Effect of Aging on Urban Land Prices in China

Sun, Tianyu and Chand, Satish and Sharpe, Keiran

UNSW Canberra

26 June 2018

Effect of Aging on Urban Land Prices in China

(Paper to be presented at the International Conference on Economic Modelling - EcoMod2018 in Venice, Italy, 4th to 6th, July, 2018)

PRELIMINARY DRAFT

Tianyu Sun*, Satish Chand and Keiran Sharpe

ABSTRACT

This paper investigates the effect of demographic changes on land prices in urban China using an Overlapping Generation (OLG) model. The model suggests that the rapid rise in land prices could be explained by the rise in per capita income and demographic changes. This finding is validated by fitting the historical data of China. We then simulate land price dynamics for China from 2000 to 2100. The simulation indicates that the rate of rise in land prices is softening. From 2035 to 2055, the effect of demographic changes on urban land prices in China will be close to zero. After 2055, the effect will turn to negative until the end of this century; however, a meltdown is unlikely.

JEL classification: E21, E31, J11, R21, R31

Keywords: Aging Population; OLG Model; Urban Land Prices; Forecast

* Corresponding author, Tianyu.Sun@student.adfa.edu.au
School of Business, UNSW Canberra, Australia (Tianyu Sun, Satish Chand and Keiran Sharpe)

Introduction

Aging population has been happening across the world. Booming research is focusing on it because it may have a profound impact on the economy. As China is facing a significant aging population, it is one of the best examples in examining its effect. According to the Life Cycle Hypothesis (LCH), this demographic change indicates that more assets would be sold by the elderly, and thus put downward pressure on the prices of houses. If true, will aging stop the undergoing rapid rising of land price in China, or even flip it to decline? Due to the importance of land price to both the households and macroeconomics[1], the scope of this effect should be investigated quantitatively beforehand. The results will also provide clues to other countries that will themselves encounter the same problems.

There is a vast literature emerges discussing the linkage between demography and economic activities[2]. Among the literature, the OLG model in chapter 4 is one of the first that systematically discussed the effect of demographic changes on land prices. Most conclusions of that chapter have not been covered in the previous research. In this chapter, we will extend this model and simulate the land price dynamics according to the predicted demographic changes of the United Nations (UN). This study is meaningful in at least two aspects as follows. First, it tests the model performance in relatively realistic situations. Second, a bulk of the literature that forecasts the land or house prices has adopted methods that are data-driven[3]. This study will provide an alternative solution, which is based on economic theories, in forecasting the dynamics of land prices.

In particular, this study attempts to quantitatively forecast the land price dynamics according to the demographic changes from 2000 to 2100 in China. The model, as mentioned above, is extended from the model of Chapter 4, and it includes four new ingredients as follows. First, this model incorporates 16 age groups, covering the adulthood from 20 to 99. Each age group has a range of five years so as to be consistent with the dataset of the UN. The multiple age groups will allow us to simulate the demographic changes in more detail. Second, the rural-urban migration has been taken into consideration in this model. In real situations, the land

---

[1] For households, the land price will affect their total wealth as housing assets constitute a large part of it (Xie and Jin 2015). In addition, the land price has a close relationship with the macroeconomic fluctuations (Liu, Wang, and Zha 2013).

[2] See, for example, Cervellati and Sunde (2011), Balestra and Dottori (2011), Curtis, Lugauer, and Mark (2015), and Muto, Oda, and Sudo (2016).

[3] See, for example, Rapach and Strauss (2009) ,Gupta and Majumdar (2015), Plakandaras et al. (2015), and Wei and Cao (2017).

price dynamics we care about mainly refers to those in the urban areas, and the rapid urbanization in China has been recognized as an important factor influencing the land price[4]. Thus, this migration should be essential in our simulation. Third, instead of designing a complicated inheritance system as exists in reality, we introduce a simple way to avoid this discussion. The key of this method is the introduction of a government sector, and the details are left in the corresponding section of this chapter. Lastly, the tax rate that serves as a pay-as-you-go pension system will be flexible in this chapter, to better corresponds with the reality.

Assuming perfect foresight of households, our baseline projection computes the transitional path of the land prices affected by the demographic changes. To show that our model could provide clues on the dynamics of urban land price in China, we use the projection results to fit the historical data from 2005 to 2015[5]. The fitted result indicates that the trend of the historical land price can be explained from the perspective of income and demography, and the well-fitting confirms the meaningfulness of our projection. In the out-of-sample periods, this projection shows that the effect of demographic changes on land prices could be divided into three periods. The first period lasts from 2000 to 2035, in which the effect stays positive. After that, this effect would be close to zero until 2055, forming a stable period. The third period consists the rest of this century, and the negative effect dominates in this period. Although a long-lasting declining period is predicted, this decline can hardly be described as a meltdown because the fall is moderate.

In addition to the baseline projection, we decompose the overall demographic changes into the changes in three distinct sources, i.e. 1) worker population, 2) longevity and 3) age structures. To analyse their effects, we conduct counterfactual simulations to reveal their roles in forming the land price dynamics. In particular, the worker population is discovered to be the main force raising the land price in China from 2000 to 2100. On the contrary, the age structure changes will depress the land prices. The effect of longevity increase is not significant in this simulation because its effect is absorbed by 1) the price rise beforehand, and 2) the effect of age structure changes. The details will be provided in the corresponding sections.

---

[4] See, for example, Chen, Guo, and Wu (2011), Li and Chand (2013), and Liu, Fang, and Li (2014)
[5] The statistical data of this land price starts from 2004.

Besides, we further studied the effect of age structure changes by looking into the behaviours of households in different age groups. To the results, we find that the per capita land demand of households by age is conditional and varies in different circumstances. Thus, the forecasts in the literature that are based on the historical survey data of households' land demand could be biased. In particular, a higher / lower growth rate of worker population will raise / depress the per capita land demand. When longevity is higher / lower, the land demand will also be higher / lower. For the age structure, a more / less centred age structure will imply a lower / higher per capita land demand.

The remainder of this chapter is organized as follows. Section 2 describes the OLG model, Section 3 presents the data, the calibration of parameters, and assumptions. The quantitative results are shown in Section 4, including the fitting of historical data, baseline projection and the counterfactual simulations. A discussion on the relationship between age structure and land price is provided in Section 5. Section 6 concludes.

Model

A. Demography

Our model consists of 16 age groups, covering the households' age from 20 to 99, and each age group spans 5 years. The households younger than 20 years are assumed not to be participating in the land market, thus the children and young teenagers aged from 0 to 19 are omitted from the model. Meanwhile, households older than 99 are assumed to leave the economy system. Within the modelled age groups, those aged from 20 to 64 are assumed to be workers as in Curtis, Lugauer, and Mark (2015), and the corresponding age groups are numbered from 1 to 9. While the rest of the households are retirees, whose age groups are from 10 to 16 (i.e. aged between 65 and 99). Although in practice the retirement ages differ across genders and careers, we take a fixed retirement age for simplicity.

The cohort size dynamics of urban residents follow the following rules:

$$N_{t,i} = \pi_{t,i} N_{t-1,i-1} + M_{t,i} \tag{7-1}$$

where $N_{t,i}$ represents the worker population of age group i at period t, and $\pi_{t,i}$ denotes the survival rate of $i-1$ age group from period $t-1$ to t. The variable $M_{t,i}$ represents the migrants of age group i from rural to urban areas in period t.

In this model, although we focus on the urban land prices, the urban population is not a closed system because of rural-urban migration. Here, the urban residents consist of two parts. The term $\pi_{t,i} N_{t-1,i-1}$ denotes the urban residents that survived to period t, and the term $M_{t,i}$ represents the immigrants.

B. Households

Preference

All households have the same preferences. They prefer consumption and land; meanwhile, they have a dis-preference for labour supply. The land is incorporated in preferences because it is tightly related with houses (Liu, Wang, and Zha 2013). This preference could be described by the utility function as follows:

$$U_{t,i} = \ln(c_{t,i}) + j_l \ln(l_{t,i}) - \tau\, n_{t,i}^{1+\eta} \tag{7-2}$$

In this equation, the variable $c_{t,i}$ represents the per capita consumption of age group i at period t. Similarly, the per capita land and labour supply are denoted by $l_{t,i}$ and $n_{t,i}$

respectively. The consumption and land are in natural-logs, so that the utility would be concave with respect to these factors. Meanwhile, the dis-utility of labour supply is in an exponential form as in Iacoviello and Neri (2010) and Liu, Wang, and Zha (2013). The parameter j_l represents the preference of land. The dis-preference of labour supply are characterized by the parameters τ and η. Because the retirees $10 \le i \le 16$ have no labour supply, the above function could be simplified as $U_{t,i} = \ln(c_{t,i}) + j_l \ln(l_{t,i})$ for these age groups.

When households are at 20 years old (the beginning of the 1st age group), they will plan their consumption, land and labour supply to maximize their utility of whole lifetime. More concretely, the utility function of their whole lifetime is as follows:

$$U_t = \sum_{i=1}^{16} \beta^{i-1} \pi_{t,i} U_{t,i} \tag{7-3}$$

Here, $U_{t,i}$ is the utility function of the ith age group as shown in Eq. (7-1) and (7-2), and the lifetime utility is the weighted sum of $U_{t,i}$ $(1 \le i \le 16)$. The weight is characterized by the time preference of households, β, and the survival rate of households, $\pi_{t,i}$. In particular, $\pi_{t,1}$ is assumed to be 1, while $\pi_{t,i}$ $(i \ne 1)$ are calculated from the statistical data of the UN (details provided in the section of data).

Budget

For the urban residents, the budget constraint when they are workers (ith age group, $1 \le i \le 9$) is as follows:

$$c_{t,i} + p_{l,t} l_{t,i} = (1 - T)(w_t n_{t,i} + d_t) + p_{l,t} l_{t-1,i-1} \tag{7-4}$$

The left side of this equation is the per capita expenditure of this age group. The expenditure consists of the consumption, $c_{t,i}$, and the market value of land, $p_{l,t} l_{t,i}$, where the variable $p_{l,t}$ denotes the price of land in period t.

The right side of Eq. (7-4) represents the income of urban workers that comes from three sources. The first source is the wage from labour supply. The wage and per capita labour supply are denoted by w_t and $n_{t,i}$ respectively. Thus, the per capita wage earning of this age group is $w_t n_{t,i}$. The second source is the profit of firms. This profit is assumed to be distributed evenly across the worker population, and the per worker profit is denoted by d_t. The first two sources of income will be taxed at rate T. This tax will be transferred to retirees, and this transfer could be viewed as a pay-as-you-go pension system. This tax rate is assumed to be flexible according to demographic conditions, and the details can be found in the parameterization section below.

The last source of income comes from the market value of the land that was owned by the households in the last period. Here, we assume that the inheritance of land is not included in this model[6]. Thus, the per capita land that could be sold in period t would be $l_{t-1,i-1}$, which is the same as the per capita land owned by this generation in the previous period. The land is sold at the current price $p_{l,t}$, thus the market value is $p_{l,t}l_{t-1,i-1}$. In addition, the age group one that has no land owned in the previous period ($l_{t-1,0} = 0$), so the market value would be zero.

For the migrants of this age group, their per capita budget constraint is shown as follows:

$$c_{t,i}^{m} + p_{l,t}l_{t,i}^{m} = (1 - T)\left(w_t n_{t,i}^{m} + d_t^{m}\right) + s_{t,i} \qquad \text{(7-5)}$$

Same as the urban residents, the migrants spend their income on consumption, $c_{t,i}^{m}$, and land, $l_{t,i}^{m}$. They also receive income as wage, $w_t n_{t,i}^{m}$, and profit distribution, d_t^{m}. The difference between migrants and urban residents lies on that the migrants not owning urban land in the previous period. However, we assume that they will bring an amount of wealth $s_{t,i}$ when they enter the urban areas. One could rationalise it as their savings. Furthermore, we assume that the wealth they bring with them follow the equation:

$$s_{t,i} = p_{l,t}l_{t-1,i-1} \qquad \text{(7-6)}$$

The right side of Eq. (7-6) is exactly the market value of land of urban residents. This assumption indicates that there is no wealth inequality between urban residents and migrants. This is a simplifying assumption that eases calculation since it means that all workers face the same budget constraint Eq. (7.4).

Because the profit is evenly distributed to all the workers, the profit earnings of urban residents and migrants are also equal, i.e. $d_t^{m} = d_t$. In addition, because the preferences of migrants are the same as that of residents in every age group, the migrants will choose the

[6] In this chapter, we assume that the land without an owner will be collected by the government, and this assumption could avoid the problem of designing a complicated inheritance system (see the government section below).

same consumption, land and labour supply as the residents due to their equality[7], i.e. $c_{t,i}^{m} = c_{t,i}, l_{t,i}^{m} = l_{t,i}, n_{t,i}^{m} = n_{t,i}$. Therefore, the budget constraint of workers, regardless of whether they are residents or migrants, could be represented by the same form as Eq. (7-4).

For urban residents, the per capita budget constraint of retirees of age group i $(10 \leq i \leq 16)$ is shown as follows:

$$c_{t,i} + p_{l,t} l_{t,i} = \frac{1}{r} T\,(w_t n_t + d_t) + p_{l,t} l_{t-1,i-1} \tag{7-7}$$

The left side of Eq. (7-7) is the expenditures of retirees. Similarly to workers, they purchase consumption and land. The income of retirees (right side of Eq. (7-7)) could be divided into two parts. The far RHS term is the land that they owned in the previous period, and the market value of this land is $p_{l,t} l_{t-1,i-1}$. This part is the same as that of the workers.

The remaining part is the pension income, and this part is represented by $\frac{1}{r} T\,(w_t n_t + d_t)$ in Eq. (7-7), where the variable n_t represents the averaged labour supply per worker. In Eq. (7-7), the parameter r denotes retiree dependent ratio[8]. Assuming that the pension income for each retiree is the same, this formula can be derived by the following steps. First, all the pension tax received from workers can be denoted by $T\,(w_t n_t N_t + d_t N_t)$, where N_t is the total worker population. Thus, for each retiree, the pension income is $T\,(w_t n_t + d_t) N_t / O_t$, where the variable O_t denotes the population of retirees. Let's define $r = \frac{O_t}{N_t}$, then the per capita pension income is $\frac{1}{r} T\,(w_t n_t + d_t)$.

The per capita budget constraint of migrant retirees $(10 \leq i \leq 16)$ is as follows:

$$c_{t,i}^{m} + p_{l,t} l_{t,i}^{m} = \frac{1}{r} T\,(w_t n_t + d_t) + s_{t,i} \tag{7-8}$$

Here, we assume that the migrant retirees will receive the same pension income as urban residents, and they will bring an amount of wealth $s_{t,i}$. Similarly to workers, we assume that $s_{t,i} = p_{l,t} l_{t-1,i-1}$, so there will be no wealth inequality between resident and migrant retirees. In addition, because the households are assumed to have the same preference, residents and

[7] Every household maximize the utility function according to the budget constraints. For the migrants, no matter what value of utility function is before migration, the decisions on expenditure and labour supply depend only on the budget constraint thereafter. Because the migrants have the same wealth and preference as residents, the decisions of migrants will be the same as residents.
[8] The retiree dependent ratio = the population of retirees / the population of workers. This ratio denotes the average number of workers per retiree.

migrants will have the same expenditure choices on consumption and land, i.e. $c_{t,i}^m = c_{t,i}, l_{t,i}^m = l_{t,i}$. Thus, for each retiree of age group i, the per capita budget constraint can be denoted by the Eq. (7-7).

C. Firms

In the modelling of households, the equations are denoted by per capita variables, such as per capita consumption, land and labour supplies. However, for the simplicity of illustration, we will use aggregate variables instead of the per capita variables in the following model sections. These aggregate variables will be denoted using uppercase letters. For example, the variables D_t will represent the aggregate profits of firms at period t, and it equals the product of per worker profit and worker population, i.e. $D_t = d_t N_t$. Meanwhile, the aggregate labour supply will be denoted as $N_{c,t}$ that:

$$N_{c,t} = \sum_{i=1}^{9} n_{t,i} N_{t,i} = n_t N_t \qquad \textbf{(7-9)}$$

Besides, the aggregate consumption and land of age group i at period t are denoted by $C_{t,i}$ and $L_{t,i}$. They satisfy the equations $C_{t,i} = c_{t,i} N_{t,i}$ and $L_{t,i} = l_{t,i} N_{t,i}$.

Technology

The production technology is assumed to have the following specification:

$$Y_t = A_t K_{t-1}^{\mu_c} L_{e,t-1}^{\mu_l} N_{c,t}^{1-\mu_c-\mu_l} \qquad \textbf{(7-10)}$$

In each period, the production Y_t requires input of capital, land and labour, which are denoted by $K_{t-1}, L_{e,t-1}$ and $N_{c,t}$. Following Liu, Wang, and Zha (2013), the values for capital and land are those for the previous period. The production function has Cobb-Douglas form. The parameters μ_c and μ_l denote the contribution share of capital and land respectively, and the parameter $1 - \mu_c - \mu_l$ represents the share of labour income. Besides, the Total Factor Productivity (TFP) affects the final output and is denoted by A_t.

Aim and budget

In the same manner as the model of Chapter 4, the firms maximize profits as follows:

$$Max \sum_t \beta_e^t \ln(D_t) \qquad \textbf{(7-11)}$$

The total profits of firms in period t is denoted by D_t, and it equals the product of per worker profit and worker population, i.e. $D_t = d_t N_t$. The time preference of firms is denoted by β_e. The firms will maximize the profits according to the budget constraint as follows:

$$D_t + \frac{K_t}{A_{k,t}} + w_t N_{c,t} + p_{l,t} L_{e,t} + \Phi_t = Y_t + \frac{1 - \delta_{\mathrm{k}}}{A_{k,t}} K_{t-1} + p_{l,t} L_{e,t-1} \tag{7-12}$$

This budget constraint is the same as that of Chapter 4 except that we omit the housing production sector.

In Eq. (7-12), the left-hand side of the equation is the expenditures of the firms. Besides distributing profits D_t, the firms have to decide on the value of capital, K_t. The latter is affected by an investment specific technology $A_{k,t}$ as in Chapter 4. Thus, this expenditure is denoted by $\frac{K_t}{A_{k,t}}$ in Eq. (7-12). During the investment, the adjustment cost is denoted by Φ_t, and its specification is the same as that of Chapter 4; that is:

$$\Phi_t = \Phi(K_t, K_{t-1}) = \frac{\phi_k}{2} (\frac{K_t}{K_{t-1}} - g_{k,t})^2 K_{t-1} \tag{7-13}$$

where the parameter ϕ_k denotes the frictions in adjusting the capital. The variable $g_{k,t}$ represents the balance growth rate of capital at period *t*, and this setting makes the capital adjustment cost equal zero along the balanced growth path.

The firms also pay workers for their labour supply. The variable $N_{c,t}$ represents the total labour supply, and formula $w_t N_{c,t}$ denotes the total wage payment of the firms. In addition, the firms have to decide on the land, $L_{e,t}$, and this expenditure is represented by the formula $p_{l,t} L_{e,t}$.

The right side of Eq. (7-12) is the income of the firms. The income is from: 1) the production, Y_t, 2) the capital owned in the last period, K_{t-1}, and 3) the land, $L_{e,t-1}$. The capital is affected by the depreciation rate, δ_{k}, and the investment specific technology $A_{k,t}$, thus its value is $\frac{1-\delta_{\mathrm{k}}}{A_{k,t}} K_{t-1}$. The land is not affected by these factors, and its market value is $p_{l,t} L_{e,t-1}$.

D. Government

In this model, instead of designing an inheritance rule of land owned by households, we assume that the government will acquire all the land whose owners have passed away. For example, in period t, a fraction $(1 - \pi_{i,t})$ of age group $i - 1$ passes away, the land they owned will be transferred to government. After that, the land collected by the government will be sold to the households and firms at the market price, $p_{l,t}$. We assume that the government holds no land at the end of every period. Thus, the role of the government is to re-distribute the land though the market. Lastly, all the revenue received by the government will be spent as government expenditure (denoted by G_t) on the goods market.

Introducing the government into this model alleviates the need for the design of an inheritance system. Different from the case in Chapter 4, the inheritance in multiple generation model could affect the wealth of generations significantly. For example, suppose that we use the same setting as in Chapter 4 that the land is inherited by the same generation as the ones that pass away. Then, if the survival rate $\pi_{i,t}$ is 0.2, then this generation will receive land that is 5 times the per capita land that they owned before. Thus, the wealth of this generation will increase significantly and affect the households' behaviour accordingly. To avoid the significant behaviour changes illustrated above, we can either design a complicated inheritance system to fit the reality or design no inheritance at all. Because the inheritance is not the focus of our research, we choose the second option and the government sector is introduced to collect and sell the land.

E. Equilibrium

The three markets in our model are the goods market, land market and labour market. For the goods market, the equilibrium condition is as follows:

$$C_t + \mathrm{IK}_t + \mathrm{G}_t + \Phi_t = Y_t + \mathrm{S}_t \tag{7-14}$$

The supply side of the goods market is represented by the right side of Eq. 7-14. The two sources are production Y_t and the wealth brought by migrants S_t. The left side of Eq. 7-14 represents the demand of the goods market. The demand consists of consumption C_t, investment IK_t, government expenditure G_t and the adjustment cost Φ_t.

Here, C_t denotes the aggregate consumption of all the age groups, i.e. $C_t = \sum_{i=1}^{16} C_{t,i}$; IK_t represents the aggregate investment that has the specification: $\mathrm{IK}_t = \frac{1}{A_{k,t}} K_t - \frac{1-\delta_{\mathrm{kc}}}{A_{k,t}} K_{t-1}$; the aggregate wealth brought by migrants is denoted by S_t, and it follows the specification that $S_t = \sum_{i=1}^{16} S_{t,i}$.

The equilibrium condition of land market has the specification as follows:

$$L_t = L_{h,t} + L_{e,t} \quad (7\text{-}15)$$

This condition is the same as that of Chapter 4, meaning that the aggregate land is owned by households and firms. The variable $L_{h,t}$ denotes the aggregate land owned by households, and it equals the sum of land owned by all the age groups, i.e. $L_{h,t} = \sum_{i=1}^{16} L_{t,i}$.

Lastly, the labour market equilibrium indicates that the demand and supply of labour is equal. This equilibrium amount of labour has been denoted by $N_{c,t}$ ($N_{c,t} = \sum_{i=1}^{9} n_{t,i} N_{t,i}$) in the previous discussion.

Data, Calibration, and Assumptions

A. Parameter Calibration

The parameters of the model is listed in Table 7-1. Comparing with the parameter values in Chapter 4, there are three main differences.

Firstly, the time lengths of age groups are different. Specifically, each age group in Chapter 4 live 30 years, while an age group in this chapter is 5 years. Thus, the parameters, such as time preference and capital depreciation, must be adjusted to fit the difference. For example, the time preference of households β is adjust to 0.9, corresponding to the annual value of 0.98. The time preference of firms β_e is calibrated lower than that of the households, so that the firms undertake investment (Liu, Wang, and Zha 2013, Iacoviello 2005). This parameter is calibrated as 0.8, so the corresponding annual rate is 0.958, and this annual rate is the same as that of Chapter 4. Similarly, the capital depreciation rate δ_{k} is calibrated as 0.4 for 5 years, indicating the annual depreciation rate is 10 percent, which is consistent with the estimations of Ng (2015).

Secondly, we omit the housing production sector that exists in the model of Chapter 4. Thus, the parameters describing the housing production sector will not exist in the model of this chapter. In addition, the land is assumed to be a necessary input of production as in Liu, Wang, and Zha (2013), thus the corresponding parameter values have to be adjusted. In particular, the land / capital share μ_l / μ_c are calibrated as 0.035 / 0.465 respectively, and the corresponding labour income share will be 0.5[9]. These calibrations corresponds with the real labour income share in China (Bai, Hsieh, and Qian 2006, Ng 2015), and the land / capital share estimation in Liu, Wang, and Zha (2013). Besides, the parameter of adjustment friction ϕ_{k} is calibrated as 10.5 (Ng 2015).

Thirdly, the parameter of the retiree dependency ratio and pension share will vary according to demographic changes. For example, when the worker population shrinks and the retiree population increases, the retiree dependency ratio will increase. The assumption that the pension share will change according to demographic changes is based on the practice of China (see the Context chapter). Specifically, we assume that the pension share will follow a

---

[9] The labour income share equals $1 - \mu_c - \mu_l$

certain rule: the pension income of retirees equals half of the per capita income of workers, i.e.:

$$\frac{(1-T)\ (w_t n_t + d_t)}{2} = \frac{1}{r}\, T\,(w_t n_t + d_t) \tag{7-16}$$

From this equation, we can solve the relation between pension share and retiree dependency ratio as follows:

$$T = \frac{r}{r+2} \tag{7-17}$$

Thus, the demographic changes will affect the pension share according to the equation above.

Besides these changes, the parameters denoting the preferences of households are assumed to have the same value as those in the Chapter 4. These parameters include: 1) the dis-preference on labour supply, τ, 2) weight on land in utility, j_l, and 3) the elasticity of utility function with respect to the labour supply, η. The calibrated values of all the parameters are shown in Table 7-1 below.

Table 7-1 Parameter Calibration of the Model

Description	Symbols	Values	Sources
Time preference of households	β	0.9	See text
Time preference of firms	β_e	0.8	See text
Capital depreciation	δ_k	0.18	See text
Capital share	μ_c	0.465	See text
Land share	μ_l	0.035	Liu, Wang, and Zha (2013)
Adjustment Friction	ϕ_k	10.5	Ng (2015)
Dis-preference on Labour supply	τ	1	Ng (2015)
Weight on land in utility	j_l	0.045	Liu, Wang, and Zha (2013)
See text	η	0.5	Ng (2015)
Pension share	T	flexible	See text
Retiree dependent ratio	r	flexible	See text

B. Exogenous Variables

In this study, our simulations rest on assumptions regarding the urban worker population, life expectancy, and age structures. These demographic factors are viewed as exogenous variables, and the data is relying on the projection of the United Nations (UN).

The first exogenous variable is urban worker population. According to the conclusions of Chapter 5, the worker population has a profound influence on land prices. Because we focus on the land price in urban areas, the urban worker population has to be taken into consideration. In particular, we assume that the rural and urban areas have the same age structure. Thus, the urban worker population can be calculated by the total worker population and the rate of urbanization (the projection data of the UN on these two factors can be seen in the survey chapter (Chapter 3)). Here, because there is no projection of urbanization rate from 2050 to 2100, we assume this rate would rise from 77 percent (the UN projection of 2050) to 80 percent with a uniform speed during this period. Then, the calculated urban worker population from 2000 to 2100 is shown in Fig. 7-1.

From Fig. 7-1, we can see that the urban worker population of China rises from 2000 to 2030 and then declines until the end of this century. The rising of the population is caused by rapid urbanization, while the decline is driven by the decline of fertility rate that is lower than the replacement level. As shown in Fig. 7-1, the population peaks in 2030 and then drops off. Although the decline will last for a long time, the range of this decline is modest compared with that of the rising before (relying on the UN projections).

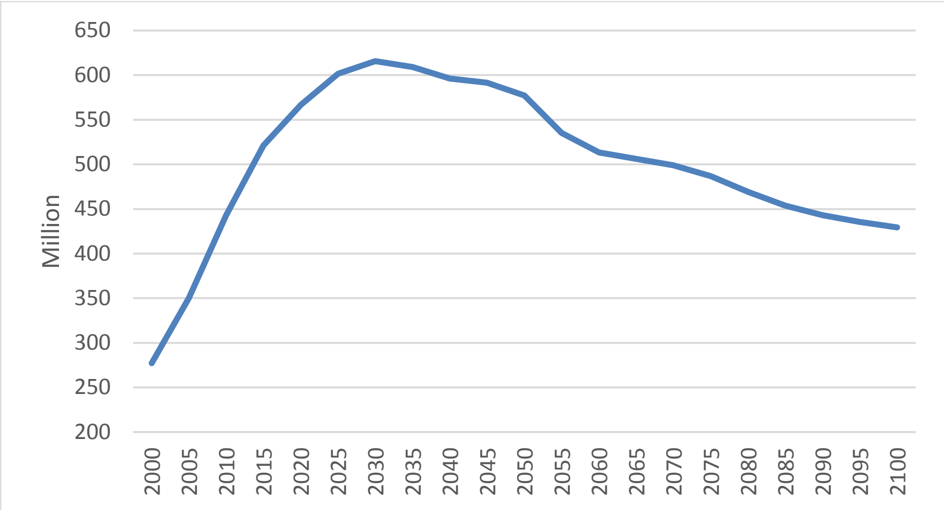

Figure 7-1 Urban Worker Population Projection

Note: source from the projection data of the UN. From 2050 to 2100, the projected urbanization rate is assumed to increase from 77 percent to 80 percent.

The second exogenous variable is the longevity of households. This variable is denoted by the survival rates of different age groups. According to the dataset of the UN, the projection of longevity in China will increase from 2000 to 2100. This increase has been shown in Fig. 7-2 by presenting the survival rates of different age groups in 2000, 2050 and 2100. As we can see, the survival rates in 2100 is higher than those in the 2050 and 2000, and this higher survival rate implies a higher longevity.

Notice that the survival rates of age group 16 increase from 14 percent to 37 percent within the period, there could be a number of households aged more than 99. For these households, their behaviours are not modelled. Here, we assume that they are taken care of by the health care centre that owned by the government. The funding of this centre could come from the housing assets of these households. Recall that the houses and land of households who are aged more than 99 are assumed to be collected by the government, the operation of this centre is funded by selling these assets.

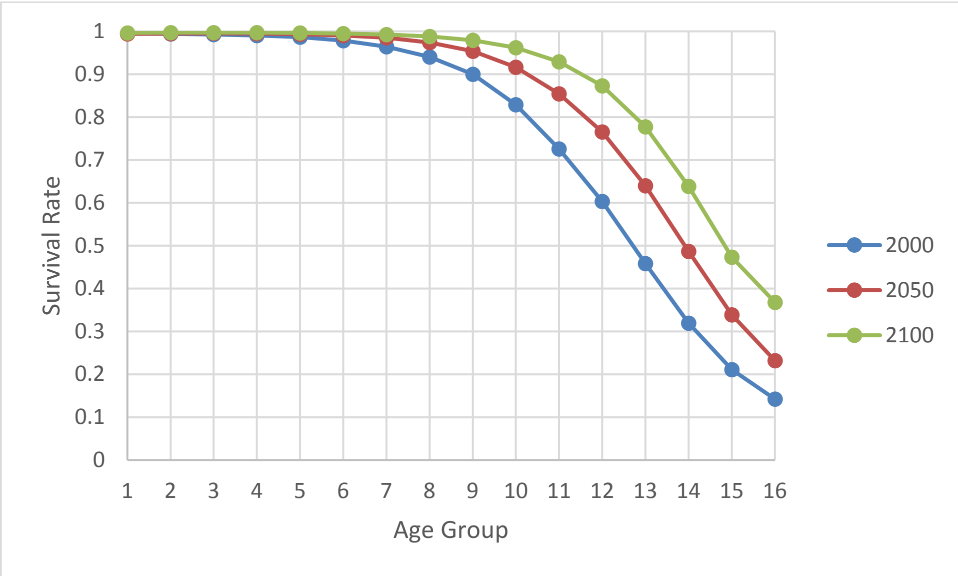

Figure 7-2 Survival Rates of Age Groups in 2000, 2050 and 2100

Note: source from the projection data of the UN.

The last exogenous variable is the age structure of households. This variable is independent only when the migration is significant. In this case, the age structure cannot be determined by the fertility rates and survival rates. Specifically, we denote this variable by the ratio of the population of age group i and total worker population. The selected age structures in 2000, 2050 and 2100 are shown in Fig. 7-3. In this figure, we can see a significant population ageing since the share of the elderly is rising along with time. Besides, the shares of age groups are not smooth. For example, in 2050, the share of the ninth age group (that is, those aged between 60 and 64) is substantially higher than the other age groups and this spike[10]

[10] The age structure spike is due to a baby boom that happens during 1986 and 1990. The birth rate during this period is higher than both the before and after. Along with the time, this baby boom will reach age 60-64 (group 9) in 2050, forming the spike as shown in the figure.

may impact on the land price. These impacts of different age structures will be discussed in section 5.

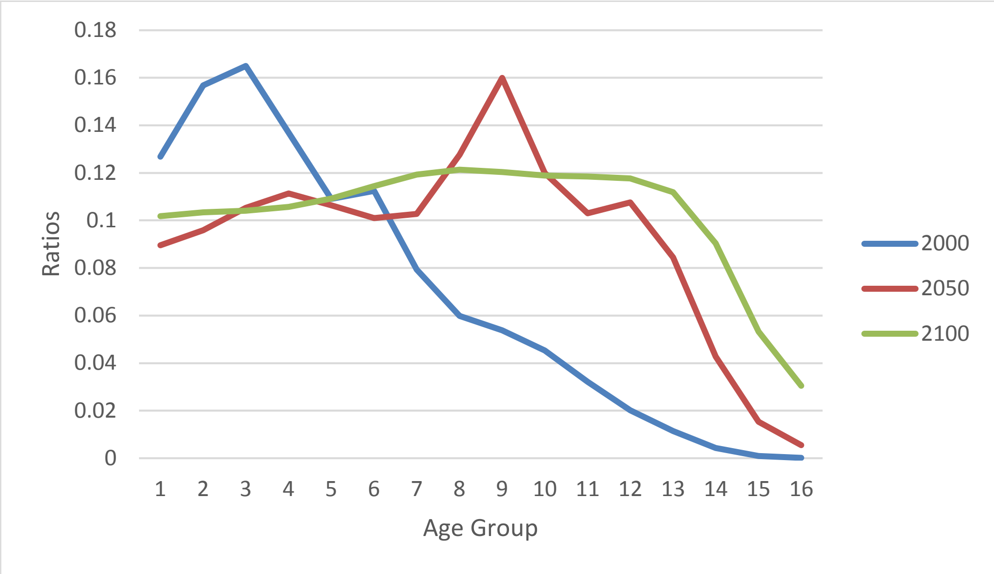

Figure 7-3 Age Structures in 2000, 2050 and 2100

Note: source from the projection data of the UN.

Quantitative Results

A. Fitting Historical Data

Before the projection and simulation, we want to know if our model could provide insights into the land price dynamics in China. In particular, we check this question by fitting our model to the historical data.

Here, this historical data is the quotient of total transaction price and land area purchased by the real estate development enterprises. Thus, it is an averaged contract price. We use this total transaction price instead of the total expenditure because: 1) according to the National Bureau of Statistics (NBS) of China, the transaction price and the land area have the same statistical calibre[11]; 2) the total expenditure includes taxes, land requisition compensation, and accounting rules[12], and these factors have not been considered in our model. Therefore, we will study the transaction price only.

This transaction price data is shown in Fig. 7-4. From 2004 to 2015, the land price in nominal terms rises from 726 to 3341 CNY/sq. m., amounting to an increase of 3.6 times. The demography itself may not form such a rapid rise, and, at least, the increase of per capita income during this period should be taken into consideration. Nevertheless, when fitting the historical data, we want to exclude the effect of income on the land price and focus on the effect of demographic changes. The reason is that, in the simulations, the expectations of future income can significantly affect the current growth rates of land price. However, forecasting income has proved to be hard in practice, and thus beyond the scope of this thesis.

To exclude the effect of income, we take the assumption that, when income increase by one percent, the land price will also increase by one percent (the elasticity is one), and this assumption is based on the following reasons. Theoretically, using the method presented in the appendix of Chapter 5, the trend growth rate of land price can be expressed as:

$$g_{pl,t} = g_{y,t} + g_{N,t} - g_{L,t} \tag{7-18}$$

Here, the variables $g_{pl,t}$, $g_{y,t}$, $g_{N,t}$ and $g_{L,t}$ denote the trend growth rates of land price, per capita income, urban worker population and land restrictions. This equation implies that our assumption will hold true when the trend in land prices net of the rate of growth in per capita

[11] See, http://www.stats.gov.cn/tjsj/ndsj/2017/indexch.htm
[12] See, http://www.stats.gov.cn/tjsj/ndsj/2017/indexch.htm

GDP is considered. In addition, the empirical studies, such as Takáts (2012) and Wang and Zhang (2014), have suggested that the one percent increase in income would correspond with one percent increase in house price. As an important constituent of housing, we suppose that it is also the case for the land price. If true, we can subtract the income growth rate from the land price growth rate to obtain the requisite data[13].

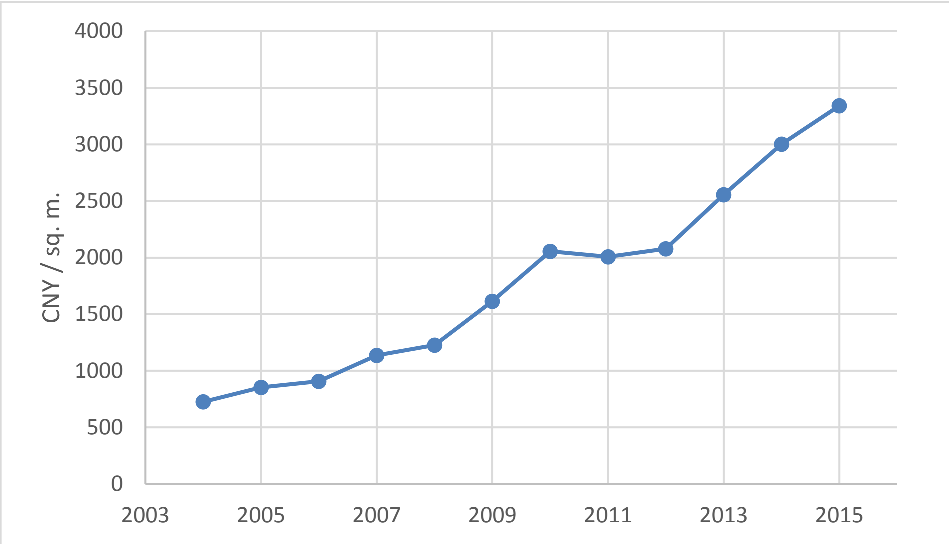

Figure 7-4 Historical Land Price of China (2004-2015)

Note: source from the database of National Bureau of Statistics of China and author calculation.

The fitted result is shown in Fig. 7-5. The blue line denotes the cumulative growth of land price that excluded the effect of income as discussed above. Comparing with the land price in Fig. 7-4, this cumulative growth is moderate. In Fig. 7-5, the red line is the baseline projection of our model. Here, the results from the baseline projection is yearly averaged so as to fit the historical data. In this figure, although the projection cannot capture all of the fluctuations in the land price, these two matches well in trend from 2005 to 2015. This result suggests that the effects of demographic changes are important in forming the land price, and our model would provide clues in forecasting these effects. Nevertheless, because the data length of this fitting is relatively short, these conclusions may need further examination as more data is made available.

In addition, the fitting result also implies that the bulk of land price dynamics in China could be explained from the perspective of income and demography. This conclusion suggests that

[13] Because both the land price and the income are in nominal terms and have inflation included, the subtraction of their growth rates would exclude the inflation.

there could be no bubble in the housing prices of China in the current stage as the findings in the empirical studies[14]. Here, the rising per capita income has contributed the most to the rise in the land price, and the demography is a secondary factor. Yet, the demographic changes are more predictable and stable. Thus, in the following section, we will focus on the impact of the demographic changes on the land price and omit the influences from other factors. Also, in all the results below, the land price and its dynamics are calculated in real terms.

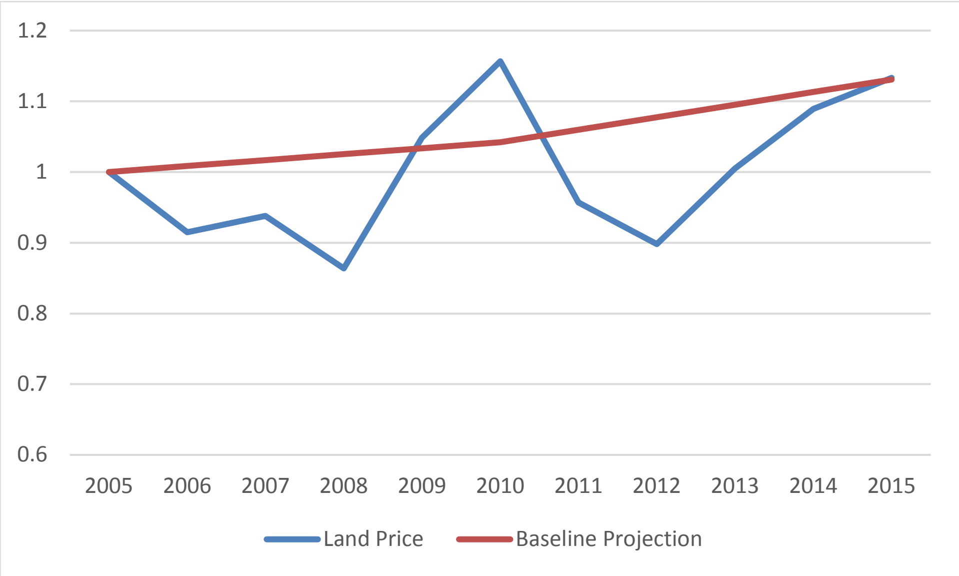

Figure 7-5 Fitting the Historical Data (excluded the effect of income, 2005-2015)

Source: author calculation.

[14] See, for example, Ren, Xiong, and Yuan (2012), Shen (2012), and Deng, Girardin, and Joyeux (2016).

B. Baseline Projection[15]

Our main results of the baseline projection can be represented by the cumulative growth of urban land price as shown in Fig. 7-6. In this figure, the dynamics of land prices from 2000 to 2100 can be divided into three stages. In the first stage, the positive effect of demographic changes will dominate from 2000 and last until 2035. After that, the second stage lasts from 2035 to 2055. Within this period, the effect of demographic changes on land price is close to zero. This stable period implies there may not be a sharp turning point in the price dynamics. In the last stage starts from 2055, the impacts from demographic changes turn to negative and will last until the end of this century. However, the downward effect is not symmetric compared with the rising in the beginning of this century. By 2100, our simulation indicates that the cumulative growth would be nearly the same as that of 2015.

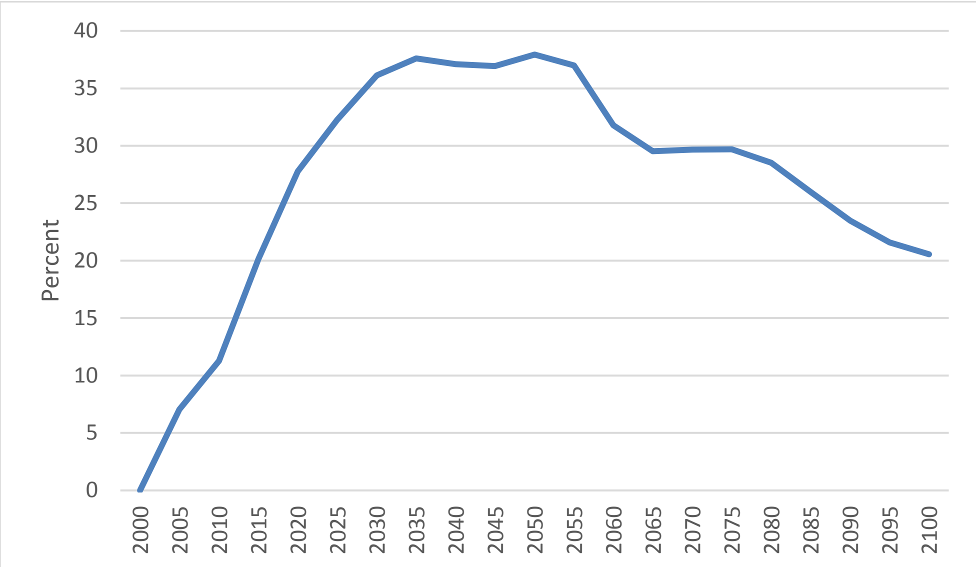

Figure 7-6 Baseline Projection: Cumulative Growth of Urban Land Price (2000-2100)
Source: author calculation.

The growth rates of urban land price from 2000 to 2100, which is shown in Fig. 7-7, can provide additional information from another angle. As we can see, the rapid rising land price has been cooling down, implying the booming of land price may not reoccur to the same extent. This result corresponds well with other empirical studies (see Wu, Gyourko, and Deng (2016)). Along with this cooling down, the growth rates will turn to negative between 2050 and 2055. After 2055, although the growth rates could be positive around 2070 (see Fig 7-7),

[15] The detail settings of the simulation will be shown in Appendix.

the overall growth rate is negative. Nevertheless, the fall can hardly be described as a meltdown because the decline is moderate.

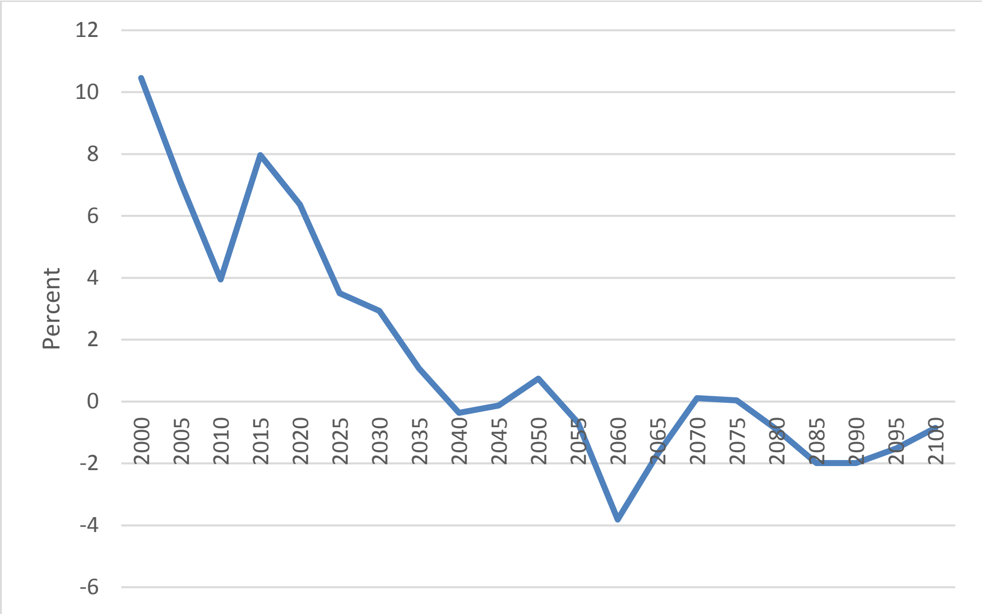

Figure 7-7 Baseline Projection: Growth Rates of Urban Land Price (2000-2100)

Source: author calculation.

Here, we want to explain three features implied in this baseline projection. The first feature is the asymmetry of the rising and the declining prices of urban land, and we will argue that this asymmetry is due to the urbanization. In 2000, the urbanization rate in China is 36 percent; however, according to the forecasts of the UN, this ratio would be 77 percent by 2050. The fast-rising urbanization continues to provide labour to the urban area, supporting the urban economic development and the corresponding rise in the price of land. Meanwhile, the rising urbanization ratio is unlikely to be reversed given the worldwide experience. Thus, the predicted decline will not be as dramatic as the rising (see Fig. 7-6, 7-7). In addition, we assume that the urbanization ratio continues to rise after 2050, and a conservative estimate of this ratio would be 80 percent by 2100, and our Baseline Projection above is based on this assumption.

Second, the cumulative growth of the land price in Fig. 7-6 is much lower than that of the worker population. Note that the worker population determines the trend of land price[16]

[16] We only consider the demographic factors in the baseline projection, and the accurate trend formed by worker population is $g_{pl} = \frac{1-\mu_c-\mu_l}{1-\mu_c} g_n$. When the parameter μ_l is small, the trend of land price would be approximately the same as the trend of worker population.

according to Eq. 7-18, this result indicates that the projection is lower than the trend. Why is that? The reason lies in the assumption that households have perfect foresight. Thus, the households foresee that the worker population will decline in the future and so will the land price. This mechanism can be explained by the Euler Equation of households as follows:

$$p_{l,t} = \beta E_t \left(p_{l,1+t} \frac{c_{t,i}}{c_{t+1,i+1}} \frac{\pi_{1+t,1+i}}{\pi_{t,i}} \right) + j_l \frac{c_{i,t}}{l_{i,t}} \quad \textbf{(7-19)}$$

According to this equation, when a lower future land price, $p_{l,1+t}$, is predicted, the current land price, $p_{l,t}$, will also decline. Therefore, the rising of the land price will not reach the same extent as indicated by the worker population. This mechanism will prevent the prices from suddenly spiking.

Third, the dynamics of the worker population suggests that the prices would tend to decline from 2035. However, our simulation indicates a stable period from 2035 to 2055. How does this difference arise? Here, we argue that this difference comes from the movement of age structure of households. Specifically, if the age structure is more / less centred, the aggregate land demand will be higher / lower, and thus the land price will tend to rise / decline[17]. After 2035, the fertility rate decline will drag down the worker population; nevertheless, because of the fall in the share of the youth population, the age structure would be more centred (as an example, see the red line in Fig. 7-3), forming an upward force supporting the land price. Consequently, the stable period of land prices comes from the overall effect of these two forces.

[17] This is one of the conclusions of the section 5 of this chapter. In that section, a detailed discussion on the relationship between age structure and land demand will be shown.

C. Counterfactual Simulations

In this study, the demographic changes are described by 1) worker population, 2) survival rates (longevity), and 3) age structures. The overall effect on the land price dynamics is caused by all the three factors. Nevertheless, the effect of each of the three factors is missing in the baseline projection above, and this question is important for the further understanding of the influence of an aging population. To this end, following Muto, Oda, and Sudo (2016), we conduct counterfactual simulations to check the effects of these three factors respectively.

First, we assume that the worker population stays the same during our simulation, and the other settings are the same as in the baseline projection. In this circumstance, the worker population would be lower than that of the baseline projection (see Fig. 7-8). The consequences of this setting on the urban land price are shown in Fig. 7-9 and 7-10.

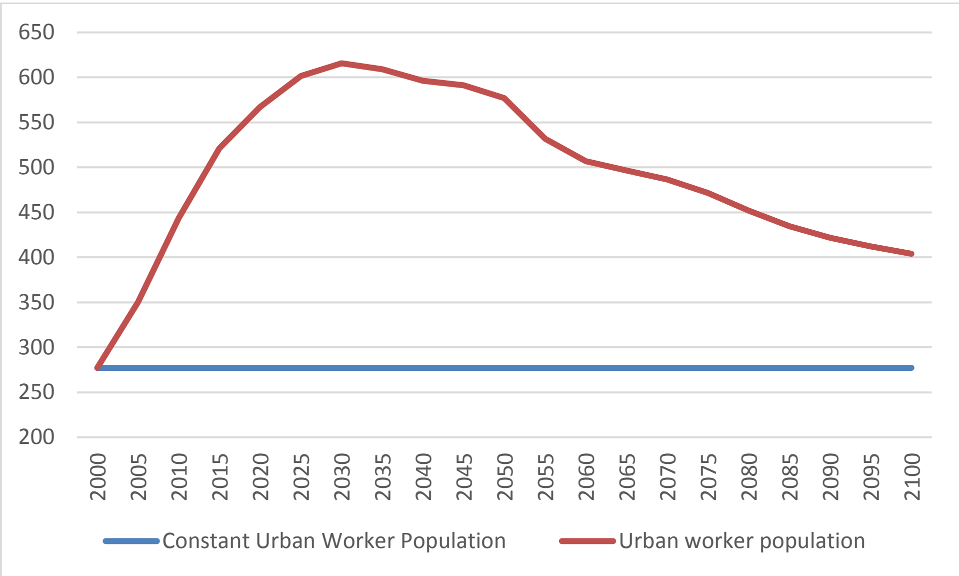

Figure 7-8 Constant Worker Population (2000-2100)

Source: author calculation.

Comparing with the baseline projection, we can see that a lower worker population will greatly lower the cumulative growth of the urban land price (see Fig. 7-9). This result suggests that the growth of urban worker population is the dominant demographic factor supporting the rising of the urban land price in the baseline projection.

Second, if we suppose that the survival rates of households are constants from 2000 (see Fig. 7-2), the counterfactual simulation results are shown in Fig. 7-11 and 7-12. As we can see, this change has little impacts on the growth rates from 2000 to 2100. Recall that we have shown that the changes in longevity have significant effect on land prices in Chapter 5, then why the lower longevity here has little influence on the growth rates?

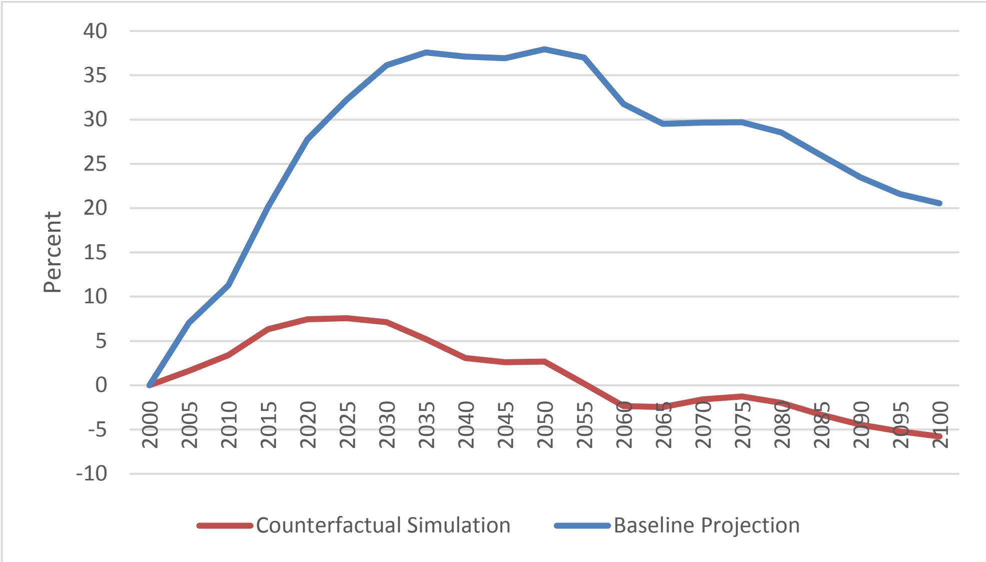

Figure 7-9 Counterfactual Simulation with Lower Worker Population: Cumulative Growth of the Urban Land Price (2000-2100)

Source: author calculation.

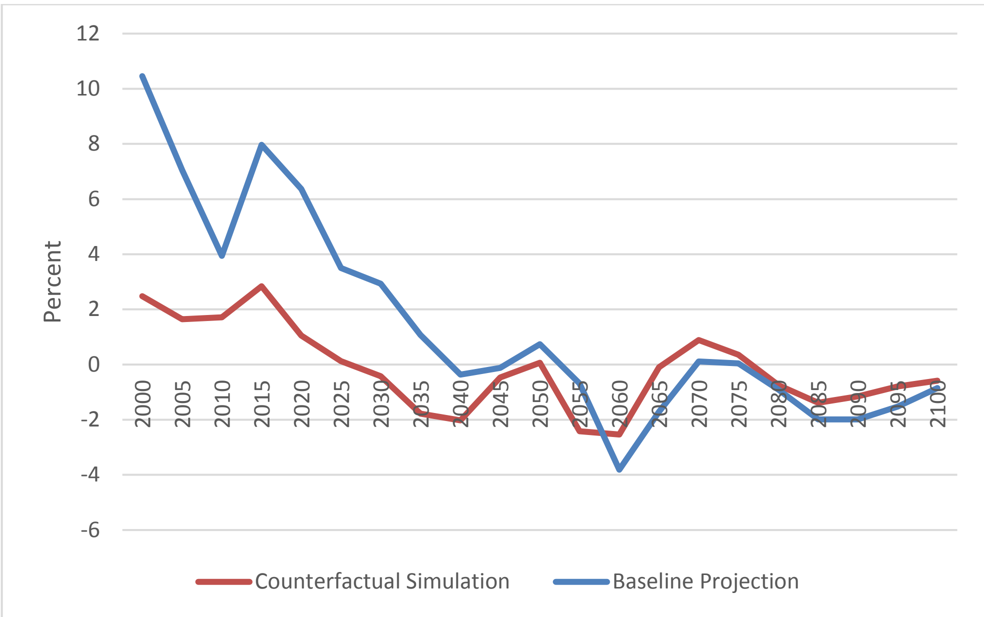

Figure 7-10 Counterfactual Simulation with Lower Worker Population: Growth Rates of the Urban Land Price (2000-2100)

Source: author calculation.

The first reason is that, because of perfect foresight, the bulk of the effect of survival rate changes happen before 2000. Thus, for the periods of our concern, the impacts have been absorbed beforehand. Second, the survival rate changes here have different consequences compared with that of the Chapter 5. When we change the survival rates in Chapter 5, the corresponding households' age structure changes. However, in this chapter, the age structure is viewed as an independent exogenous variable because of migration. Therefore, the effects of age structure changes are isolated from that of the longevity changes, so the impacts of the longevity changes are weakened.

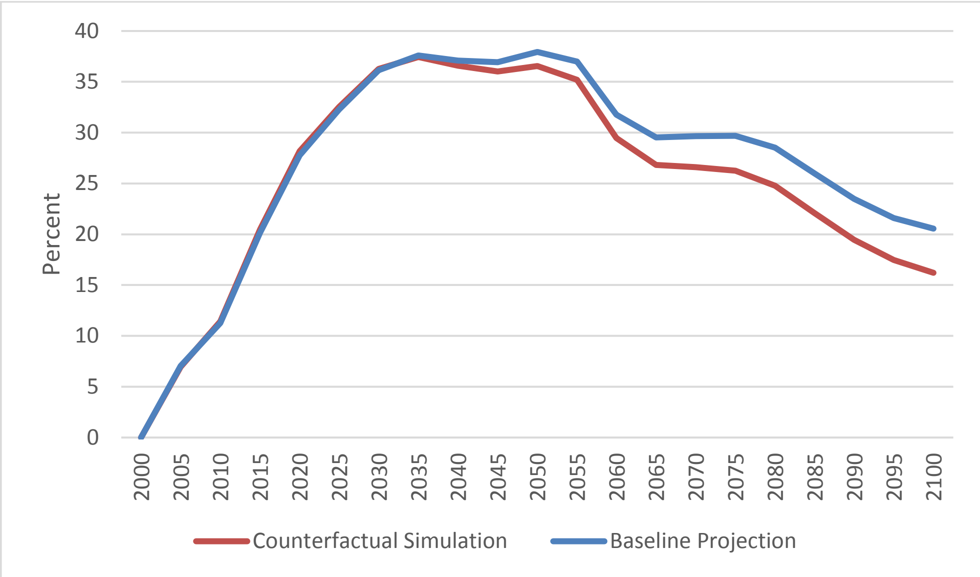

Figure 7-11 Counterfactual Simulation with Lower Longevity: Cumulative Growth of the Urban Land Price (2000-2100)

Source: author calculation.

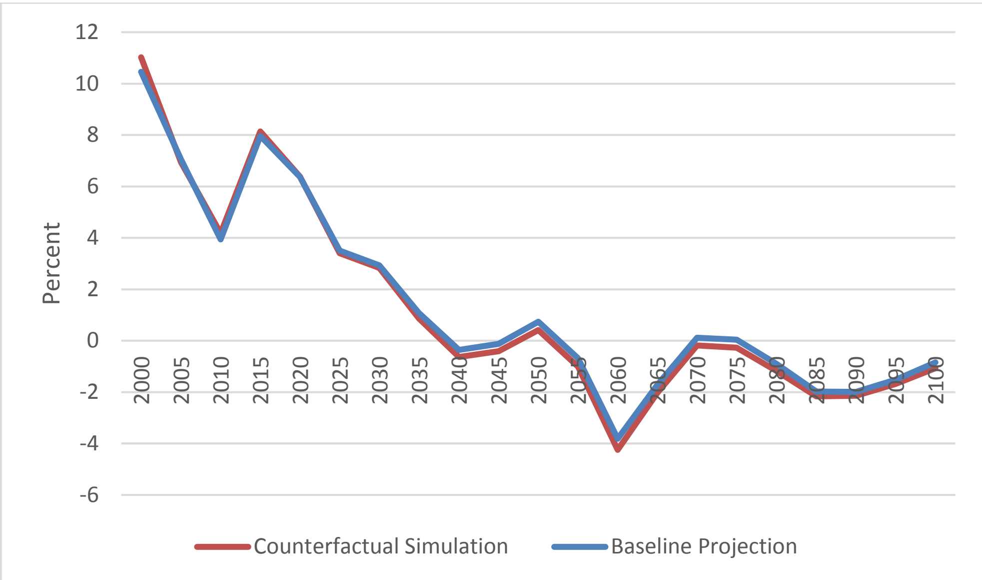

Figure 7-12 Counterfactual Simulation with Lower Longevity: Growth Rates of the Urban Land Price (2000-2100)

Source: author calculation.

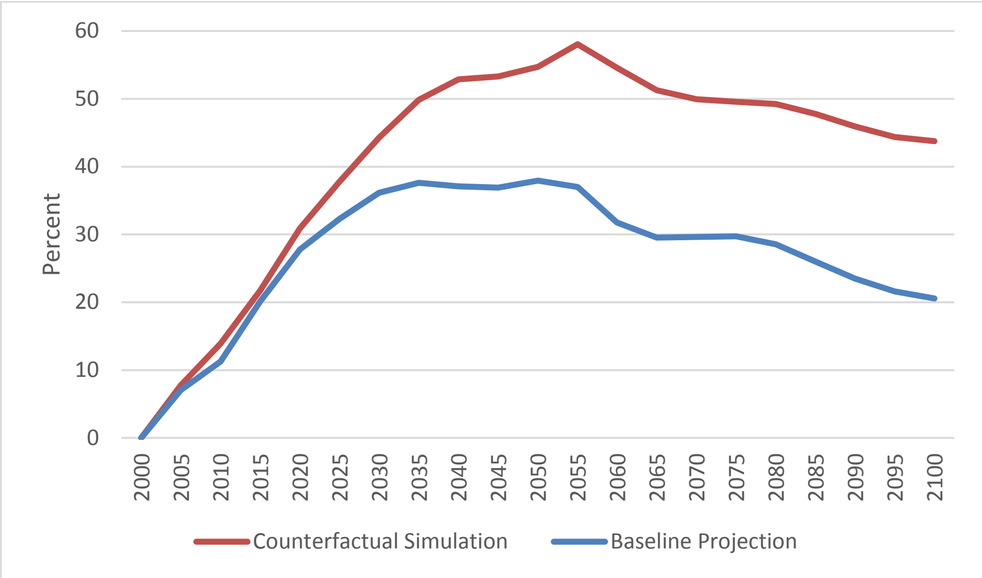

Figure 7-13 Counterfactual Simulation with Younger Age Structure: Cumulative Growth of the Urban Land Price (2000-2100)

Source: author calculation.

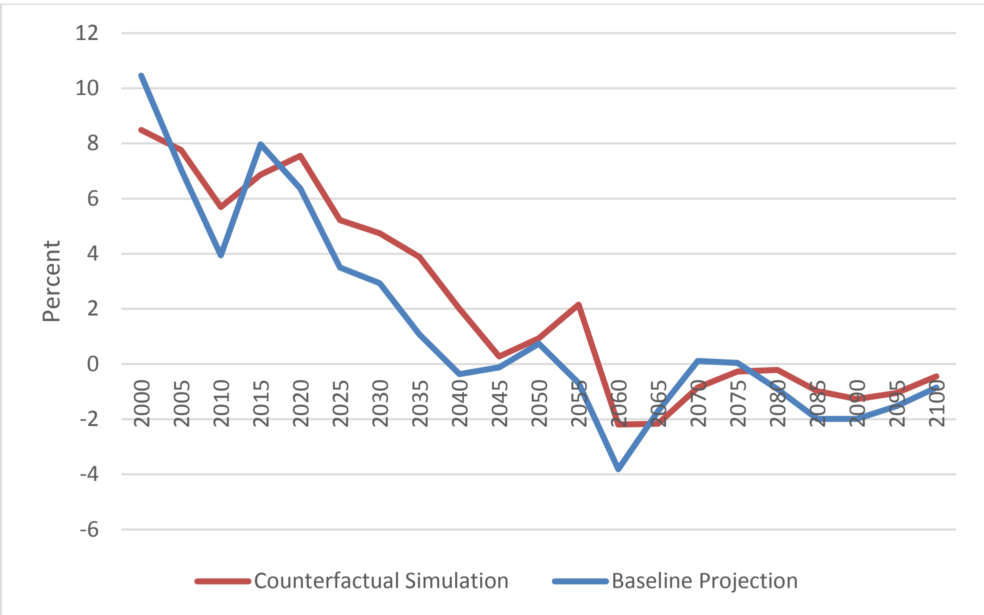

Figure 7-14 Counterfactual Simulation with Younger Age Structure: Growth Rates of the Urban Land Price (2000-2100)

Source: author calculation.

Regarding the age structure, when it is held constant to that of 2000 during the simulation, the results comparing with the baseline projection are shown in Fig. 7-13 and 7-14. Note that the age structure in 2000 is the youngest in this century (see Fig. 7-3), this comparison could tell us the effect of a younger age structure on the land price dynamics. As shown in Fig. 7-13, because of a younger age structure, the growth rates of land price are higher than that of the baseline projection in most of the periods. This result suggests that the age structure changes from 2000 to 2100 will significantly depress the growth rates of land price in urban China.

The key findings of the quantitative study in this section can be summarized as follows. First, the historical land price dynamics in China can be explained from the perspective of income and demography. Second, the on-going aging population in China will drag down the land price during the second half of this century, but will not force the dynamics into a crash. Third, the demographic factors have divergent effects on the land price. Specifically, the rising of the urban worker population is supporting the price in general, while the age structure changes are depressing it.

Age Structure and Land Demand

Within the three exogenous variables, the effects of worker population and longevity on land prices have been discussed in detail in the previous chapters. Nonetheless, the effect of age structure changes has not been discussed. Since this factor can only be isolated when migration is significant in the demographic changes, this discussion has to be located here instead of the previous chapters. Then, how does age structure affect land prices?

The key to answer the above question is noting the difference in demand for land by different age groups. As shown in Fig. 7-15, the land demand in our simulation varies across the age groups. In general, the land demand of the middle age groups is higher, and that of the youth and elderly is lower. This result corresponds well with the life cycle hypothesis about households saving behaviour. When age structure changes, the total land demand will change accordingly. For example, if more of the households are in the age group nine / sixteen, the total land demand will be higher / lower. Note that the land supply is fixed in our simulation, ceteris paribus, the changes in land demand will determine the price dynamics. Consequently, the land price will rise / decline.

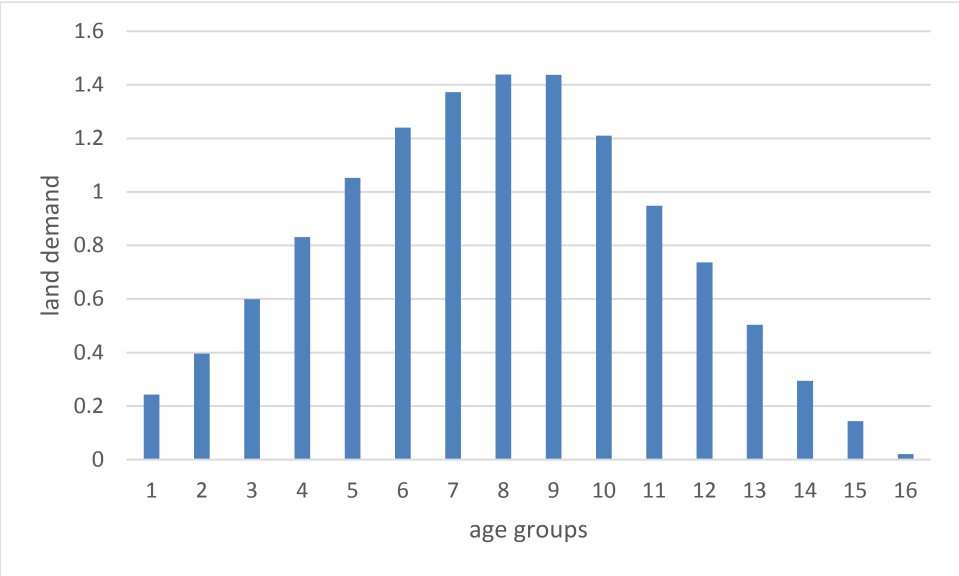

Figure 7-15 De-trended Per Capita Land Demand of Different Age Groups (Baseline Projection in 2000)

Source: author calculation.

The mechanism above provides a brief explanation about how changes in the age structure affect land prices. In fact, the empirical studies, such as Mankiw and Weil (1989), have adopted this mechanism in predicting the house prices. They used a survey data of house owned per capita by age to forecast the house price dynamics according to the predicted age structure changes. However, the model in this chapter will show that the demand is conditional on and subject to demographic changes. Therefore, the historical survey data cannot provide accurate predictions about the demand in the future.

To begin with, the growth rate of worker population will change the land owned per capita. For instance, when the worker population keeps growing, the land owned per capita would tend to decline because the land supply is fixed in our assumptions. Furthermore, even if we only consider the de-trended value of the per capita owned land, this value will also change in different circumstances. For example, the de-trended per capita owned land of the baseline projection in different periods is shown in Fig. 7-16. As we can see, this land demand by age groups varies across the periods. In 2000, the households have the highest per capita land demand among all the periods. After that, this demand decreases along with time until 2060. From 2060 to 2100, this land demand stays in a stable state.

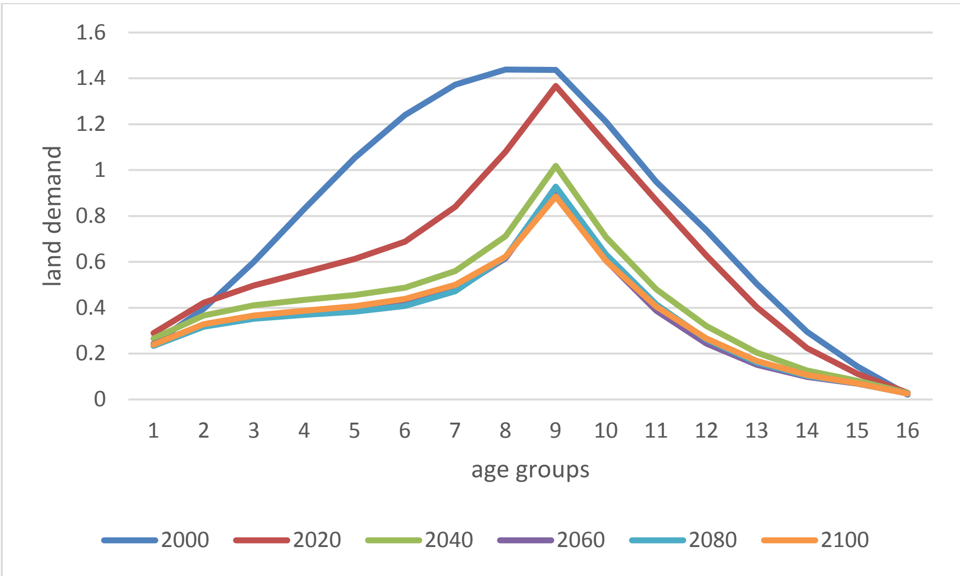

Figure 7-16 De-trended Per Capita Land Demand of the Baseline Projection

Source: author calculation.

Next, we will study the specific mechanisms that how the demand of land is affected by the demographic changes. First, we argue that a higher / lower growth rate of worker population will indicate a higher / lower land demand of households. To illustrate, we calculate the per capita land demand of households when the worker population growth rates are 0.2, 0, and -0.1 respectively, and the results are shown in Fig. 7-17. As we can see, the results correspond well with our argument above. The direct reason is that a higher land price is predicted by the households in the next period. When the worker population growth rate is higher, the price of land would tend to rise according to Eq. 7-18. Thus, purchasing land becomes a better saving method, and consequently, the land demand of households rises.

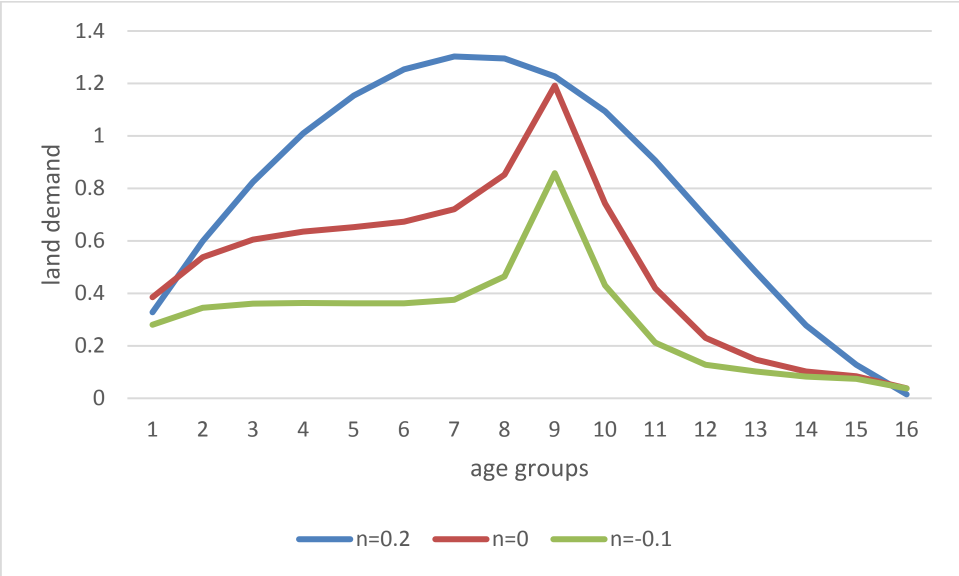

Figure 7-17 De-trended Per Capita Land Demand for three rates of growth of Worker Population

Note: the calculation is based on hypothetical worker population growth rates, and the other settings are the same as the baseline projection in 2000.

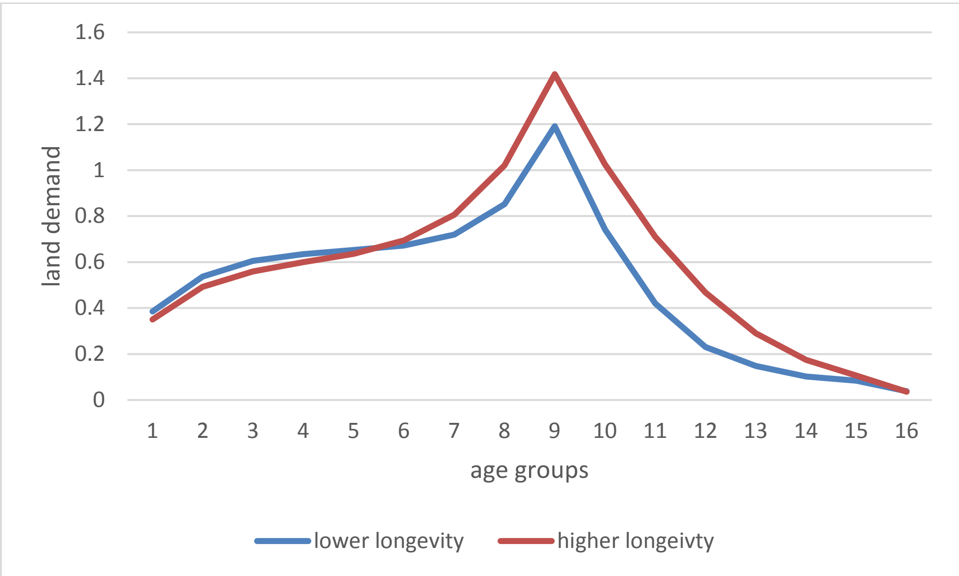

Figure 7-18 De-trended Per Capita Land Demand of Various Longevity

Note: the lower / higher longevity uses the survival rates in 2000 / 2100, other settings are the same as in the baseline projection in 2000.

Second, we argue that a higher / lower longevity suggests a higher / lower land demand of households. To test this argument, we simulate the land demand of households by changing the longevity only, and the results are shown in Figure 7-18. As we can see, the results are supportive of our argument above. The mechanism of this movement can also be explained from the perspective of households' behaviour. Note that a higher longevity indicates more savings are required to support the consumption, the land demand will increase correspondingly because land ownership is the only means of saving in the model (as it is one of the major sources of saving in reality).

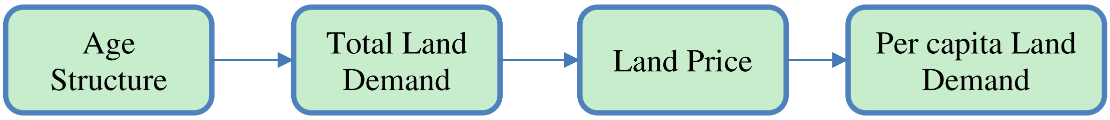

Figure 7-19 The Effect Channel from Age Structure Changes to Per capita Land Demand

Figure 7-20 De-trended Per Capita Land Demand: Age Structure Changes

Note: the calculation is based on hypothetical age structures, the detail will be listed in Appendix. The other settings are the same as the baseline projection in 2000.

Lastly, the per capita land demand will vary when age structure changes. Specifically, when the age structure is more centred, the per capita owned land will be lower ceteris paribus. The mechanism driving the differences is shown in Fig. 7-19. In the first step, the changes of age structure will affect the total land demand of households as discussed above. Supposing the age structure is more centred, then the total land demand will rise. Then, because of the rising of the land demand, the land price will rise accordingly. Finally, the raised land price will depress the per capita land demand. When we face a less centred age structure, the effects are opposite. The Fig. 7-20 below is presented as an example of this illustrated mechanism.

Conclusion

The literature on the drivers for land prices suggests that demography is an important factor[18]. However, the forecasting of the land price dynamics has long been long reliant on the data-driven methods instead of theoretical models. In this study, we want to fill this gap by forecasting the effects on land price using the case of China. Choosing China also has significant practical meaning because China is experiencing a strongly aging population, which would, according to the life-cycle hypothesis, drag down land prices. Since the land price has profound influences on the households' wealth and macroeconomic stability, our forecasting should answer the question that whether the price of land will collapse due to the aging of the population?

To answer this question, this chapter develops an OLG model with multiple generations, and uses simulations to forecast the land price dynamics using parameters for the model from urban China. To check if this simulation could provide clues to the future land price, we fit the historical data from 2005 to 2015 using the projections. The reasonable fit of the historical data to the results from the simulation indicates that the rapid rise in land price over the past decade can be explained from the perspective of income and demography. Although demography plays a secondary role in driving land prices, it is the more predictable and stable factor compared to GDP.

Next, we present the baseline projection of land price dynamics from 2000 to 2100. The result shows that the aging of the population on its own will not lead to a collapse in land prices. Specifically, although the land prices have been cooling down, demographic changes will continue to raise land prices until 2035, following which they stabilise until 2055. After that, the impact on land prices from demographic changes are negative, meaning that land prices decline until the end of this century. However, the decline of land price is predicted to be moderate and very different to the pattern during the upswing.

The forecast above is based on three exogenous variables used in this simulation: 1) worker population, 2) longevity, and 3) age structure. This chapter also examined their effects using counterfactual simulations. In particular, from 2000 to 2100, the overall effect of worker population on land price dynamics is positive, and the bulk of the rise is caused by the increase of worker population. In contrast, the overall effect of the aging age structure is

[18] See, for example, Chen, Guo, and Wu (2011), Li and Chand (2013), and Choi and Jung (2016).

negative from 2000 to 2100, which corresponds well with the Life-Cycle Hypothesis. Here, we want to emphasize that the age structure changes cannot represent the whole aging population process on its own. Instead, as illustrated in the context, the age structure is only a part of it and could be viewed as an independent variable only when the migration is significant. Lastly, the effect of longevity is not significant from 2000 to 2100 because the bulk of its effects are absorbed by 1) the price changes beforehand, and 2) the effect of age structure changes.

Besides an analysis of these issues, we discussed the drawbacks of the forecast when conducted by historical survey data. We argue that this kind of forecast depends on the per capita land owned of households; however, this land demand is conditional and will vary in different circumstances. In fact, our simulations suggest that all the three exogenous demographic factors can change the demand significantly. Thus, the data-driven methods may have limited capacity in forecasting the land price when the demographic changes are substantial.

Several caveats to the conclusions drawn above are in order here. These include the fact that the OLG model has been used for the simulations, in which the households are assumed to be homogenous in each and every age group. Further research may consider the heterogeneity agent models for improvements. The other issue regards with the data of land price that we adopt. We care about the average contract price of the land in this study; however, the real payment of the building business could also include the taxes and the compensation to households for land acquisition. Thus, the real payment could be much higher than the contract price, and these extra payments are left for further studies.

In sum, this chapter contributes the literature that studying the effect of aging by analysing the case of China. The results suggest that the demography has profound impact on the land prices, but a meltdown is unlike to happen in China. These results could also be of practical value to both the households and policymakers.

References

Bai, Chong-En, Chang-Tai Hsieh, and Yingyi Qian. 2006. "The Return to Capital in China." *National Bureau of Economic Research Working Paper Series* No. 12755. doi: 10.3386/w12755.

Balestra, Carlotta, and Davide Dottori. 2011. "Aging society, health and the environment." *Journal of Population Economics* 25 (3):1045-1076. doi: 10.1007/s00148-011-0380-x.

Cervellati, Matteo, and Uwe Sunde. 2011. "Life expectancy and economic growth: the role of the demographic transition." *Journal of Economic Growth* 16 (2):99-133. doi: 10.1007/s10887-011-9065-2.

Chen, Junhua, Fei Guo, and Ying Wu. 2011. "One decade of urban housing reform in China: Urban housing price dynamics and the role of migration and urbanization, 1995–2005." *Habitat International* 35 (1):1-8. doi: http://dx.doi.org/10.1016/j.habitatint.2010.02.003.

Choi, Changkyu, and Hojin Jung. 2016. "Does an economically active population matter in housing prices?" *Applied Economics Letters*:1-4. doi: 10.1080/13504851.2016.1251547.

Curtis, Chadwick C., Steven Lugauer, and Nelson C. Mark. 2015. "Demographic Patterns and Household Saving in China." *American Economic Journal: Macroeconomics* 7 (2):58-94. doi: doi: 10.1257/mac.20130105.

Deng, Yongheng, Eric Girardin, and Roselyne Joyeux. 2016. "Fundamentals and the volatility of real estate prices in China: A sequential modelling strategy." *China Economic Review*. doi: https://doi.org/10.1016/j.chieco.2016.10.011.

Gupta, Rangan, and Anandamayee Majumdar. 2015. "Forecasting US real house price returns over 1831–2013: evidence from copula models." *Applied Economics* 47 (48):5204-5213. doi: 10.1080/00036846.2015.1044648.

Iacoviello, Matteo. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *The American Economic Review* 95 (3):739-764.

Iacoviello, Matteo, and Stefano Neri. 2010. "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics* 2 (2):125-64. doi: doi: 10.1257/mac.2.2.125.

Li, Qiang, and Satish Chand. 2013. "House prices and market fundamentals in urban China." *Habitat International* 40:148-153. doi: http://dx.doi.org/10.1016/j.habitatint.2013.04.002.

Liu, Yansui, Fang Fang, and Yuheng Li. 2014. "Key issues of land use in China and implications for policy making." *Land Use Policy* 40:6-12. doi: http://dx.doi.org/10.1016/j.landusepol.2013.03.013.

Liu, Zheng, Pengfei Wang, and Tao Zha. 2013. "Land-Price Dynamics and Macroeconomic Fluctuations." *Econometrica* 81 (3):1147-1184. doi: 10.3982/ECTA8994.

Mankiw, N. Gregory, and David N. Weil. 1989. "The baby boom, the baby bust, and the housing market." *Regional Science and Urban Economics* 19 (2):235-258. doi: http://dx.doi.org/10.1016/0166-0462(89)90005-7.

Muto, Ichiro, Takemasa Oda, and Nao Sudo. 2016. "Macroeconomic Impact of Population Aging in Japan: A Perspective from an Overlapping Generations Model." *IMF Economic Review* 64 (3):408-442. doi: 10.1057/imfer.2016.6.

Ng, Eric C. Y. 2015. "Housing market dynamics in China: Findings from an estimated DSGE model." *Journal of Housing Economics* 29:26-40. doi: http://dx.doi.org/10.1016/j.jhe.2015.05.003.

Plakandaras, Vasilios, Rangan Gupta, Periklis Gogas, and Theophilos Papadimitriou. 2015. "Forecasting the U.S. real house price index." *Economic Modelling* 45:259-267. doi: http://dx.doi.org/10.1016/j.econmod.2014.10.050.

Rapach, David E., and Jack K. Strauss. 2009. "Differences in housing price forecastability across US states." *International Journal of Forecasting* 25 (2):351-372. doi: http://dx.doi.org/10.1016/j.ijforecast.2009.01.009.

Ren, Yu, Cong Xiong, and Yufei Yuan. 2012. "House price bubbles in China." *China Economic Review* 23 (4):786-800. doi: https://doi.org/10.1016/j.chieco.2012.04.001.

Shen, Ling. 2012. "Are house prices too high in China?" *China Economic Review* 23 (4):1206-1210. doi: https://doi.org/10.1016/j.chieco.2012.03.008.

Takáts, Előd. 2012. "Aging and house prices." *Journal of Housing Economics* 21 (2):131-141. doi: http://doi.org/10.1016/j.jhe.2012.04.001.

Wang, Zhi, and Qinghua Zhang. 2014. "Fundamental factors in the housing markets of China." *Journal of Housing Economics* 25 (Supplement C):53-61. doi: https://doi.org/10.1016/j.jhe.2014.04.001.

Wei, Yu, and Yang Cao. 2017. "Forecasting house prices using dynamic model averaging approach: Evidence from China." *Economic Modelling* 61:147-155. doi: https://doi.org/10.1016/j.econmod.2016.12.002.

Wu, Jing, Joseph Gyourko, and Yongheng Deng. 2016. "Evaluating the risk of Chinese housing markets: What we know and what we need to know." *China Economic Review* 39 (Supplement C):91-114. doi: https://doi.org/10.1016/j.chieco.2016.03.008.

Xie, Yu, and Yongai Jin. 2015. "Household Wealth in China." *Chinese Sociological Review* 47 (3):203-229. doi: 10.1080/21620555.2015.1032158.