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Does the early retirement policy really benefit women?

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Abstract

China's mandatory retirement policy requires the most female workers to retire five years earlier than their male counterparts. The conventional wisdom behind this policy is that it benefits women by relieving them from work earlier and providing them with more years of public pension benefits than men. However, is the early retirement policy really welfare-improving for women? In this paper, we quantitatively evaluate the welfare consequence of China's gender-specific mandatory retirement policy using a calibrated Overlapping-Generation model with heterogeneous agents and incomplete markets. We find that the early mandatory retirement reduces welfare for women. An important reason behind this welfare result is that China's public pension benefits are only partially indexed to growth, and therefore women who retire earlier also benefit less from economic growth than men. Our quantitative results suggest that equalizing the retirement age across gender can generate a welfare gain for both men and women.

Keywords: Social Security, China, Mandatary Retirement, Gender.

JEL Classifications: E20, E60, H30

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1 Introduction

China's mandatary retirement policy requires the most female workers to retire five years earlier than their male counterparts. Meanwhile, these women can start collecting public pension benefits five years earlier than men.[1] The conventional wisdom behind this policy is that the early retirement policy benefits women because it allows women to enjoy leisure and public pension benefits earlier than men. However, does this policy really improve the welfare for women? To the best of our knowledge, this question has not been answered in the literature. The goal of this paper is to fill this gap.

We argue that the early retirement (EAR) policy may have negative effects on individual welfare. For instance, when public pension benefits are not fully indexed to wage growth, women who retire earlier will benefit less from economic growth. This mechanism can be particularly important in emerging economies such as China. Moreover, when the annuity market (i.e. the insurance market for uncertain lifetime) is missing and labor income is an important alternative source of insurance for uncertain lifetime, retiring earlier also implies more exposures to the risk of uncertain lifetime. As is well-known in the literature, the annuity market is thin in most countries.[2] This implies that by retiring earlier, women may also get substantially more exposure to the risk of uncertain lifetime if labor income is an important alternative partial insurance for such risk.

To formalize these mechanisms, we develop an Overlapping Generations (OLG), General Equilibrium (GE) model of social security with heterogeneous agents and incomplete markets. Agents face mortality risks over the life cycle. Before retirement, agents earn labor income by supplying labor to the labor market. After retirement, they live on social security annuities and private savings. Social security annuities are financed by a payroll tax on working agents. In the model, agents can smooth consumption over time via private savings, but they do not have access to private annuity markets.[3] The benchmark model economy also features a constant rate of technological progress, but the social security benefits are only partially indexed to wage growth.[4]

[1] Some related policies are seen in many other countries in the world. Please see the appendix for a description of some related retirement policies in other countries in the world.

[2] For example, Yaari (1965), Pashchenko(2013), Zhao (2015), and among others.

[3] The data shows that the private annuity markets were very thin over the last several decades in most countries. For instance, Warshawsky (1988) estimated that only approximately 2% - 4% of the U.S. elderly population owned private annuities from the 1930s to the 1980s. A common explanation for the lack of private annuity markets is that the adverse-selection problem in private annuity markets reduces the yield on these annuities.

[4] Please see the appendix for a detailed description of the growth indexation rules for retirement benefits in different

We calibrate the benchmark model to the current Chinese economy and use the calibrated model to quantify the welfare consequence of the EAR policy. We find that switching from the current EAR policy to the equal retirement (EQR) policy (men and women both retire at age 60) can generate a welfare gain for women. Furthermore, we design additional counter-factual experiments to decompose the welfare consequence of the EAR policy. First, women can be negatively affected by early retirement because public pension benefits are only partially indexed to wage growth. To examine this channel, we reexamine the EQR policy experiment in a counterfactual economy in which public pension benefits are fully indexed to growth. In the counterfactual economy with full indexation, women suffer a welfare lose when the retirement age policy switches from EAR to EQR. Second, women get more exposures to the risk of uncertain lifetime because of the EAR policy. To study this channel, we assume away mortality risk and recompute the EQR policy experiment. We find that in the counterfactual economy without mortality risk, the welfare gain is smaller when the retirement policy switch from the EAR to the EQR.

Our paper is closely related to the large and still growing literature that studies social insurance policies (particularly, social security policy) in the context of OLG model.[5] Started with the seminal work by Auerbach and Kotlikoff (1987), this literature has studied a wide range of issues, including the saving and welfare implications of social security, policy reforms, the impact of demographic changes on social security, the impact of social security on aggregate health expenditure, and so on. For instance, Imrohoroglu, Imrohoroglu and Joines (1995) argue that optimal social security replacement rate should be 30% in the United States by assuming retirement age of 65. Conesa and Krueger (1999) study social security reforms and find a transition from the current pay-as-you-go social security system to a fully funded system lacks political support. After calibrating the model into U.S. economy, they find this two-tier social security system in general reduces welfare. Fuster, Imrohoroglu, and Imrohoroglu (2007) find that in an OLG model featuring intergenerational links and altruism, eliminating social security is welfare-improving for more than half of the current population. Kitao (2014) studies four potential reforms to make the social security system sustainable. Zhao (2014) studies the impact of social security on aggregate health spending, and finds that the

countries.

[5]Auerbach and Kotlikoff (1987), Imrohoroglu, Imrohoroglu and Joines (1995), Conesa and Krueger (1999), Huggett and Ventura (1999), Fuster Imrohoroglu, and Imrohoroglu (2007), Zhao (2011), Zhao (2014), Braun, Kopecky, and Koreshkova (2017), Zhao (2017), Imrohoroglu and Zhao (2018), etc.

expansion of social security is an important cause of the dramatic rise in health spending in the U.S. However, most existing studies only focus on the developed countries and have abstracted from the issue of differential retirement ages by gender. We argue that gender difference has important welfare implications, particularly in the developing countries like China, and thus should not be ignored in discussion of social security and retirement issues.

The rest of the paper is organized as follow: in Section 2, we introduce the benchmark model; in Section 3, we calibrate the benchmark model to the Chinese economy; in Section 4 and 5, we discuss in detail the quantitative results; in Section 6 and 7, we conduct sensitivity analysis and conclude.

2 The Benchmark Model

We construct an overlapping generations model with heterogenous agents and incomplete markets. In each period, the labor-augmented technology increases by the rate of γ. Hence, the equilibrium wage and capital stock also grow at the rate of γ.

2.1 The Individual

The economy is populated with overlapping generations of agents whose maximum lifetime is J periods. Agents face the following expected lifetime utility:

$$E\sum_{j=1}^{J}\beta^{j-1}[\prod_{k=1}^{j}\psi_k]U(c_j,h_j)$$

where β is the subjective discount rate; ψ_j is the conditional survival rate from age $j-1$ to j, c_j is consumption and h_j is hours worked.

In each period t, a new generation of agents with gender $g \in \{m, f\}$ and education level $e \in \{e_{low}, e_{high}\}$ enters the economy, where $g \in \{m, f\}$ represent male and female and $e \in \{e_{low}, e_{high}\}$ represent the low and high level of education.[6]. In addition, agents also receive idiosyncratic shock η on their labor productivity at the start of each period.

[6]In the benchmark calibration, we classify people achieved more than high school as the high educated and people achieved only high school or less as the low educated.

At time t, agents of the working age receive the after-tax labor income $(1-\tau)w_t\eta\epsilon_j^{g,e}h_j(a,e,\eta,g)$. w_t is the equilibrium wage at time t. τ is the social security payroll tax. $\epsilon_j^{g,e}$ is the common deterministic labor efficiency for agents of gender g and level of education e at age j. At the start of each period, agents draw idiosyncratic labor productivity shock η. The idiosyncratic labor productivity shock η follow a Markov process and is drawn from a 5×5 transitional matrix $\Pi(\eta,\eta') = \pi_{\eta,\eta'}$, where $\pi_{\eta,\eta'}$ is the probability of drawing the idiosyncratic labor productivity shock η' next period given today's labor productivity shock η. The policy function for the hours worked h_j at age j is a function of state variables: age, asset holding, level of education, labor productivity idiosyncratic shock, and gender.

After the (gender-specific) retirement age j_g^*, the retirement benefit is partially indexed to economic growth rate. In practice, agents receive indexation rate x of current social security benefits and $1-x$ of their own retirement benefit. For simplicity, the retirement benefit b_e^g is the same within the group of the agents with the same level of education and gender. The retirement benefits are calculated as a fraction θ of the average before-tax labor income within that group. If agents die before the maximum age J, their savings become accidental bequests that are redistributed equally to all surviving agents.

In general, the income q_j for a given agent over his or her life cycle can be expressed as[7]:

$$q_j = \begin{cases} (1-\tau)w(1+\gamma)^{j-1}\eta\epsilon_j^{g,e}h_j(a,e,\eta,g) & \text{for j<j}_g^* \\ (1-x)b_e^g + xb_e^g(1+\gamma)^{j-j_g^*} & \text{for j}\geq\text{j}_g^* \end{cases} \tag{1}$$

where

$$b_e^g = \theta\frac{\sum_1^{j^*-1}\sum_a\sum_\eta w(1+\gamma)^{j_g^*-1}\eta\epsilon_j^{g,e}h_j(a,e,\eta,g)\lambda_j(a,e,\eta,g)}{\sum_1^{j^*-1}\sum_a\sum_\eta \lambda_j(a,e,\eta,g)}$$

where $\lambda_j(a,e,\eta,g)$ is population distribution. The budget constraint faced by an agent at age j can be written as

$$c_j + a_{j+1} = q_j + (1+r)[a_j + \phi_j]$$

[7]In order to avoid complications in notation, We apply the properties of balanced growth path for normalization. Assume an agent born at time i receives wage w per unit of effective labor. At time $i+1$, the wage he or she receives equals $w(1+\gamma)$. Therefore, at time $i+j-1$, where $j < j_g^*$, the agent is at age j and receives wage $w(1+\gamma)^{j-1}$; when $j \geq j_g^*$, the agent receive retirement benefit that equals the indexational weighted average of his or her own retirement benefit and the retirement benefit of the younger cohort who just enter retirement at time $i+j$.

where r is interest rate. a_{j+1} is asset saved for $j+1$ age at age j. Agents are born with no assets $a_1 = 0$. Agents have no altruistic motivation to leave bequest, so at maximum age $a_{J+1} = 0$. ϕ_j is accidental bequest. Since at the balanced growth path, the accidental bequest is an aggregate value, and it grows by γ each period as agents age.

2.2 The Production Technology

The production technology of the economy is given by a constant return to scale Cobb-Douglas production function:

$$Q = f(K, AN) = K^{1-\alpha}(AN)^{\alpha}$$

where $A > 0, 0 < \alpha < 1$. At time t, the labor augmented technology factor equals to A_t and it grows at the growth rate γ each period. The aggregate capital stock is assumed to depreciate at the rate δ.

The first-order conditions determine the net real return to capital and the real wage of time t:

$$r = (1-\alpha)\left[\frac{K_t}{A_t N}\right]^{-\alpha} - \delta, w_t = \alpha A_t \left[\frac{K_t}{A_t N}\right]^{1-\alpha} \tag{2}$$

2.3 Competitive Equilibrium

Definition: A competitive equilibrium for a given set of the policy arrangements $\{\theta\}$ is a collection of the individual policy rules $C_j(a,e,\eta,g), S_j(a,e,\eta,g), H_j(a,e,\eta,g)$ for the agents who are born in time t with the relative prices of labor and capital$\{r,w\}$ at time t, the population measure $\lambda_j(a,e,\eta,g)$, and the accidental bequest Φ_t of time t, such that at time $t+J$

1. The individual decision rules solve the individual's optimization problem.

2. The aggregate factor inputs are generated by the decision rules of the agents:

$$K = \sum_j \sum_a \sum_e \sum_\eta \sum_g \lambda_j(a,e,\eta,g) S_j(a,e,\eta,g)(1+\gamma)^{J-j} \tag{3}$$

$$N = \sum_j^{j_g^*-1} \sum_a \sum_e \sum_\eta \sum_g \lambda_j(a,e,\eta,g)\eta\epsilon_j^{g,e} H_j(a,e,\eta,g) \tag{4}$$

3. The relative prices $\{r,w\}$ solve the firm's profit maximization problem by satisfying the firm's first order condition

4. Given the relative price $\{r, w\}$, the government policy $\{\theta\}$, and the lump-sum transfer Φ, the individual policy rules C_j, S_j, H_j solve the individual's problem.

5. The commodity market clears:

$$\sum_j \sum_a \sum_e \sum_\eta \sum_g \lambda_j (C_j + S_j)(1+\gamma)^{J-j} = F(K, AN)$$

$$+(1-\delta) \sum_j \sum_a \sum_e \sum_\eta \sum_g \lambda_j S_{j-1} (1+\gamma)^{J-j} \tag{5}$$

where K is the capital stock at time $t+J$ and A is labor-augmented productivity at time $t+J$.

6. The population measure is updated through:

$$\lambda_{j+1}(a', e, \eta', g) = \sum_j \sum_a \sum_e \sum_\eta \sum_g \Pi(\eta', \eta) \psi_{j+1} \lambda_j (a, e, \eta, g) \tag{6}$$

7. The social security system is self financing:

$$\tau = \frac{\sum_{j_g^*}^{J} \sum_a \sum_e \sum_\eta \sum_g \lambda_j (a, e, \eta, g)[(1-x) b_e^g (1+\gamma)^{J-j} + x b_e^g (1+\gamma)^{J-j_g^*}]}{w(1+\gamma)^{J-1} N} \tag{7}$$

8. The lump-sum distribution of accidental bequest is determined by

$$\Phi = \sum_j \sum_i \sum_e \sum_\eta \sum_g (1-\psi_{j+1}) \lambda_j (a, e, \eta, g) S_j (a, e, \eta, g)(1+\gamma)^{J-j} \tag{8}$$

$$\Phi_t = \phi_t = \frac{\Phi}{(1+\gamma)^{J-1}} \tag{9}$$

3 Calibration

The benchmark model is calibrated to the Chinese economy in 2010 with each period representing one year. Table 1 summarizes the main results of the benchmark calibration.

Table 1: Benchmark Calibration

Parameter	Description	Value/source
Demographics		
ψ_j^g	survival probability	Chinese Census (2010)
J	maximum age	81 (100 years old)
	men to women ratio	to match 1.0321 gender ratio of the working age population
	percentage of college educated	25% of men; 75% of women Chinese Census (2010)
Preference		
β	subjective discount rate	0.98 (Conesa and Krueger, 1999)
σ	coefficient of relative risk aversion	2.00 (Kitao, 2014)
κ	IES of labor	4.00 Kitao, 2014)
χ_m	leisure weight of male	to match 46.40 hours/week Chinese Census in 2010
χ_f	leisure weight of female	to match 43.63 hours/week Chinese Census in 2010
Labor Productivity		
$\epsilon_j^{e,g}$	age-gender-specific productivity	calculated by auther with CHNS data
ρ	persistence parameter	0.83 (He, Ning and Zhu, 2017)
σ_η^2	variance	0.075 (He, Ning and Zhu, 2017)
Production		
α	share of capital income	0.50 (Song et al, 2011)
δ	depreciation rate	0.10 (Song et al, 2011)
γ	economic growth rate	0.055 (Song et al, 2011)
Government		
θ	replacement rate	0.35 (Salditt et al,2007)
x	indexation rate	0.50 (Song et al, 2011)

3.1 Demography

Agents enter economy at age 20. We set the male to female gender ratio at birth to 1.0492 so that the men to women gender ratio of the working age population from 20 to 60 years old in the model matches the men to women gender ratio of the working age population in the 2010 Chinese Census data which is 1.0321.[8] Each period the agents face a gender specific survival probability of ψ_j^g to live to the next period. The survival rate ψ_j^g is obtained from Chinese Census in 2010.[9] Those who survive every period die at age 100. The mandatory retirement age is set to 60 for men and 55 for women to match Chinese legal retirement age. [10] According to the Chinese Census in 2010, for the population above 20 years ago, 25% of men and 22% of women are college educated. The model is calibrated to match these numbers.

[8]This means, at age 20, for every 100 female agents enter the economy, there are 104.92 male agents enter the economy. In the 2010 Chinese Census data, the gender ratio at age 20 is 1.0271. A more detailed discussion can be found in Section 6.3.

[9]The date measures the national average population and the number of the mortality from Nonmember 1, 2009 to October 31, 2010 by age and gender. Therefore, the survival rate =1−mortality/average population

[10]Workers at manufacture jobs retire at 55 for men and 50 for women. However, there are two reasons we pick mandatory retirement ages as 60 for men and 55 for women. First, manufacture jobs do not represent the whole labor market. Second, in our study five year retirement age difference is more significant than actual retirement age.

3.2 Preference and Production Technology

We use the separable CRRA utility function adopted by Kitao (2014), where χ_g, $g \subset \{m, f\}$, is the weight on leisure for men or women.

$$U(c,h) = \frac{c^{1-\sigma}}{1-\sigma} + \chi_g \frac{(1-h)^{1-\kappa}}{1-\kappa}$$

The intertemporal substitution rates of consumption and labor, σ and κ are set to 2 and 4 following Kitao (2014). The subjective discount factor β is set to 0.98 which is commonly used in economic literature.

The labor share in the production function α and the depreciation rate are set to 0.5 and 0.1 which is used by Song et al. (2011). The labor-augmented productivity factor A is normalized.

According to the Chinese National Bureau of Statistics (NBS), the average of hours worked per week are 46.40 for men and 43.63 for women. Therefore, we divide the average working hours per week by the maximum 98 hours per week. The average labor input is 47.35% for men and 44.52% for women. Those two numbers are used to pin down the leisure weights of men and women.

3.3 Labor Productivity

We use the China Health and Nutrition Survey (CHNS) data to calibrate the parameters related to labor productivity. Particularly, we assume that the log of the idiosyncratic productivity shock η follows a standard AR(1) process as in the quantitative macro literature, and we set the persistence parameter of the AR(1) process to 0.83 and the variance of the persistent shock to 0.075 based on the estimates in He, Ning and Zhu (2017). We then discretize the AR(1) process into a 5-state Markov chain using the Tauchen (1986) method.

The age-efficiency productivity ϵ is also estimated using the CHNS data. We follow the empirical method adopted by Kambourov and Manovskii (2009). Specifically, we estimate following equation:

$$wage_{its} = \beta_0 + \beta_1 age_{it} + \beta_2 age_{it}^2 + \delta_t year_t + \lambda_s province_s + \epsilon_{its}$$

where $wage_{its}$ is the natural logarithm of the average annual earning of cohort i at year t in province s, and age_{it} is the age of cohort i at year t. $year_t$ and $province_s$ are two sets of year and province dummies.

We use this empirical model to estimate the four types of agents in our model: the low educated male, the low educated female, the high educated male and the high female. Then, we calculate the earning profile based on the predicted values of $wage_its$ and adjust the vertical intercepts of the earning profiles to match the average earning gap between these groups in the data.

Figure 1 shows the smoothed age-efficiency labor productivity ϵ over the life cycle of Chinese workers by gender and level of education.

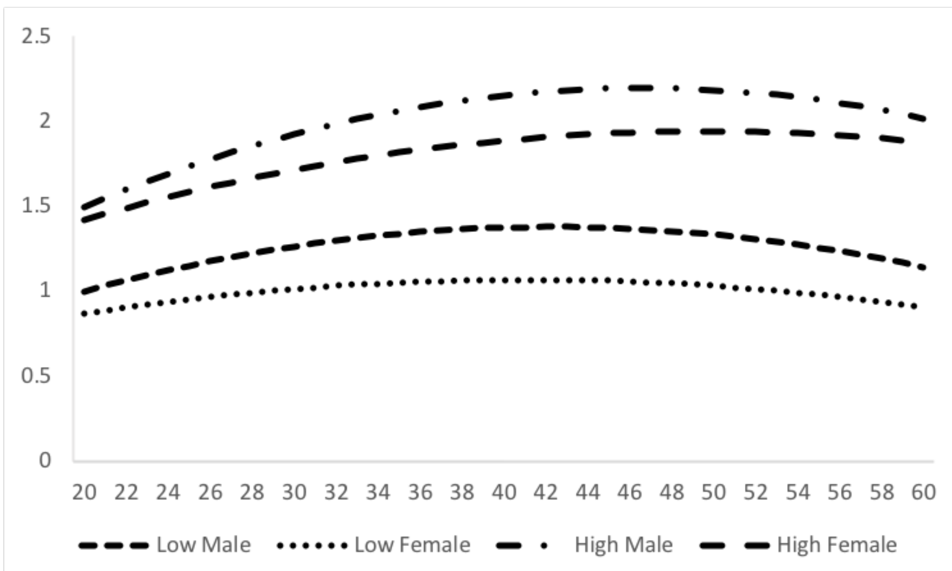
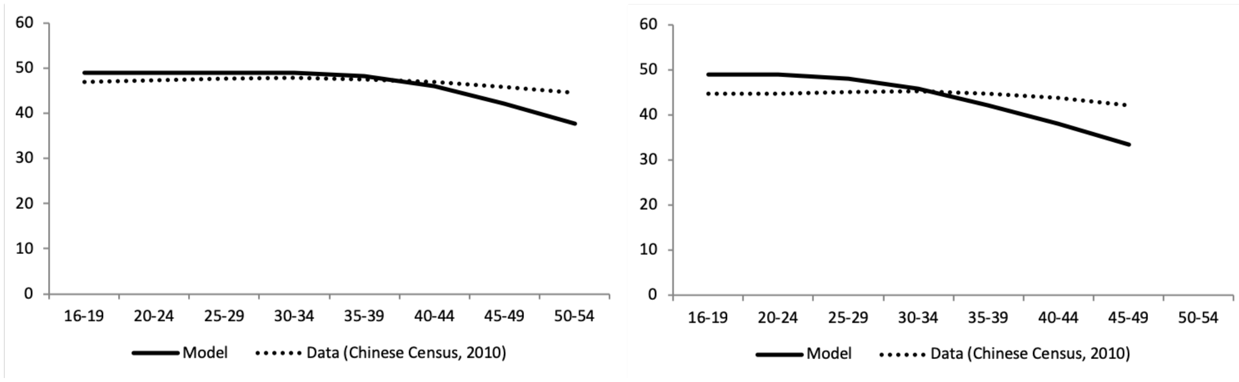


Figure 1: Age-dependent labor productivity $\epsilon_j^{g,e}$

3.4 Social Security Replacement Rate

According to the executive order from Chinese State Council in 2012, the social security benefit was raised to about 18,000 yuan a year. According to the data from National Bureau of Statistic of China in 2012, the average income for urban residents is 52,120.7 yuan. This indicates the social security replacement rate is approximately 35 percent. This estimate is close to Song et al. (2015). They estimate the replacement rate to be about 40 percent. In the cross-country study of the retirement programs conducted by Salditt et al. (2007), they also documented that 35 percent replacement rate is the target of the Chinese PAYG social security program.

Figure 2: Hours Worked: Model vs. Data



(a) Male

(b) Female

3.5 Model Fit

Figure 2 shows the average hours worked generated by model comparing to the cross-sectional data from Chinese Census in 2010. The agents in the model work more at young age than in the data, because it is crucial to generate income for consumption and accumulate wealth since the agents cannot borrow against future. In reality, even with incomplete financial market, young workers may choose to work less due to family transfer or are force to work less because of inexperience. To compensate for the over-working, the agents in the model work significantly less in the late working age comparing to the data. Another reason of this decreasing pattern of the hours worked is related to the hump-shaped of age-dependent labor productivity $\epsilon_j^{g,e}$. Since the agents have to decrease their hours worked at some point, they cannot do it at young age because of the reason explained above; they cannot do it at prime working age either because of the high opportunity cost. Therefore, decreasing hours worked at late working age is the best option.

Table 2: Benchmark Model - Model vs. Data

Statistics	Model	Data	Source
Return to capital	13.06%	21.04%[a]	Bai, Hsieh & Qian, 2006
Social security tax rate	17.19%	20.00%	Census, 2010
Share of population of age 65+[b]	25.67%	11.75%	Census, 2010
Gender ratio of age 60+	0.8638	0.9614	Census, 2010

[a] 2005.
[b] The denominator is the populate of age 20 and above.

Table 2 summarizes some statistics calculated from the model and compares them to the data. According to Bai, Hsieh and Qian (2006), the return to capital in China is about 20% from 1998 to

2005. Other papers, such as Song et al (2011), match this return to capital rate using an output growth rate of 11.2 percent which is much higher than the one we use in the benchmark model. We use much lower output growth rate because we calibrate the model in 2010 when the economic growth rate became much lower after the Great Recession in 2009. The Chinese social security payroll tax is 20% paid by the employers. The individuals pay another 8%, but that amount goes to the private saving account rather than the PAYG social security program. The model generates a social security tax rate of 17.19% which is smaller than the tax rate in data. Realistically, the social security tax rate in data cannot be adjusted every year, and therefore, should be higher than model so that the social security program is sustainable. Furthermore, the population structure in the model does not match the data well. Because there is not population growth rate in the model, the share of the population above 65 years old is significantly higher than the one in the data. In addition, because of the higher percentage of the retirees, the men to women gender ratio is lower in the model since women tend to live longer than men.

4 Main Result

In the benchmark model, men retire at 60 and women retire at 55. In our first counter-factual experiment (CE1), we set both men and women retirement age at 60. We compare the steady state levels of these two models. Table 3 summarizes the results.

Table 3: Benchmark Experiment

	Benchmark	CE1	Compare
Interest rate	0.1364	0.1368	0.29%
Hours worked male	0.4735	0.4721	-0.30%
Hours worked female	0.4452	0.4419	-0.74%
Social Security tax rate	0.1719	0.1514	-11.93%
Accidental bequest	0.0023	0.0024	4.35%
Wage	0.1057	0.1056	-0.09%
Capital stock	0.1792	0.1840	2.68%
Output	0.0826	0.0848	2.66%

In CE1, the EQR policy is implemented instead.

As women work five years more in the CE1 with the EQR policy, the overall labor supply is higher than the labor supply in the benchmark with the EAR policy. Because of the increase in the labor supply, the output is strictly higher in the CE1, as well as the savings and the marginal productivity of capital are higher which leads to more savings and a higher interest rate. The higher labor supply also lowers the equilibrium wage slightly. With a lower wage rate, the average hours worked by male and female[11] are lower. Since women retire five years later, there are less people claiming the Social Security benefit and women make contribution to the Social Security program in the extended five working years. Both effects lead to the decrease in the Social Security tax rate.

4.1 Welfare Analysis by Gender and Education Type

Table 4 shows the welfare changes (measured by consumption equivalent variation[12]) comparing the CE1 with the EQR policy to the benchmark model with the EAR policy. Using the consumption equivalent variation, on average men and women who are born in the benchmark economy have to be compensated 2.21% and 1.93% more consumption in order to be indifferent to those men and women who are born in the economy with the equal retirement age policy. This result indicates a welfare gain for both men and women if the equal retirement age policy is implemented.

Table 4: Benchmark Experiment - Welfare Change

	Consumption Equivalent Variation	
	Male	Female
All	2.21%	1.93%
Low educated	2.25%	1.97%
High educated	2.06%	1.70%

Compared to men, women enjoy a smaller welfare gain under the equal retirement age policy. This happens because of several reasons. For the male agents, the reason of the welfare gain is simple: tax rate reduction. For the female agents, the reasons are much more complicated. More detail of the female welfare effect is discussed in Section 5.

The high education agents have smaller welfare gains comparing to the agents with the low level of education for both genders. To understand this result, we need to look at the changes in the consumption and leisure of the high and low educated agents. In the eenchmark experiment, the low educated male agents decrease hours worked by 0.29% and the high educated male agents decrease hours worked by 0.39%. At the same time, the average consumption increases by 2.61% for the

[11]Hours worked for female is calculated as the average worked by female between age 20 to 54.
[12]CEV measures how much consumption has to be compensated to make the agents in the counter-factual model indifferent from the agents in the benchmark model.

low educated agents and 2.40% for the high educated agents. Therefore, the high educated agents gain more leisure and less consumption from the increase of the female retirement age. However, the gap within the two leisure changes is small, as well as the gap within the two consumption changes. In addition, the changes in consumption is significantly larger than the changes in leisure. Hence, the increase in consumption is the dominating effect in the welfare change. Also, because of the concavity of the utility function, the high educated agents, who have the higher level of consumption, have less increase in utility.

In conclusion, because the consumption change is the dominating change, the low educated agents who are at the lower consumption level have more consumption gain, which results having a higher amount of increase in the welfare.

5 Decomposition of Welfare Change

In this section, we study the composition of this welfare change. We consider two channels that lead to the welfare gain caused by the increase in the female retirement age: the partial indexation and the protection against mortality risk.

5.1 Growth Effect and Indexation

In the benchmark model, the wage grows at the economic growth rate. When the agents retire, only half of their retirement benefits grow at the economic growth rate because of the partial indexation. Therefore, under the early retirement age policy, the Social Security benefit of women grow five years less comparing to the Social Security of men because they retire five years earlier than men. Hence, the welfare of women increases in the counter-factual economy with the equal retirement age policy as they retire five year later. In order to examine the significance of the effect of the partial indexation, we make sure in the new counter-factual experiment (CE2) with the EQR policy the Social Security benefit grows at the full economic growth rate for the same number of years as the benchmark model. Since in the benchmark the Social Security benefit of women grows for 34 years, the Social Security benefit of women is set to grow for 34 years as well in the CE2. Furthermore, since the female Social Security benefit will be lower in CE2 comparing to CE1, we increases the replacement rate to 39.15% so that the Social Security tax rate stays the same as in the

CE1. Table 5 compares the results from CE2 to the benchmark model.

Table 5: No Indexation Channel

	Benchmark	CE2	Compare
Interest rate	0.1364	0.1366	0.15%
Hours worked male	0.4735	0.4717	-0.38%
Hours worked female	0.4452	0.4424	-0.63%
Social Security tax rate	0.1719	0.1514	-11.93%
Accidental bequest	0.0023	0.0024	4.35%
Wage	0.1057	0.1057	0.00%
Capital stock	0.1792	0.1842	2.79%
Output	0.0826	0.0849	2.78%

In CE2, the follow changes are made EQR, 34 years of full indexation and $\theta = 39.15\%$.

As shown in Table 5, the results from the CE2 is similar to the results from the CE1 in Table 3. The capital stock and wage rate are higher, and the interest rate is lower in the CE2. These results make sense as the increase in the capital stock increases the marginal productivity of labor and reduces the marginal productivity of capital. As expected, by shutting down the indexation channel, switching to the EQR policy provides smaller welfare gain for women as shown in Table 6..

Table 6: No Wndexation Channel - Welfare Change

	Consumption Equivalent Variation	
	Male	Female
Benchmark Experiment	2.21%	1.93%
No Indexation Channel	2.37%	1.77%

5.2 Mortality Risk

Previous literature also point out the effect of the labor income as a partial insurance against the mortality risk, which refers to the uncertainty of lifetime.[13] In an environment with the mortality risk, the early retirement cause women to live on their savings besides the social security benefits and to be exposed to more years of the uncertain lifetime. As a result, women have to save more for the longer retirement, which leads to more losses if they die early.[14] On the other hand, if they live too long they are likely to outlive their savings since they have more years of retirement. By

[13]For example, before the agents enter the economy, they have an expected lifetime, which are 77 for men and 81 for women. However, since every period, there is an certain percentage of agents die, in fact, only a few agents would die at the life expectancy. Most of the agents will die either earlier or later than the life expectancy.

[14]In other words, women lose five years opportunity to adjust their saving conditionally on their survival.

increasing the retirement age, women have fewer years to live on the savings, and therefore, are less exposed to the mortality risk. Hence, women are benefited through the equal retirement policy.

To test the magnitude of this effect, we do another counter-factual experiment in winch agents face no mortality risk. We let survival rate for all ages equal to one and set the maximum age to the life expectancy in the benchmark model which is 77 for men and 81 for women. If the effect is significant enough, when the mortality risk is absent and women are not exposed to the uncertain lifetime, the implementation of the equal retirement age policy should benefits women less than in the environment without the mortality risk.

Table 7: Mortality Risk

	Consumption Equivalent Variation	
	Male	Female
Benchmark Experiment	2.21%	1.93%
No mortality risk	1.97%	1.71%

In Table 7, the second row shows the welfare effect of the increase in the female retirement age when the mortality risk is missing. As shown, the welfare gains in the economy without mortality risk are significantly smaller than the welfare gains the benchmark. In the benchmark, the extra five years of working reduce the time of retirement which agents have to live on savings besides the social security benefit. This effect reduces the chance of an agent to outlive or underlive his or her savings, and therefore, reduces the mortality risk. Now, in the counter-factual experiment where there is no mortality risk, the extra working years no longer provide the benefit of the production against the mortality risk. Hence, the welfare gain should be smaller. As the theory predicted, the results are consistent with our expectation: the increase in the retirement age benefits women less in the environment without the mortality risk than in the environment with the mortality risk.

6 Further Discussion

To further understand the implications of this model, we vary the replacement rate, the economic growth rate and the gender ratio. We find that the increase in the female retirement age can have opposite effects on the saving decision of the agents in the economies depending on the level of the replacement rate. In addition, we also find the welfare gain of the increase in the female retirement age generally decreases as the economic growth rate increases within the common range. At last, in an economy with unskewed gender ratio at birth, the welfare gain of the increase in the female retirement age is slightly less.

6.1 Replacement Rate

First, we examine the sensitivity of the replacement rate θ in the benchmark model and explore the welfare effect caused by the increase in the female retirement age. The results in Table 8 illustrate that extending the female retirement age is welfare improving when the replacement rate is at 15% and above. When the replacement rate is lower than 15% and close to 0, the increase in the female retirement age leads to a welfare loss for the male agents and a small welfare gain for the female agents. Overall, as the replacement rate increases, the welfare gains of the increase in the female retirement age increase for both men and women.

Table 8: Replacement rate

	Consumption Equivalent Variation	
Replacement rate	Male	Female
0%	-1.47%	0.54%
15%	0.17%	0.92%
25%	1.19%	1.34%
35%	2.21%	1.93%
45%	3.25%	2.54%
55%	4.43%	3.36%
65%	5.64%	4.26%

This pattern is caused by the change in the saving behavior of women in response to the extension of the female retirement age from the low to high level of replacement rate.[15].The increase of the female retirement age has two opposite effects with regard to the saving decision of women. First, women have more opportunities to save since they work more years and have more labor income. Second, women have less desire to save since the retirement life is shorter.

When the replacement rate and the tax rate are low, the saving is already high, and therefore, the interest is low. In addition, when the retirement life becomes shorter, the saving become less needed.

[15]Men save more under the equal retirement age policy as long as the replacement rate is above 0 since the increase in the female retirement age brings the tax rate deduction, and therefore, more income for men. When the replacement rate equals 0, men gain no benefit from the increase in the female retirement age. Even worse, because of the increase in the labor supply which leads to a decrease in the wage, the income and savings of men actually decrease slightly.

Hence, when the replacement rate is low, women actually save less in the equal retirement system. The opposite is true when the replacement rate is high. The high replacement rate causes high social security tax rate, which leads to lower labor income and lower savings. The low savings leads to a higher marginal product of capital. This makes saving more attractive when the retirement age increases. Therefore, women take the opportunities of the extra five working years to accumulate more wealth which overwhelm the effect of shorter retirement life. Hence, when the replacement rate is high, women save less in the early retirement economy and more in the equal retirement economy. Since the wage is determined by the marginal product of labor and the marginal product of labor is higher when the amount of capital increases and lower when the amount of capital decreases, the increase in the female retirement age decreases the wage when the replacement rate is low and increases the wage when the replacement rate is high. In the special case when the replacement rate equals 0, the channels of the tax rate deduction and the indexation are gone. Women still gain benefits from less exposed to the mortality risk for working more years, but men lose benefit due to the decrease in the wage.

The tax rate deductions range from the highest 12.57% when the replacement rate equals to 15% and lowest 11.93% when the replacement rate equals to 35%. The tax rate deductions show no significant pattern. For the indexation effect, when the replacement rate is low, the difference between the partial and the full indexation is negligible. The income loss from the partial indexation is small. Therefore, the welfare gain from the extension of the female retirement age is even smaller from this channel when the replacement rate is low. As the replacement rate increases, the loss from the partial indexation becomes greater. Therefore, the welfare gain of the increase in the female retirement age becomes greater as the replacement rate increases. This channel contributes to the increase in the welfare gain as the replacement rate increases. At last, the social security is a substitute for the annuity which protects the agents from the mortality risk as the same as the labor income. When replacement rate is high and saving is low, agents are well protected against the mortality risk. In this case, the increase in the years of working is less influential for women since women are already protected against the motility risk. Therefore, the welfare gain of the increase in the female retirement age become smaller from this channel as the replacement rate increases.

The magnitude of the welfare change is larger for men than for women when the replacement rate increases from 15% to 65%. This is because that women are held back by the cost of the increase in the retirement age. Women have to give up the claim of the social security benefits for five years when the retirement age increases. The cost increases as the replacement rate increases. Therefore, the female welfare gain increases slower than the male.

6.2 Growth Rate

Next, we do sensitivity analysis with respect to the growth rate γ. As shown in Table 9, the increase in the female retirement age leads to welfare gains for both men and women. The magnitude of the welfare gains decreases as the growth rate increases, then at a certain point around 8% growth rate, the magnitude of the welfare gain starts to increase.

Table 9: Growth rate

	Consumption Equivalent Variation	
Growth rate	Male	Female
0%	3.36%	3.79%
1%	3.02%	3.18%
2.5%	2.53%	2.54%
5.5%	2.21%	1.93%
8%	2.23%	1.79%
10%	2.36%	1.89%

The movement pattern of the welfare gains coincident with the changes in the tax rate deduction. The tax rate deduction is high at 14.03% when the growth rate is 0% and decreases to 11.93% as the growth rate increases to 5.5%. Then tax rate deduction return to 12.45% when the growth rate is 10%.

The growth rate affects the tax rate deduction in two ways. First, because of the partial indexation, the gap between the wage earnings and the social security benefit is small when the growth rate is low. Hence, the social security tax rate is high when the economic growth rate is low. Therefore, the extension of the female retirement age has a great impact on the social security tax rate deduction when the economic growth rate is low. As the growth rate increases, the social security tax rate becomes smaller, so does the impact of the extension of the female retirement age. Hence, the tax rate deduction becomes smaller as the economic growth rate increases. Second, while in a model where the economic growth rate is high, the extension of the female retirement age actually decreases the female social security retirement benefit. For example, when the growth rate is at 10%, after extending the female retirement age, women earn less income from 55 to 60 comparing to the social security benefit they would have earned under the early retirement age policy. This happens because the agents work less, especially in the late-working ages. Since the social security benefit is determined by the average lifetime labor income, the extra five-year income drags down that average and causes the female social security benefit to be lower in the economy with the equal retirement age policy. Therefore, with lower social security benefits after the female retirement age increases, the tax rate deduction becomes larger.

Hence, the higher the tax rate deduction is, the more welfare gained after the increase of the female retirement age. The tax rate deduction decreases at first since the labor income grow faster than the social security benefit because of the partial indexation. However, when women earn less labor income in the equal retirement system than the social security benefit they would have claimed in the original early retirement system, the female social security becomes smaller under the equal retirement age policy. Therefore, the tax rate deduction becomes larger, so does the welfare gain.

6.3 Gender Ratio

Since 1990, the new-born generations in China have very skewed gender ratio. Figure 3 shows the men to women ratio by all ages according to 2010 Chinese Census data. As shown in the graph, the ratio greatly increases since 1990 cohort who were 20 years old in 2010, and stabilizes around 120 for the younger cohorts who were born after 2000s. That is, for every 100 girls are born, there are 120 boys are born at the same time. On the right hand side of Figure 3, the men to women gender ratio greatly declines for the elders who are above 70 years. This is because women have longer life expectancy.

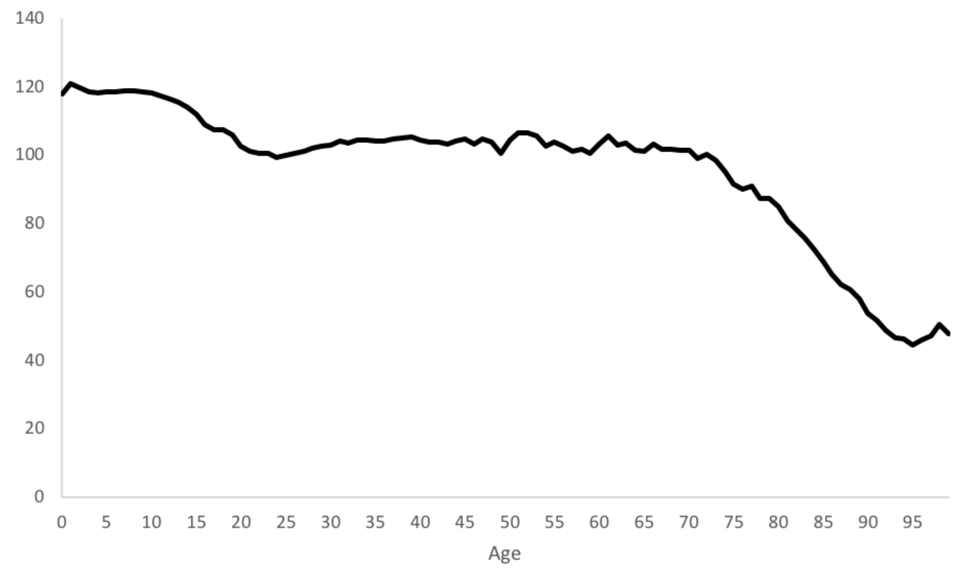


Figure 3: Cross-sectional Gender Ratio in 2010

Figure 4 shows the population pyramid using the 2016 data from the Chinese National Bureau of Statistics. Each bar in the population pyramid represents the population of a five-year cohort as a percentage of the total population. As shown in the graph, since the mid-age population takes up the majority of overall population, the gender ratio of the total population is 1.0492, which is not as skewed as the younger generation. Compared to the 2010 data, the gender ratio of the youngest cohort decreases to 1.1569 but still in disparity.

Figure 4: Population Pyramid in 2016

This skewed gender ratio among children and teenagers may have little effect on the Chinese economy in 2010, but as they enter the labor market in the next few decades, the disparity in gender ratio will affect the Chinese economy and the policy making. Taking the early retirement age policy in the social security system as an example, holding everything else constant, a relative lower percentage of the female agents will decrease the burden of the social security tax on the working population. It makes the equal retirement age policy less welfare improving.

To quantitatively evaluate the effect when the generations with the skewed gender ratio take over the working-age population, we change the gender ratio at 20 years old in the benchmark model from 1.0492[16] to 1.20. First, we compare this counter-factual experiment with the benchmark model. Second, we explore the effect of the increase in the female retirement age with the skewed gender ratio and compare with the conclusion in the eenchmark experiment.

In Table 10, the third column from the left under title ”Skewed“ summarizes the counter-factual experiment with the skewed gender ratio and the early retirement age policy. As shown in the last column, the Social Security tax rate decreases, because there are fewer female agents claiming

[16]Please check Section 3.1 for more details.

Table 10: Benchmark vs. Skewed

	Benchmark	Skewed	Change
Interest rate	0.1364	0.1369	0.37%
Hour worked male	0.4735	0.4731	-0.08%
Hours worked female	0.4452	0.4446	-0.13%
Social Security tax rate	0.1719	0.1698	-1.22%
Accidential bequest	0.0023	0.0023	0.00%
wage	0.1057	0.1055	-0.19%
Capital stock	0.1792	0.1813	1.17%
Output	0.0826	0.0836	1.21%

the Social Security benefits and more male agents contributing to the Social Security program. In addition, since the share of the male workers increases and the male workers are more productive and work longer hours, the output increases and the wage decreases due to the increase in the labor supply. Moreover, the interest rate increases because the higher labor input increases the marginal product of capital. At last, the capital increases because of the increase in the savings due to the higher income.

Table 11: Skewed Gender Ratio

	Consumption Equivalent Variation	
	Male	Female
Benchmark Experiment	2.21%	1.93%
Skewed gender ratio	2.10%	1.83%

In Table 11, the second row summarizes the welfare changes comparing the counter-factual model with the skewed gender ratio and the equal retirement age policy to another counter-factual model with the skewed gender ratio and the early retirement age policy. As we expected, with fewer women the increase in the female retirement age generates a smaller general equilibrium effect compared to that in the benchmark experiment. With a smaller tax rate deduction, men benefit less from the retirement policy change.

7 Conclusion

This paper investigates the welfare consequence of the early retirement age policy for women in a quantitative overlapping generation model. Our quantitative results suggest that the early retirement policy is detrimental to the welfare of both men and women. When we apply the equal retirement age policy in a counter-factual experiment, both men and women are better off. In addition, the high educated group benefit less from the equal retirement age policy comparing to the low educated group.

Furthermore, we explore the reasons behind the positive welfare effect of the equal retirement age policy. We find the two reasons. First, when women work five years less than men, women lose five years full indexation to the economic growth because of the partial indexation. By increasing the female retirement age, women lose less benefit from the economic growth. Second, the earlier the agents retire, the more mortality risk the agents are exposed to. Therefore, women are benefited from the protection against the mortality risk when the retirement age of women is increased.

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Appendix A: Retirement Policies and Indexation Rules in The World

Developed countries

Among the major countries in the world, the majority of the developed countries implement equal retirement age policy. Some developed countries that are implementing early retirement policy for women are in transition to the equal retirement in next few years or decades. Ideally, if social security benefit is 100% indexed to economic growth, the legal rule of indexation should take into account CPI inflation and real income growth, in another word nominal income growth. However, not of all the develop countries are indexed to economic growth. Here are some example of early retirement policy and indexation rules in developed countries.

In Austria, the retirement ages[17] for earning-related pension are 65 for men and 60 for women. The public pension system consists of two part. A minimum guaranteed pension for all citizen through social assistance scheme. In addition, an earning-related social security covers to all employees. The both minimum and earning-related pension benefits are only indexed to CPI inflation.

[17] Here and following, we reference the retirement age as the minimum eligible age to claim for the old-age pension benefit, which is the most commonly adopted and major composition of the social pension.

In Italy, the retirement ages are 65 for men and 60 for women. The main social pension scheme in Italy covers the whole population. In addition, the government provides a minimum guaranteed income (about 5143 euro in 2008) to the elderly who has low income[18] including social pension benefit. The minimum guaranteed income are indexed to nominal GDP per capita. However, the main social pension benefit is not to economic growth but only to CPI inflation. Specifically, the social security benefit is indexed 100% of the inflation rate for the amount of pension up to three times the minimum, 90% for the amount between three and five times the minimum, and 75% for the part above five times the minimum.

In the U.K. the retirement ages are 65 for men and 60 for women in 2009. Similar to Austria, the social pension program consists of a flat-rate minimum guaranteed social insurance pension and an earning-related social security. Regarding indexation, the minimum guaranteed social insurance pension is fully indexed to nominal economic growth. However, the earning-related social security is indexed to CPI until 2012. After 2012, the earning-related social security is indexed to nominal economic growth as well.

Developing Countries

The social pension schemes in the developing countries are understudied. There lacks a reliable source that is in English for information regarding retirement age or indexation of the developing countries in Asia and Latin America.

Early retirement policy for women is more commonly adopted in developing countries. For example: in Bulgaria, the retirement ages are 63 for men and 59 for women; in Estonia, the retirement ages are 63 for men and 60 for women; in Lithuania, the retirement ages are 62.5 for men and 60 for women; in Poland, the retirement ages are 65 for men and 60 for women for those who earn their pension right before the end of 2008; in Romania, the retirement ages for earning related pension are 58 for women and 63 for men; in Slovakia, the retirement ages for earning related pension are 62 for men and 57 for women.

The indexation rules in developing countries are partial or no indexation to nominal income growth. For example, in Bulgaria, the pension benefits are indexed to a 50% of CPI inflation and

[18]Low income are define as below 5,311 euro per year for the elder between age 65 and 69, and 7,540 for the elders who are age 70 and above. For married people, the low income is defined as below 11,071 euro per year for the total income of the couple in the age between 65 and 69, and 12,683 for age 70 and above.

50% nominal income growth; in Estonia, the pension benefits are fully indexed to CPI inflation; in Lithuania, there is no existing indexation rule for social pension; in Poland, the pension benefit is indexed 100% to CPI inflation and 20% to real income growth; in Romania, the pension benefit is fully indexed to real income growth; in Slovakia, the pension benefit is indexed 50% to CPI inflation and 50% to nominal income growth.

Appendix B: Brief Introduction about Chinese Social Pension System

Chinese social pension system consists of three parts: urban employee social insurance pension system, public service employee retirement pension system and the rural resident pension system. The first two are often referred as ”the two pillars system”. The rural resident pension system started in 2009 and is relatively small. The public service employee retirement pension system is equivalent to traditional DB system in the U.S. It covers 40 million participants and is funded by government revenue. The urban employee social insurance pension system consists of two pieces: a pay-as-you-go pension founded by a 20% employer contribution and a 401(k)-type of funded individual account financed by employee contribution of 8%. The urban employee social insurance pension system covers about 320 million participants.