Tax rate	
ti_h	income tax rates	0.0198
μ	the property tax rate	0.012

4.4. Model solving

To solve the CGE model, the general calculation programs include GEMPACK (Generalized Algebraic Modeling System), GAMS (General Equilibrium Modeling Package) and MPSGE (Mathematical Programming System for General Equilibrium) (Du Yuming, 2004) [26]. This paper uses GAMS to obtain results as shown in figures 4 and 5.

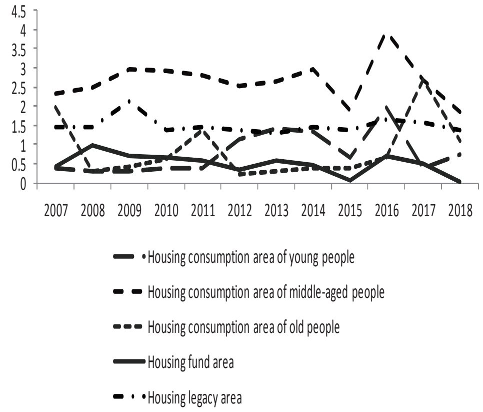

Figure 4: Housing consumption of the young, the middle-aged and the old, housing finance and housing legacy

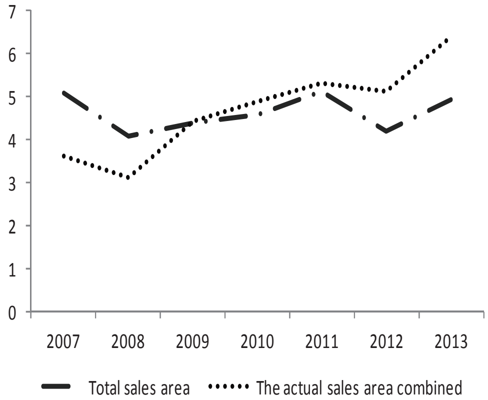

Figure 5: The sales area in model and the sales area in reality

From figures 4 and 5, we can conclude that the housing consumption area of the middle-aged is larger than that of the youth and the old. In addition, according to the model simulation, although there are some differences between China's urban housing consumption and the actual sales area, the overall trend is the same. Therefore, we can conclude that the theoretical model in this paper can simulate the real supply and demand situation of the urban residential market appropriately, and it better fits the change trend of China's urban housing demand.

4.5. Model application

Aging affects residents' housing decisions largely through population amount and the population structure (the proportion of young people and the elderly, the elderly dependency ratio, and the retirement age). Therefore, the paper assumes these following plans:

1) Increasing the proportion of middle-aged people by 10%, all else equal

Middle-aged proportion refers to the ratio of the number of middle-aged people to the number of elderly people. As the main body of the overall population, the middle-aged people's income is lucrative and stable, their social status is higher, and they are confronted with the pressures of raising their children and supporting the elderly. Middle-aged ratio reflects the actual pension burden of middle-aged people. Compared with the old-age dependency ratio, the middle-aged ratio removes their raising burden on young people. The simulated results are shown in figure 6.

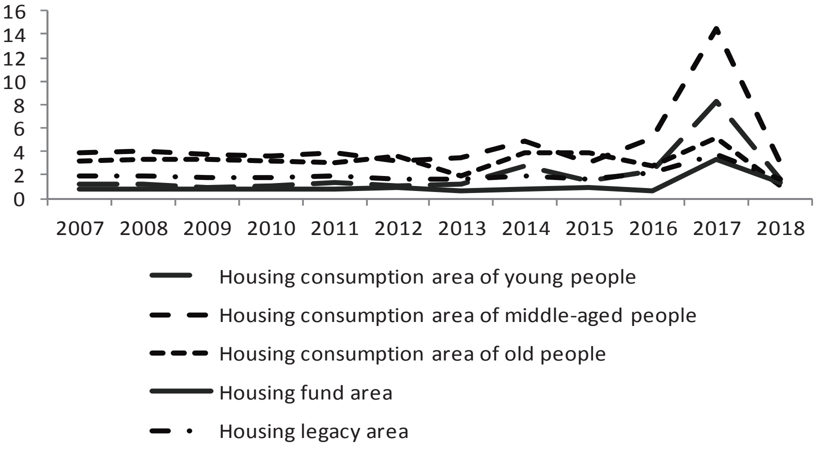

Figure 6: Change trend of housing consumption of young people, middle-aged people and the old and housing fund, housing legacy

Through the simulation results in figure6, we can see that when the middle-aged ratio is increased by 10%, housing consumption of young and middle-aged people increased at the same time, and the gaps of consumption among these three groups are narrowing. This shows that as the main provider of funds, the increase of the middle-aged proportion leads to a substantial increase of housing purchase funds. One part of the funds is used to support young people to purchase houses, and the other part is used for their own consumption.

2) Postpone the retirement age from 60 to 65, all else equal

According to China's actual situation and the relevant policies, this article proposes postponing the retirement age from 60 to 65 years old and studies the effect of the change in the retirement age on the housing consumption of three age groups. The result is shown in figure 7:

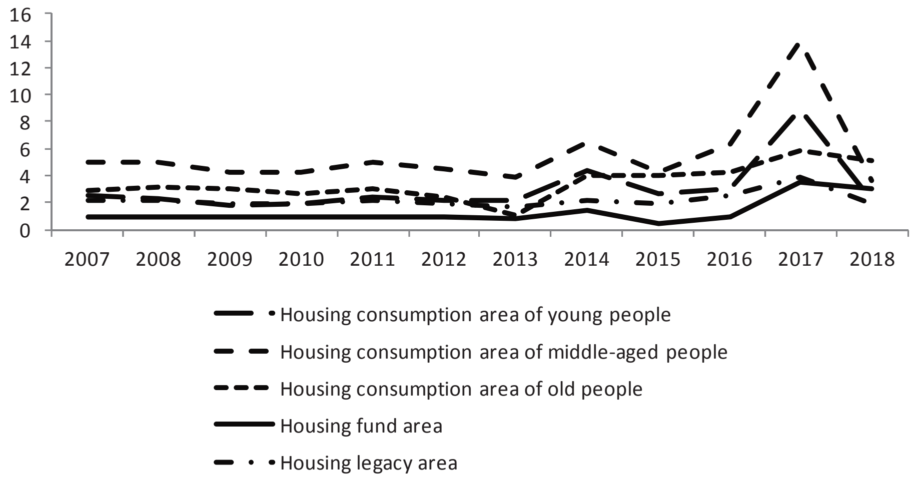

Figure 7: Change trend of housing consumption of young people, middle-aged people and the old and housing fund, housing legacy

Through the simulation results in figure 7, we can conclude that the increase of the retirement age causes the housing consumption of middle-aged people to increase rapidly at first and then become less than the housing consumption of the old. This suggests that older people's housing consumption has great potential. The increase in the number of old people and the postponing of the retirement age result in the amount of old people's income and its discount increasing rapidly. Because the consumption is a function of income, the increase of income brings about an increase of money earned by the elderly. This higher labor remuneration will result in increasing housing demand. Given the number of old people and their income levels, it is easy to understand why the housing consumption of old people is initially less than that of the middle-aged people but later becomes more than that of the middle-aged people.

3) The elderly dependency ratio increased by 10%, all else equal

As the international measure index of aging, the elderly dependency ratio can describe an aging trend and its degree comprehensively and profoundly. The result is shown in figure 8:

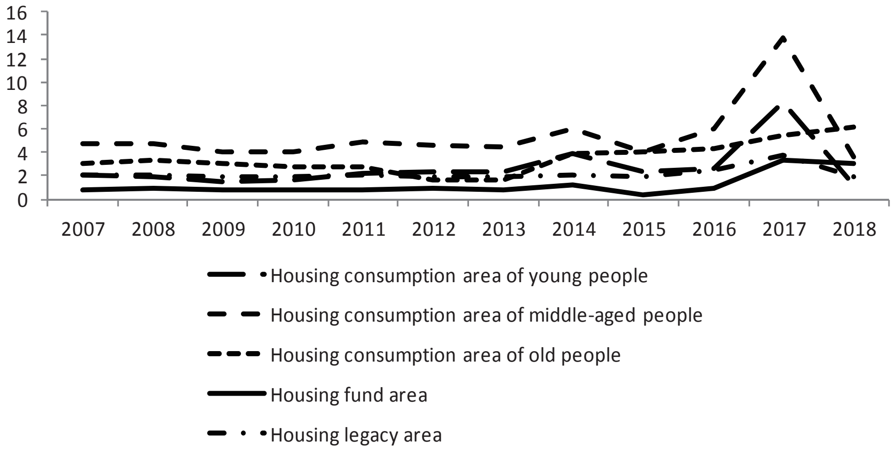

Figure 8: Change trend of housing consumption of young people, middle-aged people and the old and housing fund, housing legacy

The increase of the elderly dependency ratio implies a relative decrease of the proportion of middle-aged people and young people and a relative increase of old people. Through the simulation results of figure 8, the increase in the elderly dependency ratio will bring about an increase in the housing demands of the three groups at the same time. This suggests that aging can lead to an increase of total urban housing demand. Because the increases in housing demand vary among the three groups, the housing demand structure also changes. Although young people and the middle-aged remain the main consumers of housing, their housing consumption has sharply decreased in 2017; in contrast, the consumption of old people continues to grow quickly. In 2018, old people's housing consumption is greater than the total housing demand of young and middle-aged people. The reason is that the increase in the numbers of old people results in an increase in the housing demands of old people. Therefore, apartments for the elderly has promising market prospects, and real estate developers should rationally develop the elderly housing market.

4) Comprehensive reform

Finally, given all of the above plans, this paper attempts to discuss the comprehensive effect of the above situations on the real estate market. The result is shown in figure 9:

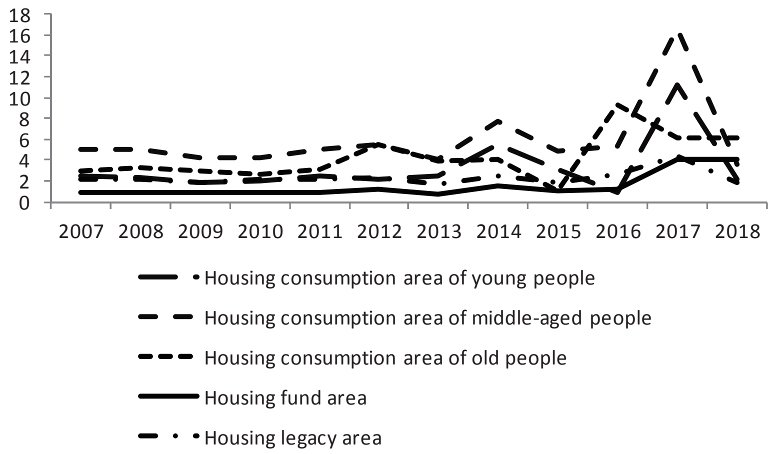

Figure 9: Change trend of housing consumption of young people, middle-aged people and the old and housing fund, housing legacy

As is shown in figure 9, young and middle-aged people remain the main consumers of housing, but the housing demand of old people has been increasing fast. From 2007 to 2015, the housing demand of old people is less than that of young and middle-aged people. In 2016, the housing demand of old people exceeds that of young and middle-aged people for the first time. From then on, the housing demands of the three groups all decrease. The housing demand of old people is greater than that of young and middle-aged people again in 2018. The reasons are as follows: from 2007 to 2015, young people and middle-aged people account for a large part of total housing consumers, whereas old people only make up a relatively small part; therefore, then generate less demand. In 2016, China's population peaks and the housing demands of the three groups also reach their maximums. After 2016, the housing demand declines quickly with the decrease of population. Note that the housing demand of old people is greater than the total amount of the other two groups because with the aging process, old people account for more and more of the total population. In addition, the adjustment of the retirement age brings about an improvement of income levels, which directly leads to an increase in old people's housing demand. In view of this pattern, China's government and real estate developers should consider that increase and regulate the housing market rationally.

4.6. Conclusion analysis and discussion

(1) Young and middle-aged people are the main consumers of housing

Housing consumers are divided into three consumption groups in this paper. This will be helpful to our study of the effects of the changes in each age group on urban housing demand. As seen from the above analysis, no matter how aging affects housing demand, young and middle-aged people remain the main demanders for urban housing. The main reasons are as follows. First, as the 1981-1990 "baby boom" generation gradually enters the marriage and childbearing period, urban housing demanders increase rapidly; their housing demands belong to the rigid demand. Second, middle-aged people are quite stable in both their social status and family income, and they have a great deal of savings; thus, they create investment demand for housing. Third, middle-aged people are the main part of the population in China at present, which causes young and middle-aged people to become the two main bodies of housing consumption in China.

(2) When the middle-aged ratio increases by 10%, the housing consumption of young and middle-aged people will increase and housing legacy will decrease.

Because young people have been in society for a very few years, their incomes are low. Consequently, middle-aged people become the main body to support the elderly. The proportion of middle-aged people in this paper refers to the ratio of the middle-aged population and the elderly population; this ratio reflects the pension burden of middle-aged people. When the middle-aged ratio is increased by 10%, the housing consumption of young and middle-aged people will increase at the same time. It is largely because that middle-aged group is the main body to support the young and the elderly that the increase in population of middle-aged people will naturally lead to an increase of young and middle-aged people's housing consumption at the same time.

(3) Aging increases the urban housing demand of the young and middle-aged people; the old and housing legacy stay constant

Aging brings about the increase of the urban housing demand of the young, the middle-aged people and the old at the same time. With the deepening of aging, nuclear families, "empty nest" families, newly married and child-free families and single families constitute the greatest proportion of urban households in China. The increase in the quantity of families inevitably leads to an increase in demand for housing. In addition, except for family size, housing demand is highly related to the level of household income. With the improvement of family income levels, housing demand is also showing a rising trend. Finally, urbanization is also a main cause of the increase of urban housing demand. Urban housing demand primarily depends on two factors: the population scale and the urbanization rate. With the expansion of the population scale, the urban population will continue increasing, and the new urban population will lead to an increase in housing demand. Therefore, it is concluded that the aging population structure change, family size miniaturization and urbanization are the primary factors in the increase of housing demand.

(4) When postponing the retirement age from 60 to 65 years old, the housing consumption of middle-aged people will increase rapidly, but then less than that of old people

Delaying retirement age from 60 to 65 years old can increase the middle-aged ratio and greatly reduce the elderly dependency ratio at the same time. As is shown in the figures, the housing consumption of the young, the middle-aged people and the old has presented an "inverted U" growth trend. The trend will peak between 2016 and 2017, and then decrease rapidly. However, in the long term, the housing consumption of middle-aged people will be less than that of the old. This difference is because with the improvement in people's income and the social security system, old people's capital increases rapidly. In addition, because of the unique physical and psychological characteristics of the old, they are willing to live alone, resulting in an increase of their housing demand. The "inverted U" change trend of middle-aged people leads to their housing consumption increasing initially and then decreasing.

5. Empirical analysis of the effect of aging on China's urban housing demand

Traditional multiple linear regression assumes that all data are steady. That is, regression parameters are not associated with the location of the observation point; thus, the regression parameters and regression model of the traditional multiple linear regression have a global scope [27]. However, in studying the real estate market, both the variables and regression parameters have spatial correlation. In other words, geographically weighted regression regresses each observation point and defines the distance between the estimated point and the other points as the weight. Therefore, using the idea of local smooth, Fortheringham and others invented a regression model to analyze spatial characteristics among variablesGeographically Weighted Regression.

5.1. Data source and target selection

This article selects commercial housing sales area, foreign direct investment, family quantity, per capita GDP, the elderly dependency ratio, disposable income per capita, living space per capita, the price of commercial housing, gross domestic product (GDP), China's urbanization rate, interest rate and other economic indexes of 287 Chinese cities in 2010 and uses a geographically weighted regression model to analyze the effect of aging on urban housing demand. The data primarily come from WIND, CEIC and the national bureau of statistics database (as shown in table 2).

Table 2: Variable selection

The dependent variable		commercial housing sales price
The independent variables	market	foreign direct investment
	economy	GDP, per capita disposable income, per capita GDP, interest rate
	supply	living space per capita, the price of commercial housing
	demand	China's urbanization rate
	population	the total population, family quantity, the elderly dependency ratio

This paper primarily uses ArcGis9.3 software to achieve geographically weighted regression; and the city in the software which is divided according to the prefecture level administrative region is matched with the city of download data the software matches the cities input with cities with data downloaded. Moreover, this paper merges and deletes the data of some cities.

5.2. constructing and testing the model

Before the geographically weighted regression model is established, this paper tests geographical variability with each location variable, as shown in table 3.

Table 3: geographical variability tests of GWR

Year	F	DIFF of Criterion
2010	2.477290	−0.823498

As seen in table 3, the DIFF of Criterion of the elderly dependency ratio in the geographically weighted regression model is negative; therefore, in 2010, the distribution of aging is affected by geographical location.

Table 4: variance comparison between Geographically weighted regression and global OLS GWR ANOVA Table

Source	The sum of squared residuals	Degrees of freedom	Mean square error	F - value
Global Residuals	114917119668.98	7		
GWR improvement	2058822578.17	2.566	802270171.594	
GWR Residuals	112858297090.81	257. 434	438397433.573	1.838542

Table 4 shows that GWR improvement is 2058822578.17, which is greater than zero. In other words, the sum of squared residuals of the global OLS is greater than are those of a geographically weighted regression. Therefore, the geographically weighted regression model is superior to the global OLS. Under the 1% significant level, the F-value is equal to 1.838542 > 1.830007, which means that rejecting the null hypothesis is better. Comparing the geographically weighted regression model and global OLS regression model, the geographically weighted regression model is better.

Classic AIC, AIC, BIC/MDL and CV reflect the model fitting quality to a certain extent; thus, this paper summarizes Classic AIC, AIC, BIC/MDL and CV for the geographically weighted regression and global OLS in 2010, as shown in table 5.

Table 5 shows that Classic AIC, AIC, BIC/MDL and CV of the geographically weighted regression are smaller than are those of global OLS. Therefore, we can determine that the geographically weighted regression model is superior to the global OLS.

Table 5: The correlation coefficient comparison between Geographically weighted regression and global OLS in 2010

regression model	Classic AIC	AICc	BIC/MDL	CV
OLS	6058.014	6058.448	6089.019	496111895.658
GWR	6057.049	6057.740	6083.099	489683613.746

5.3. *Spatial autocorrelation analysis*

Moran's I is a statistical analysis technology that is used to analyze regional economic behavior depending on spatial distribution. Moreover, it is used to determine whether each specific area in a certain area has a spatial correlation, as shown in figure 10.

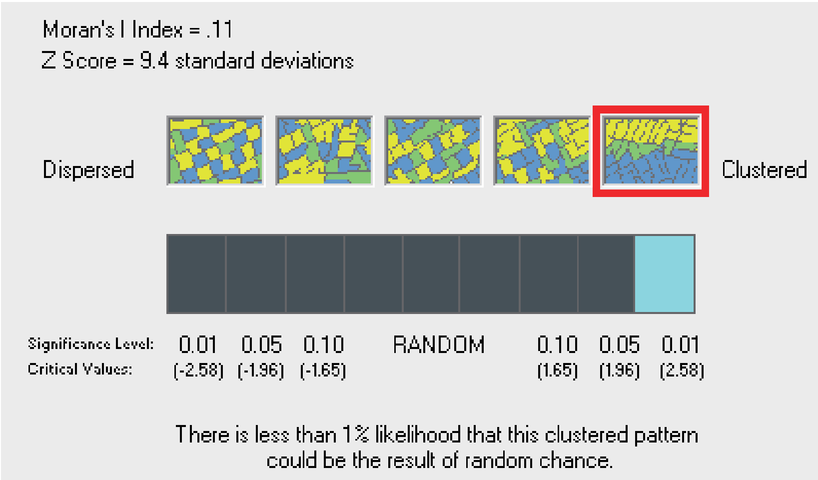

Figure 10: Global Moran's I of 287 cities

Figure 10 shows that the global Moran's I Index is equal to 0.11 with Z equal to 9.4, which means that the null hypothesis should be rejected under the 1% significance level and that there is global spatial autocorrelation in the model. Thus, there is a spatial positive correlation between the regression coefficients of the elderly dependency ratio of the 287 cities on housing demand.

However, global Moran's I index only shows the average difference of a regional economy in space; it cannot reflect the local space differences of the regional economy. Therefore, the local spatial autocorrelation analysis should be included in this paper. To visualize the local spatial correlation, this paper uses the Getis - word G index to analyze hot spots, as shown in figure 11.

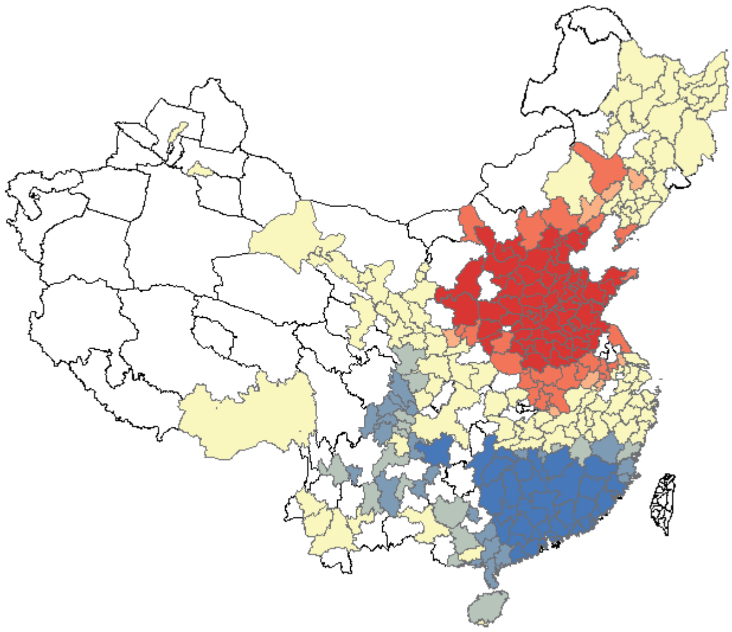

Figure 11: Getis - word G index hot spot analysis diagram

In figure 11, the blue part represents an accumulation of cold spots, and the red part represents an accumulation of hot spots. There are no hot or cold spots in the yellow and light blue parts. The cities in the hot spot areas are those whose coefficients are greater than are those in the regression model of the elderly increasing return ratio and housing demand. The cities in cold spot areas are those whose coefficients are less than are those in the regression model of the elderly increasing return ratio and housing demand. The Getis - word G index of hot spot analysis diagram shows that in those 287 cities, high-value gathered areas and low-value gathered areas appear simultaneously. Specifically, Beijing is the center of a "hot spot". Moreover, it includes many cities of Hebei, Shanxi, Henan, Shanxi, Tianjin and Shandong. Specifically, it includes shijiazhuang, baoding, langfang, tangshan, cangzhou, hengshui, handan, xingtai, tangshan, qinhuangdao and xinzhou. It is mined in yangquan, luliang, xi 'an, tongchuan, yanan, baoji, xianyang, weinan, hanzhong, yulin, ankang, shangluo, zhengzhou, kaifeng, luoyang, pingdingshan, anyang, hebi, xinxiang, jiaozuo, puyang, xuchang, luo river, sanmenxia, xinyang, zhoukou, shangqiu, nanyang, zhumadian, laiwu, dongying, Texas, heze, zaozhuang, jining, liaocheng, weifang, zibo, taian, jinan, binzhou, Qingdao, linyi, rizhao, zhengzhou and luoyang. Cold spot areas include, for example, most of the cities of Hunan, Fujian, Guizhou, Guangdong, Hubei and Jiangxi provinces.

5.4. Conclusion analysis and discussion

Through establishing a geographically weighted regression model, this paper uses spatial analysis software such as arcGIS and the 2010 data of 287 Chinese cities, such as the elderly dependency ratio and housing sales area, to study the effect of aging on urban housing demand. The conclusions are as follows:

(1) Aging has a significantly positive influence on urban housing demand in China, and because each city's aging degree is different, the housing demands are different. As a result, it is rational for the government to analyze and forecast the change tendencies of the population structure in our country and to control the population flow rate of some first-tier and second-tier cities, that is, to control the situation that in some parts of cities, housing demands are too exuberant and some are too cheerless.

(2) The "hot spots" are largely distributed in the northeast coastal areas of China, for instance, in Beijing, Hebei, Shanxi, Henan, Shanxi, Tianjin and Shandong. The "cold spot" areas are largely distributed in the southeast coastal areas including Hunan, Guizhou, Guangdong, Hubei, Fujian and Jiangxi province. The

average level of the effect of aging on urban housing demand in hot spot areas is slightly higher than in cold spot areas. Therefore, by changing the household registration system, the government can control the population structure of different regions. As a result, housing demand in "hot spots" can be controlled, housing demand in "hot spot" and "cold spot" areas can be balanced, the growth rate of house prices will be slowed, housing demand in "cold spot" areas can be improved, and the vacancy rate will be reduced.

5.5. *The shortage and prospect of research*

First, the data lag. Because our country input-output table is compiled every five years and the main problem discussed in this paper is the effect of aging on urban housing demand, it is necessary to make the initial year as near the nascent period of aging as possible. Therefore, this article uses the input-output table of 2007 as the basis of data.

Second, the division of consumers is largely based on the subjective understanding of the author, and there are some differences in comparison to the reality. Because the theoretical model of this article is combined with the overlapping-generations model and general equilibrium model, it is reasonable to depict the characteristics of consumers' life cycles and their consumer behavior characteristics. In this paper, the division of consumers is largely based on reality but does not consider consumer behavior characteristics. In the future, we should fully consider these two aspects and ensure that the overlapping-generations model has better realistic guiding significance.

Third, this model does not divide housing consumers at the same age according to income. Because fluctuation in price has a very important effect on the purchase behaviors of residents at different income levels, it is relatively rough to divide housing demanders based merely on age. In the future, we should focus on income and consider dividing the resident sector into the urban residents and non urban residents.

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