Does the early retirement policy really benefit women?

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October 7, 2020

Abstract

China's mandatory retirement policy requires 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, 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 consequences of China's gender-specific mandatory retirement policy using a calibrated overlapping generations model with heterogeneous agents and incomplete markets. We find that early mandatory retirement reduces welfare for women. One of the reasons for this result is that China's public pension benefits are only partially indexed to economic growth, and therefore, women who retire earlier than men benefit less from economic growth. Our quantitative results suggest that equalizing the retirement age across genders will generate welfare gains for both men and women.

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

JEL Classifications: E20, E60, H30

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1 Introduction

China's mandatory retirement policy requires female workers to retire five years earlier than their male counterparts and start collecting their public pension benefits.[1] The conventional wisdom behind this policy is that the early retirement policy benefits women because it allows them to enjoy leisure and public pension benefits earlier than men. However, does this policy really improve 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 has negative effects on individual welfare. For instance, when public pension benefits are not fully indexed to wage growth, women who retire earlier benefit less from economic growth. This phenomenon is particularly important in emerging economies such as China. Moreover, early retirement implies greater exposure to the risk of an uncertain lifetime, especially when the annuity market (i.e., the insurance market for uncertain lifetimes) is absent and labor income serves as the primary means to insure against an uncertain lifetime. As shown in previous studies such as those of Yaari (1965), Pashchenko (2013), and Zhao (2015), the annuity market in most countries is weak. Therefore, by retiring earlier, women have substantially greater exposure to the risk of an uncertain lifetime, especially when the replacement rate[2] of the social security program is low.

To formalize these mechanisms, we develop an overlapping generations (OLG) general equilibrium (GE) model with heterogeneous agents and incomplete markets. Agents face mortality risks over their lifetime. Before retirement, agents earn labor income by supplying labor to the labor market. After retirement, they live on social security annuities and their private savings. Social security annuities are financed by a payroll tax on working agents. In the model, agents can smooth their consumption over time through 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,

[1] Related policies are in place in many other countries around the world. The appendix gives a description of some of these policies.

[2] The replacement rate is retirement benefits over average lifetime earnings. The replacement rate of the social security program in China is about 35%.

[3] The data show that private annuity markets have been very weak in most countries over the last few decades. For instance, Warshawsky (1988) estimated that only approximately 2% - 4% of the U.S. elderly population owned private annuities between the 1930s and the 1980s. A common explanation for the weak private annuity markets is that the adverse selection problem reduces the yield on annuities. For example, individuals usually have more information about their own health than insurance companies. Therefore, people who are likely to live longer are more willing to enroll in the commercial annuities.

but social security benefits are only partially indexed to wage growth.[4]

We calibrate the benchmark model to the Chinese economy in 2010 and use the calibrated model to quantify the welfare consequence of the EAR policy. We find that switching from the current EAR policy (men retire at 60 and women retire at 55) to an equal retirement (EQR) policy (men and women both retire at age 60) generates welfare gains for women. Furthermore, we design additional counterfactual experiments to decompose the welfare consequences 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 explore this channel, we reexamine the EQR policy in a counterfactual economy in which public pension benefits are fully indexed to wage growth. In the counterfactual economy with full indexation, women suffer a welfare loss when the retirement age policy switches from the EAR to the EQR. Second, women have greater exposure to the risk of an uncertain lifetime because of the EAR policy. To study this channel, we ignore the mortality risk and recompute the EQR policy experiment. We find that in a counterfactual economy without the mortality risk, the welfare gain of switching to the EQR policy is smaller.

Our paper is closely related to the large and still growing body of literature on social insurance policies (particularly social security policies) in the context of OLG models.[5] Starting with the seminal work by Auerbach and Kotlikoff (1987), the literature has explored a wide range of related issues, including savings, the welfare implications of social security and policy reforms, the impact of demographic changes on social security, and the impact of social security on aggregate health expenditure. For instance, Imrohoroglu, Imrohoroglu, and Joines (1995) argue that the optimal social security replacement rate in the U.S. should be 30%, assuming a retirement age of 65. Conesa and Krueger (1999) study social security reforms and find that a transition from the current pay-as-you-go social security system to a fully funded system lacks political support. After calibrating the model to the U.S. economy, they find that a 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 population. Kitao (2014) studies four potential reforms to make the social security

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

system sustainable and suggests that increasing the retirement age is the ideal approach from a welfare perspective. Zhao (2014) studies the impact of social security on aggregate health spending and finds that the expansion of social security is an important cause of the dramatic rise in health spending in the U.S. However, most existing studies focus on developed countries and neglect the issue of gender differences in retirement ages. We argue that such gender differences have important welfare implications, particularly in developing countries like China, and thus should not be ignored in the discussion of social security and retirement.

The remainder of the paper is organized as follows. In Section 2, we introduce the benchmark model; in Section 3, we calibrate the benchmark model to the Chinese economy; in Sections 4 and 5, we discuss in detail the quantitative results; in Section 6, we conduct a sensitivity analysis, and in Section 7, we offer some conclusions.

2 The Benchmark Model

The benchmark model is an overlapping generations model with heterogeneous agents and incomplete markets. In each period, the labor-augmented technology increases by a rate of γ. Hence, the equilibrium wage and capital stock also grow at a 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 $h_j \in [0,1]$ is the number of hours worked.

In each period, a new generation of agents of gender $g \in \{m,f\}$ and education level $e \in \{e_{low}, e_{high}\}$ enters the economy, where $g \in \{m,f\}$ represents male or female and $e \in \{e_{low}, e_{high}\}$ represents a low or high level of education.[6] In addition, agents also receive an idiosyncratic shock

[6]In the benchmark calibration we classify agents who were educated beyond high school as having a high level of education, and agents who were educated up to high school or less as having a low level of education.

η to their labor productivity at the start of each period.

At time t, agents of 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 education level e at age j. At the start of each period, agents experience an idiosyncratic labor productivity shock η. The idiosyncratic labor productivity shock η follows 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 idiosyncratic labor productivity shock η' given the previous labor productivity shock η. The policy function for hours worked h_j at age j is a function of several state variables: age, asset holding, education level, labor productivity idiosyncratic shock, and gender.

After the (gender-specific) retirement age j_g^*, retirees receive a social security income that is partially indexed to the economic growth rate. Specifically, retirees receive the indexation rate x of the retirement benefit of currently working agents and $1-x$ of their own retirement benefit. For simplicity, the retirement benefit b_e^g is the same within a group of agents with the same level of education and of the same gender. The retirement benefits are calculated as a fraction θ of the average before-tax labor income of 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 lifetime can be expressed as[7]:

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

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 the 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]To avoid complications in the notation, we apply the properties of a balanced growth path for normalization. We assume that 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 aged j and receives wage $w(1+\gamma)^{j-1}$; when $j\geq j_g^*$, the agent receives a retirement benefit that equals the indexed weighted average of his or her own retirement benefits and the retirement benefits of the younger cohort, who have just reached retirement at time $i+j$.

where r is the interest rate. a_{j+1} is the assets saved for old age $j+1$ at age j. Agents are born with no assets $a_1 = 0$. Agents have no altruistic motivation to leave bequests, so at the maximum age, $a_{J+1} = 0$. ϕ_j represents accidental bequests. As accidental bequests is an aggregate value, it grows by γ in each period at equilibrium.

2.2 The Firm

The Firm's production technology is given by a constant return to scale Cobb-Douglas production function:

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

where $A > 0$ and $0 < \alpha < 1$. At time t, the labor-augmented technology factor equals A_t, and it increases at the growth rate γ in 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 real wages at 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 policy arrangements $\{\theta\}$ is a collection of individual policy rules $C_j(a, e, \eta, g), S_j(a, e, \eta, g), H_j(a, e, \eta, g)$ for agents who were born at 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 accidental bequests Φ_t at 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 agents' decision rules:

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

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

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

4. Given the relative price $\{r, w\}$, government policy $\{\theta\}$, and a 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 the 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:

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

8. The lump-sum distribution of accidental bequests 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

Our 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 data(2010)
J	maximum age	81 (100 years old)
Preference		
β	subjective discount rate	0.98 (Imrohoroglu, Imrohoroglu and Joines, 1995)
σ	coefficient of relative risk aversion	2.00 (Kitao, 2011)
κ	IES of labor	4.00 (Kitao, 2011)
χ_m	leisure weighting of males	to match 46.40 hours/week in Chinese Census data(2010)
χ_f	leisure weighting of females	to match 43.63 hours/week in Chinese Census data(2010)
Labor Productivity		
$\epsilon_j^{e,g}$	age-gender-specific productivity	calculated by the authors using 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 the economy at age 20. We set the male to female gender ratio at birth to 1.0492, so that the gender ratio in the working age population (those aged 20 to 60 years old) in the model matches the gender ratio in the working age population in the 2010 Chinese Census data, which is 1.0321.[8] In each period, the agents face a gender-specific survival probability of ψ_j^g of living to the next period. The survival rates ψ_j^g are obtained from the 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 the Chinese legal retirement age. [10] According to the Chinese Census in 2010,

[8]This means that, at age 20, for every 100 female agents that enter the economy, 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 data measure the national average population and the number of deaths from November 1, 2009 to October 31, 2010 by age and gender. Therefore, the survival rate =1−mortality/average population

[10]The retirement age for manufacturing workers is 55 for men and 50 for women. However, we pick the mandatory retirement ages of 60 for men and 55 for women for two reasons. First, manufacturing jobs do not represent the

25% of men and 22% of women were college educated in the population aged 20 years and above. The model is calibrated to match these numbers.

3.2 Preference and Production Technology

We use the separable constant relative risk aversion (CRRA) utility function adopted by Kitao (2011), where χ_g is the gender leisure weights which help pin down the distinct labor preference of men and 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, respectively, following Kitao (2011). The subjective discount factor β is set to the value of 0.98, which is commonly used in the economics literature.

The share of labor in the production function α and the depreciation rate are set to 0.5 and 0.1, respectively, which are both values used by Song et al. (2011). The labor-augmented productivity factor A_t is normalized to 1 when $t = 0$.

According to the Chinese National Bureau of Statistics, the average 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 labor hours of 98 hours per week.[11] The average labor input is therefore 47.35% for men and 44.52% for women. These two numbers are used to determine the leisure weighting for men and women.

3.3 Labor Productivity

We use China Health and Nutrition Survey (CHNS) data to calibrate the parameters related to labor productivity. We assume that the log of the idiosyncratic productivity shock η follows a standard first-order autoregressive (AR(1)) process as in the quantitative macro literature, and 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 five-state Markov chain using the Tauchen (1986) method.

whole labor market. Second, in our study, the five-year retirement age difference is more significant than the actual retirement age.

[11] Assuming a worker can work 14 hours a day and 7 days a week on average at the maximum.

We also estimate the age-efficiency productivity ϵ using the CHNS data and follow the empirical method adopted by Kambourov and Manovskii (2009). Specifically, we estimate the 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 earnings of cohort i in year t in province s, and age_{it} is the age of cohort i in year t. $year_t$ and $province_s$ are year and province dummies.

We use this empirical model to estimate the four types of agents in our model: males with a low education level, females with a low education level, males with a high education level, and females with a high education level. We then calculate the earnings profiles of these groups based on the predicted values of $wage_{its}$, and adjust the vertical intercepts of the earnings profiles to match the average earnings gaps among these groups in the data.

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

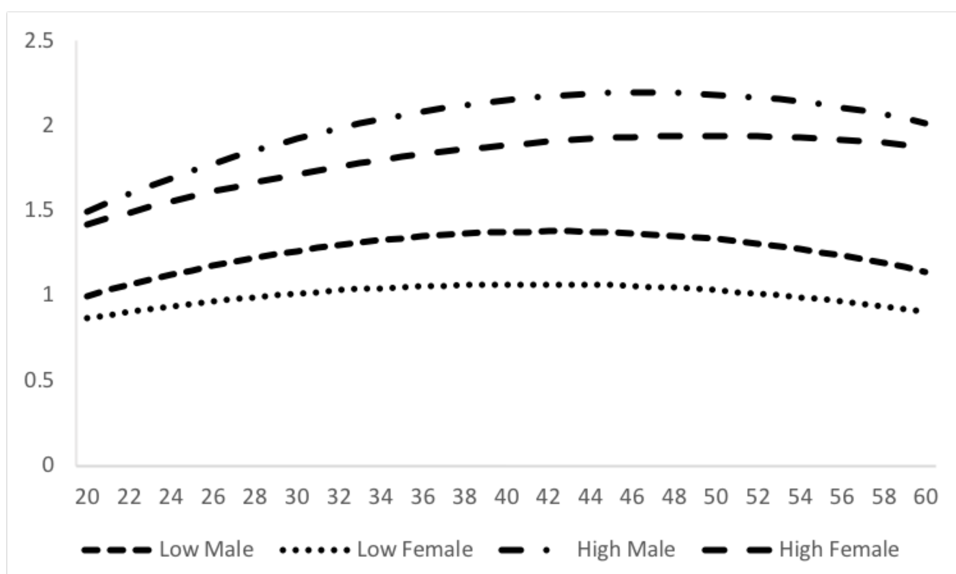
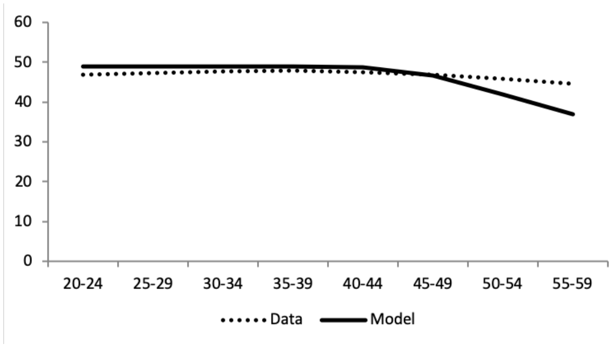


Figure 1: Age-dependent Labor Productivity $\epsilon_j^{g,e}$

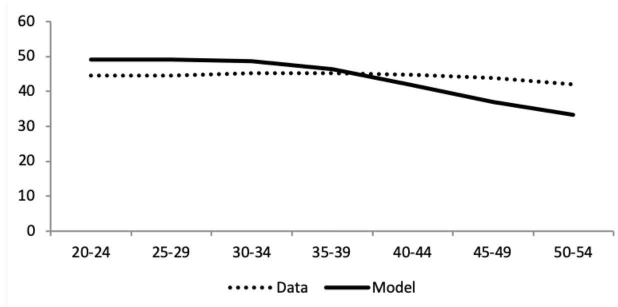
3.4 Social Security Replacement Rate

An executive order of the Chinese State Council in 2012 increased social security benefits to about 18,000 yuan a year. According to data from the National Bureau of Statistics of China,

Figure 2: Hours Worked: Model vs Data



(a) Male



(b) Female

the average income for urban residents in 2012 was 52,120.7 yuan. This gives a social security replacement rate of about 35%. This number is close to the estimation in Song et al. (2015)of about 40%. However, their estimate includes individual accounts in the Chinese retirement pension program, which is similar to the 401k program in the U.S. and is not a pay-as-you-go social security system. A cross-country study of retirement programs by Salditt et al. (2007) documents that a 35% replacement rate is the target of the Chinese pay-as-you-go social security program.

3.5 Model Fit

Figure 2 shows the average hours worked generated by the model compared to the cross-sectional data from the Chinese Census in 2010. The agents in the model work more at a young age than in the data, because it is crucial to generate income for consumption and accumulate wealth to protect themselves against the labor productivity shocks given that the agents cannot borrow against the future. In reality, even with an incomplete financial market, young workers may choose to work less due to family transfer or be forced to work less because of inexperience. To compensate for over-working at a younger age, the agents in the model work significantly less in their later working life compared to the data. Another reason for this decreasing pattern of hours worked is related to the hump shape of age-dependent labor productivity $\epsilon_j^{g,e}$. The agents have to decrease their hours worked at some point, but prefer not to work less at a young age because they can accumulate savings while they are young; they also avoid working less during their prime working age because of the high opportunity cost. Therefore, decreasing the hours worked in later working life is the best option.

Our benchmark model generates an interest rate of 13.6%. According to Bai, Hsieh, and Qian (2006), the return on capital in China was approximately 15-20% in the two decades before 2005, which is slightly higher than that in our model, because we calibrate our model to the 2010 data, when the economic growth rate and the return on capital were lower.

The Chinese social security payroll tax paid by employers is 20%. Employees pay another 8%, but that amount goes into a private savings account rather than into the pay-as-you-go social security program. The model generates a social security tax rate of 17.19%, which is slightly lower than the tax rate in the data. This is partly because the actual Chinese social security program does not balance its budget every year.

4 Main Results

In the benchmark model, men retire at 60 and women retire at 55. In our first counterfactual experiment (CE1), we set the retirement age for both men and women to 60. We compare the steady state levels of the two models. Table 2 summarizes the results.

Table 2: Benchmark Experiment

	Benchmark	CE1	Compare
Interest rate	0.1364	0.1368	0.29%
Hours worked men	0.4735	0.4721	-0.30%
Hours worked women	0.4452	0.4419	-0.74%
Social Security tax rate	0.1719	0.1514	-11.93%
Accidental bequests	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 under the EQR policy, the overall labor supply is higher than the labor supply in the benchmark model under the EAR policy. Because of the increase in labor supply, the output is strictly higher in the CE1, so the capital and marginal productivity of capital lead to greater 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 men and women [12] are lower. As women retire five years later, there are fewer people claiming social security benefits

[12]Hours worked for women is calculated as the average worked by women aged 20 to 54.

and more people making a contribution to the social security program in the extended five working years. Both effects lead to a decrease in the social security tax rate.

4.1 Welfare Consequences by Gender and Education Type

Table 3 shows the welfare changes in terms of consumption equivalent variation (CEV) comparing CE1 with the EQR policy to the benchmark model with the EAR policy.[13] When measured by the CEV, on average, men and women born in the benchmark economy have to be compensated 2.21% and 1.93% more to be no different to men and women born in the economy with the EQR policy. This result indicates a welfare gain for both men and women under the EQR policy.

Table 3: Benchmark Experiment - Welfare Change

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

Women enjoy a smaller welfare gain than men under the EQR policy. The greater welfare gain of the male agents is due to tax rate reduction. In the CE1 with the EQR policy, men pay a lower tax rate because they do not carry the extra social security tax burden of female early retirement like they do in the benchmark model. The reasons for the smaller welfare gains of the female agents are much more complicated, and are discussed in Section 5.

Agents with a high education level experience smaller welfare gains than agents with a low level of education in both genders. To understand this result, we need to look at the changes in the consumption and leisure of the more and less educated agents. In the benchmark experiment, the less educated male agents reduce their average working hours by 0.29% and the more educated male agents decrease their hours worked by 0.39%. At the same time, the average consumption increases by 2.61% for the less educated agents and 2.40% for the more educated agents. Therefore, the agents with a high education level gain more leisure and less consumption than the agents with a low education level. However, the increase in consumption is greater than the increase in leisure. The changes in consumption are also significantly larger than the changes in leisure. Hence,

[13] CEV measures how much consumption has to be compensated to eliminate differences between the agents in the counterfactual model and the agents in the benchmark model.

the increase in consumption is the dominating effect in the welfare change. Also, because of the concavity of the utility function, the better educated agents, who have a higher level of consumption, have a smaller increase in utility.

In conclusion, because the consumption change is the dominating change, agents with a low education level who have a lower consumption level experience greater consumption gains, which results in a greater increase in 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 gains caused by increasing the female retirement age: partial indexation and protection against the mortality risk.

5.1 Growth Effect and Indexation

In the benchmark model, wages grow at the economic growth rate. When agents retire, their retirement benefits grow at only half of that rate because of partial growth indexation. Therefore, under the EAR policy, the social security benefits of women grow for five years fewer than the social security benefits of men because they retire five years earlier than men. The welfare gains for women in the counterfactual economy under the EQR policy are partly due to the greater benefit they accrue from economic growth, as they retire five years later than in the benchmark economy. To examine the significance of the effect of partial indexation, we run another counterfactual experiment (CE2) with the EQR policy in which social security benefits grow at the full economic growth rate for the same number of years as the benchmark model.[14] Furthermore, we adjust the replacement rate so that the social security tax rate stays the same as it is in CE1. Table 4 illustrates the results from CE2 relative to the benchmark model.

As shown in Table 4, the results of CE2 are similar to the results of CE1 in Table 3. The capital stock and wage rate are higher and the interest rate lower in the CE2. These results make sense, as an increase in capital stock increases the marginal productivity of labor and reduces the marginal

[14] As in the benchmark the social security benefits for women grow for 34 years, the social security benefits for women in CE2 are set to grow for the same interval.

Table 4: No Indexation Channel

	Benchmark	CE2	Compare
Interest rate	0.1364	0.1366	0.15%
Hours worked men	0.4735	0.4717	-0.38%
Hours worked women	0.4452	0.4424	-0.63%
Social security tax rate	0.1719	0.1514	-11.93%
Accidental bequests	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%

productivity of capital. As expected, by shutting down the indexation channel, switching to the EQR policy provides smaller welfare gains for women, as shown in Table 5.

Table 5: No Indexation 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

Individuals face a mortality risk because they do not know the timing of their death.[15] This lifetime uncertainty makes savings a risk if individuals die without spending all of their assets. Greater saving leads to a greater risk. In our benchmark model, women are more exposed to the mortality risk than men because they have to save more for their retirement due to the EAR policy and their longer life expectancy.

The literature points out that annuities, social security, and labor income all reduce the mortality risk because they reduce the amount of savings needed for retirement. However, in the model, the absence of an annuity market and the low social security income (because of the low replacement rate) mean that individuals rely heavily on labor income to protect themselves from the mortality risk. When the EAR policy is replaced with the EQR policy, women have more years of labor income, and therefore benefit from the extra years of working.

[15]For example, before the agents enter the economy, they have a life expectancy of 77 years for men and 81 for women. However, as in every period a certain percentage of agents die, only a few agents will die at their life expectancy: most of the agents will die either earlier or later than the life expectancy.

To test the magnitude of this effect, we reexamine the effect of the EQR policy in an environment without mortality risk. We set the survival rate for all ages to 1 and set the maximum age as the life expectancy in the benchmark model, which is 77 for men and 81 for women. If the effect is significant, then when the mortality risk is absent and women are not exposed to an uncertain lifetime, the implementation of the EQR policy should benefit women less than in the environment with the mortality risk.

Table 6: Mortality Risk

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

The second row of Table 6 shows the welfare effect of increasing the female retirement age when the mortality risk is absent. As shown, the welfare gains in an environment without the mortality risk are significantly smaller than the welfare gains in the benchmark experiment. In CE1, female agents spend fewer years in retirement because of the EQR policy. This effect reduces the amount of savings that the agents must accumulate for retirement and therefore reduces the mortality risk. In an environment where there is no mortality risk, the extra working years no longer provide the benefit of protection against the mortality risk, as all agents survive to life expectancy. Hence, the welfare gains should be smaller. The results are consistent with our expectation: an increase in the retirement age benefits women less in an environment without the mortality risk than in an environment with the mortality risk.

So far, the welfare effects through the two channels tested count for only one fifth of the welfare gains of increasing the female retirement age. In fact, there are other mechanisms that contribute to the unexplained part of the welfare gains. First, the mechanism that benefits men by reducing the social security tax rate also helps women. However, this channel benefits women less because they originally work for only for 35 years before retirement, whereas men work for 40 years. Moreover, when the retirement policy switches from EAR to EQR, women have to pay five more years of tax while they continue to work. Second, in our model, the predicted deterministic labor productivity $\epsilon_j^{e,g}$, which is estimated using observable data, does not decline as quickly in old age. Therefore, the marginal income from the additional years of working outweighs the social security benefit.

Furthermore, our model does not feature an increasing disutility of labor over age.[16] Combined with $\epsilon_j^{e,g}$, which does not decrease as quickly, this makes working in old age especially attractive. The two mechanisms therefore make individuals want to work for as many years as possible.

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 increasing the female retirement age can have two opposite effects on the saving decisions of agents in the economy. Depending on the replacement rate, agents choose to either increase or decrease their savings when the retirement policy switches from EAR to EQR. In addition, in an economy with an unskewed gender ratio at birth, the welfare gains of increasing the female retirement age are slightly less.

6.1 Social Security Replacement Rate

First, we examine the sensitivity of the replacement rate θ in the benchmark model and explore the welfare effect caused by increasing the female retirement age. The results in Table 7 illustrate that extending the female retirement age is welfare improving when the replacement rate is at 15% or above. When the replacement rate is lower than 15% and close to 0, increasing the female retirement age leads to a welfare loss for male agents and a small welfare gain for female agents. Overall, as the replacement rate increases, the welfare gains from the adoption of the EQR policy increase for both men and women.

Table 7: Welfare Consequences of the EAR Policy and 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%

[16]Some models, such as that of Kitao (2011), include a certain amount of disutility (which increases with age) to the utility function of the individual who chooses to work regardless of the hours worked to capture endogenous retirement decisions.

This pattern is caused by a change in the savings behavior of women in response to the extension of the female retirement age given the level of the replacement rate.[17]. Increasing the female retirement age has two opposite effects with regard to the savings decision of women. First, women have more opportunities to save because they work for longer and have more labor income. Second, women have less desire to save, as their retirement life is shorter.

When the replacement rate and the tax rate are low, the saving rate is already high, and therefore the interest rate is low. In addition, when the retirement life shortens, less savings are needed. Hence, when the replacement rate is low, women actually save less under the equal retirement system. The opposite is true when the replacement rate is high. The high replacement rate causes a high social security tax rate, which leads to lower labor income and lower savings. The low savings rate leads to a higher marginal product of capital. This makes saving more attractive when the retirement age increases. Therefore, women take the opportunity of the extra five working years to accumulate more wealth, which overwhelms the effect of a shorter retirement life. Hence, when the replacement rate is high, women save less under the EAR policy and more under the EQR policy. As wages are 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 wages when the replacement rate is low and increases wages when the replacement rate is high. In the special case when the replacement rate equals 0, the tax rate deduction and the indexation channels disappear. Women still gain benefits from being less exposed to the mortality risk by working more years, but men lose benefits due to wage decreases.

The tax rate deductions range from 12.57% when the replacement rate is 15% to 11.93% when the replacement rate is 35%. The tax rate deductions show no significant pattern. In terms of the indexation effect, when the replacement rate is low, the difference between partial and full indexation is negligible. The income loss from partial indexation is small. Therefore, the welfare gains from extending the female retirement age are even smaller through this channel when the replacement rate is low. As the replacement rate increases, the losses from partial indexation are greater. Therefore, the welfare gains of increasing the female retirement age rise as the replacement rate increases. The

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

indexation channel contributes to this increase in welfare gains as the replacement rate increases. Finally, social security is a substitute for annuities, and it protects agents from the mortality risk in the same way that labor income does. When the replacement rate is high and the saving rate is low, agents are well protected against the mortality risk. In this case, increasing the years of working is less influential for women because women are already protected against the motility risk. Therefore, the welfare gains of increasing the female retirement age become smaller through the mortality risk 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% because women are held back by the cost of increasing the retirement age. Women have to give up their claim on social security benefits for five years when the retirement age increases, and the cost increases as the replacement rate increases. Therefore, female welfare gains increase more slowly than those of males.

6.2 Gender Ratio

Since 1990, the new generations in China have had a very skewed gender ratio. Figure 3 shows the gender ratio by all ages according to the 2010 Chinese Census data. As shown in the graph, the ratio greatly increases from 1990 (represented by the cohort who were 20 years old in 2010), and stabilizes at around 120 for the younger cohorts born after 2000. That is, since 2000, for every 100 girls born there have been 120 boys. The right-hand side of Figure 3 shows that the gender ratio declines substantially for individuals older than 70 years because women tend to survive longer than men.

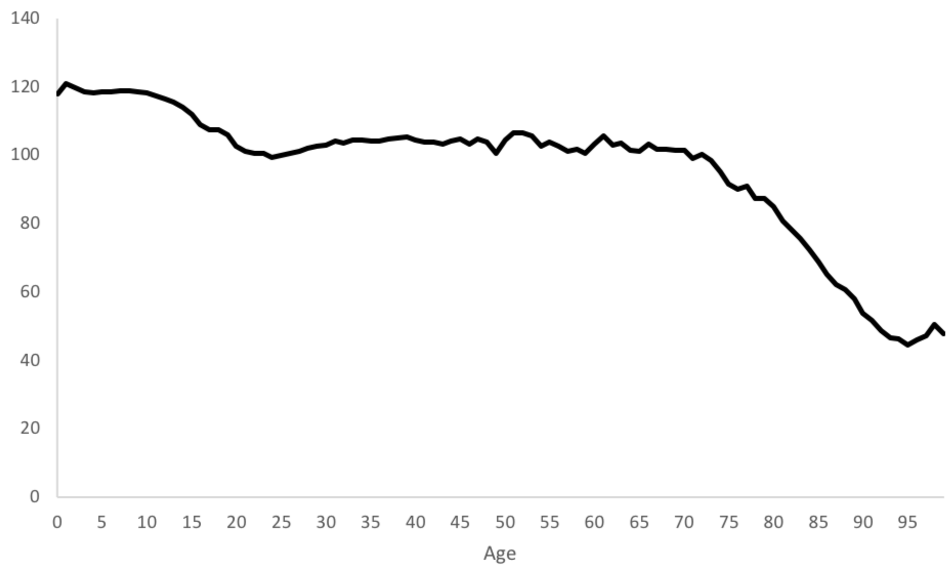


Figure 3: Cross-sectional Gender Ratio in 2010

Figure 4 shows the population pyramid using 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, the middle-aged population makes up the majority of the overall population, and the gender ratio for the total population is 1.0492, which is not as skewed as that for the younger generations. Compared to the 2010 data, the gender ratio of the youngest cohort decreases to 1.1569.

Figure 4: Population Pyramid in 2016

This skewed gender ratio among children and teenagers may have had little effect on the Chinese economy in 2010, but as this cohort enters the labor market in the next few decades, the disparity in the gender ratio will affect the Chinese economy and policy making. Taking the EAR policy in the social security system as an example and holding everything else constant, a relatively lower percentage of female agents will decrease the burden of social security tax on the working population. This makes the EQR policy less welfare improving.

To quantitatively evaluate the effect when the generations with a skewed gender ratio become the working-age population, we change the gender ratio at 20 years old in the benchmark model from 1.0492[18] to 1.20. First, we compare this counterfactual experiment with the benchmark model. Second, we explore the effect of increasing the female retirement age with the skewed gender ratio, and compare the results to the conclusions of the benchmark experiment.

In Table 8, the third column from the left entitled "Skewed" summarizes the counterfactual experiment with the skewed gender ratio and the EAR policy. As shown, the social security tax rate decreases, because there are fewer female agents claiming social security benefits and more male

[18] Please check Section 3.1 for more details.

Table 8: Benchmark vs. Skewed

	Benchmark	Skewed	Change
Interest rate	0.1364	0.1369	0.37%
Hour worked men	0.4735	0.4731	-0.08%
Hours worked women	0.4452	0.4446	-0.13%
Social security tax rate	0.1719	0.1698	-1.22%
Accidental bequests	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%

agents contributing to the social security program. In addition, because the share of male workers increases and male workers are more productive and work longer hours, the output increases and wages decrease due to the increase in the labor supply. Moreover, the interest rate increases because the higher labor input increases the marginal product of capital. Finally, capital increases because of the increase in savings due to higher incomes.

Table 9: Skewed Gender Ratio

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

In Table 9, the second row summarizes the welfare changes in the counterfactual model with the skewed gender ratio and EQR policy compared to another counterfactual model with the skewed gender ratio and the EAR policy. As expected, with fewer women, increasing the female retirement age has a smaller effect on the general equilibrium than 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 EAR policy for women in a quantitative overlapping generations model. Our quantitative results suggest that the EAR policy is detrimental to the welfare of both men and women. When we apply the EQR policy in a counterfactual experiment, both men and women are better off. In addition, better educated workers benefit less from the equal retirement age policy than less educated workers.

We explore the reasons behind the positive welfare effect of the EQR policy and find two. First, when women work five fewer years than men, they lose five years of full indexation to economic growth due to partial indexation. By increasing the female retirement age, women lose fewer benefits due to economic growth. Second, the earlier that agents retire, the greater the mortality risk to which they are exposed. Therefore, women benefit from protection against the mortality risk when their retirement age is increased.

Finally, we analyze the effect of the social security replacement rate and the gender ratio on the welfare consequences of the EQR policy. We find that a higher replacement rate leads to greater welfare gains through individual saving decisions. When there are more men in the economy (as is expected based on current trends in China), the welfare gains from the adoption of the EQR policy are smaller.

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Appendix A: Retirement Policies and Indexation Rules Across the World

Developed countries

The majority of developed countries implement an equal retirement age policy, and some developed countries that have an early retirement policy for women are transitioning to an equal retirement policy in the coming years. Ideally, if the social security benefit is completely indexed to economic growth, then indexation should take into account CPI inflation and real income growth, or nominal income growth. However, not all developed countries index their social security benefits to economic growth. Here are some example of early retirement policies and indexation rules in developed countries.

In Austria, the retirement ages[19] are 65 for men and 60 for women. The public pension system consists of two parts. A minimum pension is guaranteed for all citizens through a social assistance scheme, and an earnings-related social security scheme covers all employees. Both the minimum and earnings-related pension benefits are indexed to CPI inflation only.

[19]Here and in what follows, retirement age refers to the minimum eligible age at which an individual can claim their old-age 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 per year in 2008) to elderly people with low incomes[20] including social pension benefits. The minimum guaranteed income is indexed to the nominal GDP per capita. However, the main social pension benefit is not indexed to economic growth but only to CPI inflation. Specifically, social security benefits are indexed at 100% of the inflation rate for up to three times the minimum pension, 90% for between three and five times the minimum pension, and 75% for above five times the minimum pension.

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

Developing Countries

Social pension schemes in developing countries are understudied, and there is a lack of reliable sources in English on retirement ages and indexation in developing countries in Asia and Latin America.

Early retirement for women is a more commonly adopted policy in developing countries. For example, in Bulgaria, the retirement ages are 63 for men and 59 for women; in Estonia, they are 63 for men and 60 for women; in Lithuania, they are 62.5 for men and 60 for women; in Poland, they are 65 for men and 60 for women for those who accrued their pensions before the end of 2008; in Romania, the retirement ages for earnings-related pensions are 58 for women and 63 for men; and in Slovakia, the retirement ages for earnings-related pensions 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, pension benefits are 50% indexed to CPI inflation and 50% to nominal income growth; in Estonia, they are fully indexed to CPI inflation; in Lithuania, there are

[20] A low income is defined as below 5,311 euro per year for elderly people between the ages of 65 and 69, and 7,540 for elderly people aged 70 and above. For married people, a low income is defined as a total combined income of less than 11,071 euro per year for couples aged between 65 and 69, and 12,683 for couples aged 70 and above.

no existing indexation rules for social pensions; in Poland, pension benefits are 100% indexed to CPI inflation and 20% to real income growth; in Romania, pension benefits are fully indexed to real income growth; in Slovakia, pension benefits are 50% indexed to CPI inflation and 50% to nominal income growth.

Appendix B: A Brief Introduction to China's Social Pension System

China's social pension system consists of three parts: an urban employee social insurance pension system, a public service employee retirement pension system, and a rural resident pension system. The first two are often referred to as "the two pillars of the system." The rural resident pension system only started in 2009 and is relatively small. The public service employee retirement pension system is equivalent to the traditional defined benefit (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 parts: a pay-as-you-go pension based on a 20% employer contribution, and a 401(k)-type individual account financed by employee contributions of 8%. The urban employee social insurance pension system covers about 320 million participants.