Social Security and Female Labor Supply in China

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Abstract

This paper studies how a potential policy change that raises women's social security eligibility age from 50 to 60 would affect women's employment, human capital, and earnings in China. I develop a dynamic model of female labor supply, featuring voluntary retirement; occupational choice; human capital accumulation contingent on occupation, age, and employment status; and child care using time inputs from parents, grandparents, and formal child care from the market. I estimate the model parameters by matching moments on employment, wages, and the time allocation of child care from micro data in China. The policy counterfactual raising women's social security eligibility age yields two main findings. First, the policy change leads to only a moderate increase in aggregate labor supply because it affects the employment of old and young women in opposite directions. The reduction in social security insurance encourages women above the age of 50 to supply more labor. Yet low-skilled young women with children reduce their labor supply in response to the children's grandmothers working more and providing less child care. Second, since human capital accumulation is faster on the earlier career path rather than later, the reduction in early career employment leads to persistent losses in human capital and earnings for low-skilled women.

Keywords: China; Social security; Female labor supply; Child care; Human capital; Life cycle

JEL Classification: D15, J13, J22, H55

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1 Introduction

Under the current Chinese social security policy, women are entitled to withdraw social security benefits as early as age 50, while men are entitled to do so at age 60.[1,2] To maintain fiscal sustainability in the presence of an aging population, the Chinese government plans to raise women's social security eligibility age to 60. This paper studies how this policy change would affect Chinese women's employment, human capital, and earnings.

The current social security policy is an important factor affecting Chinese women's labor supply. Figure 1 plots the employment rates by age of urban Chinese women between ages 24 and 60 using data from the Urban Household Survey of China (UHS).[3] Before age 50, around 80% of Chinese women are employed. Once eligible for social security benefits at age 50, Chinese women drop out of the labor force very quickly. After the policy change, women between ages 50 and 60 would no longer be eligible for social security. The reduction in social security insurance will incentivize women to work more years and accumulate more human capital.

However, this policy change may bring about unintended effects to the labor supply of younger women, because women between age 50 and 60 are very likely to have young grandchildren and provide a substantial amount of child care to them under the current policy, which enables the children's mothers to stay in the labor market.[4] According to the 2008 wave of the China Time Use Survey (CTUS), around 30% of the grandparents between ages 50 and 64 provide positive child care hours, and they take care of children as a primary activity for 13 hours per week on average, conditional on provision.[5] The employment rate of young women with children under 7 is on average 26 percentage

[1]Technically speaking, only female workers are eligible at age 50, while civil servants are eligible at age 55. Fang and Feng (2018) document that around 93% women are eligible at age 50 in practice.

[2]A common practice in many countries–especially in developing countries– is to assign women a younger social security eligibility age than men. See https://en.wikipedia.org/wiki/Retirement_age#cite_note-72 for retirement ages across the world. One potential explanation is that, historically, old women are physically disadvantaged as factory labor workers.

[3]I exclude self-employed workers because they are enrolled in social security on a voluntary basis. Maurer-Fazio et al. (2011) document a similar pattern for labor force participation using the Population Census of China.

[4]See Figure 3 in Section 3.

[5]As a comparison, Rupert and Zanella (2018) document that only 13% of American grandparents in the same age group provide positive child care hours and spend 11 hours per week conditional on the provision using the Health and Retirement

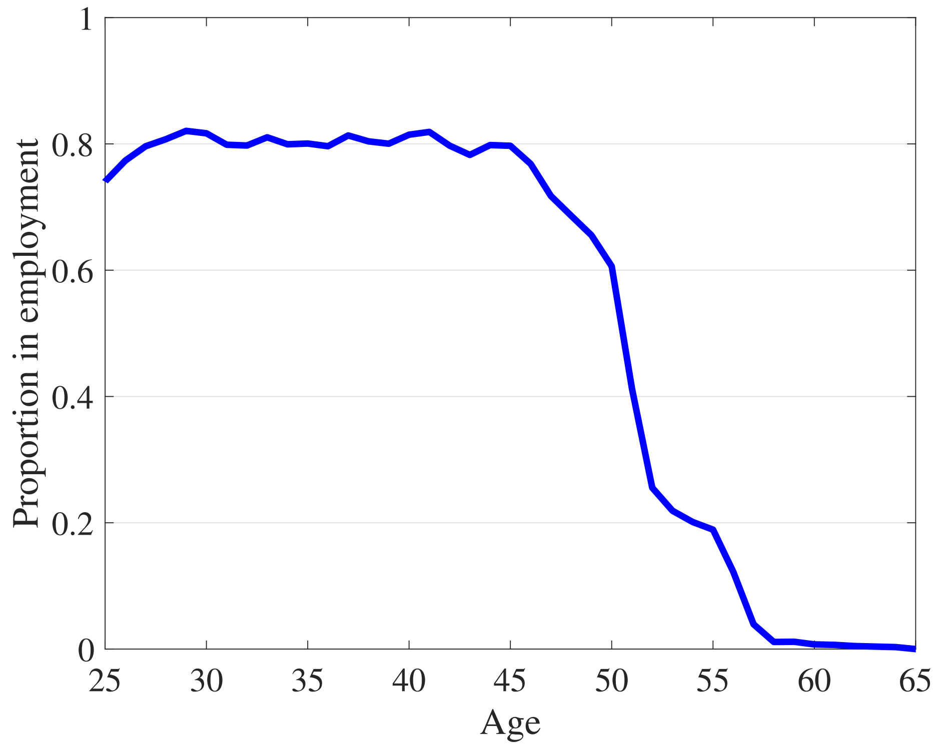

Figure 1: Employment rate of Chinese urban women by age

Source: Urban Household Survey of China 2007–2009. The employment rate is defined as employed workers as a share of total population, excluding self-employed workers, students, and the disabled. See Section 1.1 of the Technical Appendix for more details about the construction procedure.

points higher in households that include children's grandparents relative to those without.[6] This may also contribute to the distinction between the patterns of young women's employment in China and other countries. In China, the employment rate of young women is around 80%, whereas in many other countries, the presence of children significantly lowers the employment rate of women in their early careers compared with those in their later careers (see Attanasio et al. (2008) for the United States and Adda et al. (2017) for Germany).[7] Under the new policy, when grandmothers supply more labor and reduce child care hours to their grandchildren, the younger women have to either provide child care themselves or purchase formal child care services from the market. Additionally, early career em-

Survey (HRS) of the United States.

[6]I don't distinguish between women's parents and in-laws and simply refer to them as grandparents hereafter.

[7]This is not a consequence of women adjusting the intensive margin of labor supply. In Section 1.5 of the Technical Appendix, I document that part-time jobs account for a very small fraction of employment.

ployment is critical for human capital accumulation and will have dynamic effects on women's human capital and earnings later on the career path. The question of how much younger women will adjust their labor supply is important for understanding the overall policy impact.

In this paper, I develop a dynamic overlapping generations (OLG) model to address those issues and look at policy impacts on employment and human capital for both young and old women. The model features voluntary retirement; occupational choice; human capital accumulation contingent on occupation, age, and employment status; and child care using time inputs from parents, grandparents and formal child care from the market. In the model, young and old generations form households and jointly decide on consumption, savings, employment, and child care time allocation. Households with children need to spend a minimum amount of time with children. I allow for three types of child care providers: parents, grandparents and formal care from the market. The time that parents and grandparents spend time with children directly affects their time available for leisure and work. Formal care from the market is purchased with monetary resources. To better understand the career costs of children on women's employment and human capital, I introduce occupational choice and state-contingent dynamic human capital accumulation. More specifically, human capital accumulates in periods on the job and depreciates in periods of non-employment. The speed of human capital accumulation is a function that varies across occupations and changes linearly by women's age. With this setup, the opportunity cost of non-employment varies by age, which allows me to precisely estimate how much the reduction in early career employment affects human capital and earnings over the life cycle.

I estimate the model using the method of simulated moments (MSM). The internal parameters of the model are estimated with moments on employment and wages from the UHS and child care time from the CTUS. I classify occupations in the UHS as either high- or low-skilled occupations according to their task intensities and estimate the human capital accumulation functions by matching moments on wage growth by groups of occupation, age, and employment history. I find that human capital accumulates at a faster speed for women employed in high-skilled occupations and at younger ages.

I also use the employment share of occupations to estimate the parameters of the occupational choice problem and use moments on child care hours by both young and old to estimate the parameters of preference for child care.

The model provides a good fit with the aggregate female employment rate by age. The model captures the elasticity of retirement to the social security entitlement and can thus replicate the drastic decrease in women's labor supply at age 50. Two features of the model allow younger women with children to supply labor, enabling me to match the employment rate of around 80% in their early careers. First, intergenerational time transfer allows the old women to retire and provide child care, which relaxes the time constraint of young women. Second, the human capital growth rate is declining in age, implying a higher opportunity cost of non-employment at the earlier career stage. The model matches the movement of high-skilled labor as a fraction of employment over the life cycle by capturing the labor supply incentives with respect to having children for women employed in different occupations. The model can generate similar patterns of child care provision in both the extensive and intensive margins. It also matches women's child care provision by their employment status.

I validate the model by showing that the model reproduces the marginal effect of the presence of the old generation on young women's employment. This evidence indicates that my model correctly captures the role of intergenerational time transfer in determining young women's labor supply. I also use the model to replicate the empirical literature that studies the causal effect of retirement on the provision of child care by conducting regression discontinuity (RD) experiments to exploit the differences in the population around the age of social security eligibility.

I use the model to conduct a counterfactual policy experiment to raise the social security entitlement age from 50 to 60 and then evaluate the changes in economic variables in a new steady state. Women under the new policy are not eligible for social security between ages 50 and 60, and the extra social security revenue will be reimbursed to the whole working population via income taxes. Under the new policy, the probability of choosing high-skilled occupation increases from 25% to 32% because of the reduction in the present discounted value (PDV) of social security programs. Overall welfare evaluated on a consumption-equivalent basis shows a negative change of - 0.1%.

The policy counterfactual yields two main findings. First, although the policy change removes social insurance for 10 years, it leads to only a moderate increase in lifetime labor supply up to around 3 years. The policy change stimulates the labor supply of women above age 50 from 20% in the benchmark to around 65% in the counterfactual. However, the employment rate of low-skilled young women decreases. After the policy change, children's mothers act strategically in response to the reduction in grandparental child care support. The higher wages of high-skilled women enables them to purchase child care services from the market as a substitution, whereas the lower wages of low-skilled women prompt them to stay at home. Second, early career employment is critical for human capital accumulation and has dynamic effects on the periods that follow. A reduction in early career employment leads to persistent loss of human capital and earnings for low-skilled women. These results are robust in alternative setups of population aging and the elastic supply of formal care in the market.

Related literature This paper is primarily related to the literature on social security reform relative to the global trend of an aging population. Previous literature on Chinese social security reform has focused on the changes in benefit level after the policy reform. İmrohoroğlu and Zhao (2018) investigate the impact on household savings and output and argue that dynastic models featuring intergenerational monetary transfer would lead to conclusions that are different from the life cycle models. He et al. (2019) study the impact of the reduction in social security benefits on household savings and labor supply. Song et al. (2015) study the optimal social security policy design along the transition path. In this paper, I restrict my analysis to the change in social security entitlement age and focus on the impacts on women. To make the study suitable for a policy analysis of female labor supply in China, I introduce features of intergenerational time transfer and dynamic human capital accumulation, both of which turn out to be key in matching patterns of female labor supply in the benchmark economy as well as in understanding the policy impacts in the counterfactual economy.

The paper is also related to the large literature that studies the role of children in characterizing mothers' labor supply(e.g., Hotz and Miller (1988), Ribar (1995), and Bick (2016)) and grandparents' labor supply (Rupert and Zanella (2018)). In particular, I highlight the intergenerational linkage of grandparental child care and marry two literatures that are intrinsically linked but typically studied separately. The first literature studies the impact of grandchildren on the elderly's labor supply and retirement behavior. Rupert and Zanella (2018) and Frimmel et al. (2020) find that becoming a grandparent increases the probability of leaving the labor market in the United States and Austria, respectively. Feng and Zhang (2018) show that retirement is associated with an increase in the provision of child care in both the extensive and intensive margins. The second literature studies the impact of the accessibility to grandparental child care on the labor supply of children's mothers. Maurer-Fazio et al. (2011) and Li (2017) provide evidence that in China, the presence of old household members is associated with a higher employment rate for young women in the household, especially in households with young children. Compton and Pollak (2014), Bratti et al. (2018), and Garcia-Moran and Kuehn (2017) find similar positive correlations in the United States, Italy, and Germany, respectively. In this paper, instead of focusing on either the young or the old generation, I provide a unified framework in which both the old and the young jointly make decisions on labor supply and child care. In this way, I address the endogeneity of labor supply/retirement and child care and the simultaneity of the actions of the young and old, which allows me to obtain precise estimates on policy impacts over the life cycle. I show that the coordination of child care between the young and old generations is quantitatively important in driving the main results.

Outline The rest of the paper is organized as follows. Section 2 lays out an OLG model with endogenous labor supply/retirement and child care decisions. Section 3 presents data sources and empirical findings about Chinese women's employment and wage dynamics by occupation as well as their time use on child care. Section 4 presents my calibration choices of the model and the model fitness. In Section 5, I conduct a policy experiment by raising women's social security eligibility age to 60 and explore its impact on various labor market outcomes. Section 6 checks the robustness of the results.

Section 7 concludes.

2 Model

This section develops an OLG model of female labor supply. The key features of the model include women's labor supply and retirement choices, child care using time inputs from parents, grandparents, and formal child care services from the market, and occupational choice and human capital accumulation contingent on age, occupation, and employment status.

2.1 Setting

Time is discrete. The economy is populated by an infinitely lived government and overlapping generations of individuals. The size of cohort grows at rate g.

There are two genders in the economy. Individuals enter the economy at the same age 22 and live consecutively through the young and the old stage, each lasting for 24 years. Since I use two years as a model period, a life stage is also equivalent to $T = 12$ model periods. A household consists of two overlapped successive generations of two genders, i.e. household members $i \in \mathcal{I} = \{\texttt{yf}, \texttt{ym}, \texttt{of}, \texttt{om}\}$, each referring to young female, young male, old female, and old male, respectively.

To simplify the problem, I do not model the marriage decision. All individuals are married in all periods.[8] Young women give birth to children stochastically. Old individuals belonging to the same household are subject to a common mortality shock. Within a household, the measure of the young generation is normalized to 1 and the measure of the old generation is denoted as m^o. Before the mortality shock hits the household, m^o is equal to g^{-T}, a constant that takes the value of the population ratio of the young generation relative to the old generation in the same household and m^o becomes 0 after the mortality shock. At the end of period-T, a new household is formed with the evolution of individuals' household member categories: any living old generation in the current household leaves

[8] The marriage rate of Chinese urban population between age 24 and 50 is around 88% in 2007.

the economy, the young generation in the current household becomes the old generation in the new household, and the children from the current household enter the economy as the young generation in the new household.

Alive household members jointly make decisions to maximize the same utility objective. The household maximization problem can be formulated into a recursive problem, in which the value function denoted as V_j for a household with the young generation being age j.

2.2 States, choices, and preference

States Households are heterogenous in terms of the assets a, children age π, and a set of income-related state variables $\mathbf{s} = \{s^i\}_{i\in\mathcal{I}}$, which is a collection of individuals' income-related variables s^i.[9] I summarize the states as $\mathbf{x} = (a, \pi, \mathbf{s})$. Individual-$i$'s income-related state variables include occupation k^i, human capital h^i, income shock ϵ^i that determine the wage income, and retirement status r^i and average lifetime earnings z^i that determine the social security income.

Choices The household jointly choose $\mathbf{d} = \{k^{\text{yf}}, r^{\text{of}},\ \mathbf{n},\ \mathbf{l},\ \mathbf{q},\ q^n,\ a',\ \mathbf{c}\}$, each referring to :

- occupation of young women: $k^{\text{yf}} \in \{1, ..., K\}$
- retirement of old women: $r^{\text{of}} \in \{0, 1\}$
- working hours: $\mathbf{n} = \{n^i\}_{i\in\mathcal{I}}$
- leisure: $\mathbf{l} = \{l^i\}_{i\in\mathcal{I}}$
- household members' child care hours: $\mathbf{q} = \{q^i\}_{i\in\mathcal{I}}$
- formal child care hours from the market: q^n
- asset: a'

[9]Note that this formulation easily nests the case where the old generation is not present in the household. In this case, I set all state variables for the old generation to values of 0.

- consumption of the young and the old generation: $\mathbf{c} = \{c^y, c^o\}$

Also note that some of the choices may only apply to certain periods and are potentially subject to the current states. For example, the occupational choice is only made at the beginning of period 1 and the retirement decision only applies to households in which the old women are not yet retired. This will become more clear when I introduce the corresponding elements in the following sections.

Preference Preferences are assumed to be time-separable, with a constant discount factor β. The period utility function of household is denoted as $u(\mathbf{c}, \mathbf{l}, \mathbf{q})$. which is derived from private consumption of generations, private leisure, and child care hours of all household members. The functional form will be specified in the section of calibration.

2.3 Government policies

Government taxes wage incomes to finance an exogenous public expenditures G and the socials security expenditures to retired workers. G works as a residual to balance government budget in the benchmark and is invariant to the changes in policy environment. Wage income tax is proportional to personal before-tax wage income, and the tax rate is denoted as τ.

Social security Retired workers receive social security incomes each period until they die. Social security pays at the amount of $b(z)$, which is a function of individuals' average lifetime earnings z. Individuals are eligible for social security benefits when they exceed their gender-specific eligibility age. Once retired, they will leave the labor market forever.[10] Women are entitled to collect social security benefits at age 50 and men are entitled at age 60.

[10]In UHS, 7.91% of the retired workers (and 8.75% retired female workers) are rehired, see Table A1 of the Technical Appendix. I thus do not allow for rehiring in the model.

Government budget balanced with

$$\tau \sum_i w^i \mathbb{1}_{\{n^i=\bar{n}\}} - \sum_i b(z^i)\mathbb{1}_{\{r^i=1\}} - G = 0$$

2.4 Household income and the monetary budget constraint

Household income includes both asset income and labor income. Household members pool labor incomes from each household member and share a common savings account.

Savings Assets are used to finance periods out of the labor force, fluctuations in household earnings due to productivity shocks, and costs associated with children and retirement. a_t denotes the household savings account shared by parents and grandparents, which accumulates at a constant return r each period. Allowing for savings is important to understand how policy change affects individuals' dynamic labor supply incentives. Household savings rate is as high as 22% in 2015, suggesting the important role of private savings in smoothing consumption for periods of retirement. A shared savings account allows for costless transferring of monetary resources across parents and grandparents.[11]

Labor income Household after-tax labor income y^j is the sum of after-tax labor income from each household members:

$$y_j(s, \{n^i\}_{i\in\mathcal{I}}; \mathcal{T}) = \sum_i m^i y^i_j(s, n^i; \mathcal{T}) \tag{1}$$

y^j_i refers to individual i's after-tax labor income, which includes after-tax wage income and social security income and is given by

$$y^i_j(s^i, n^i; \mathcal{T}) = \mathbb{1}_{\{n^i_j=\bar{n}\}} w^i_j(o^i_j, h^i_j, \epsilon^i_j)(1-\tau) + \mathbb{1}_{\{r^i_j=1\}} b(z^i_j) \tag{2}$$

[11] The assumption of perfect risk sharing may seem extreme, however, İmrohoroğlu and Zhao (2018) documents that this setup can predict the right direction of transfers between parents and grandparents by age.

Budget constraint The household receives labor and asset income and purchase private consumption goods and market formal child care of amount q^n at price p^n. The household also chooses asset for next period a'. The household budget constraint is thus given as

$$c^y + c^o m^o + a' + p^n q^n = (1+r)a + y_j(s, \{n^i\}_{i\in\mathcal{I}}; \mathcal{T}) \tag{3}$$

2.5 Time endowment

Every individual is endowed with 1 unit of time each period, which can be allocated across three types of activities : working n, child care q and leisure l.

q and l are continuous variables and n is induced by the individual's employment status, which takes value of $\bar{n}$ if employed and 0 otherwise. With this individual time allocation constraint, I assume explicitly that each activity can only be conducted separately. Retired individuals supply 0 market hours. Non-retired women (yf or of) make period-by-period decision on whether to work, while non-retired men (ym or om) always supply $\bar{n}$ hours.

$$l^i + q^i + n^i \leq 1, \quad l^i \geq 0, \quad q^i \geq 0 \qquad \forall\, i \in \mathcal{I} \tag{4}$$

$$n^i \begin{cases} = 0 & \text{if } r^i = 1 \\ \in \{0, \bar{n}\} & \text{if } r^i = 0 \;\;\&\;\; i \in \{\text{yf}, \text{of}\} \\ = \bar{n} & \text{if } r^i = 0 \;\;\&\;\; i \in \{\text{ym}, \text{om}\} \end{cases} \tag{5}$$

2.6 Children and child care

Fertility process All young women have children by age 40. Households are heterogeneous in the time of child birth, and the fertility rate in period j is denoted by δ^c_j. Stochastic fertility allows me to capture the costs of child care for women at at different ages. To simplify the problem, I assume that women give birth only once in their life. In the benchmark, I further assume that women will give birth to a boy and a girl at a time, who will become the male and female household member in the same generation in the successive household. This assumption also implies a constant size of population.

Child care time cost A household with children at age π needs child care for κ_π amount of time. To capture the channel of intergenerational time transfer, I allow both the young and old generation to be child care providers. Additionally, households can also purchase formal child care service from the market. The **child care time constraint** for the household is thus given as

$$\sum_{i \in \mathcal{I}} q^i + q^n \geq \kappa_\pi \tag{6}$$

which is a transformation technology that linearly combines household members' time q^i and formal child care time q^n to meet the minimum requirement κ_π.

Children require child care up till age 16. Before age 6, households can only purchase formal care from the market at price p^n. After age 7, children attend compulsory public education for a fixed amount of q^{school} hours. q^n for children above 7 will be the sum of q^{school} and the purchased formal care hours. To engage in formal care, the household must make a minimum amount of $\underline{q^n}$ hours purchase. Formal care unit price is denoted as p^n, which potentially vary according to children's age.

Formal child care supply To capture the potential impact of policy change on formal care supply and formal care prices, I specify a flexible formal child care supply function Equation (7). Q^n is the amount of aggregate supply of formal child care. $\xi_1 > 0$ refers to the case where child care supply is elastic with supply elasticity $\frac{1}{\xi_1}$ to formal care price. When $\xi_1 = 0$, the economy features perfectly elastic supply of formal child care.

$$p^n = \xi_0 + \xi_1 Q^n \tag{7}$$

2.7 Occupations, human capital and wages

Occupations differ in the costs upon entry and the expected income flows over the life. Modeling occupational choice allows me to capture differences in labor market attachment and wage growth across occupations, enabling me to obtain precise estimates on the policy impacts.

Occupational choice At the beginning of period 1, households choose occupations for young women, subject to occupational-specific training costs ψ^k and unobserved labor market shocks ε^k to occupations:[12]

$$k^{\text{yf}} = \underset{k \in \{1,\dots,K\}}{\arg\max} \{V_1(a - \psi_k, \pi, \mathbf{s}) + \varepsilon_k\}$$

The variance of the unobserved shocks controls the relative importance of other unobservable factors to the expected returns in determining women's occupational choice, thus allows for the flexibility of the elasticity of occupational choice probability to the policy changes.[13]

Occupation will be fixed for an individual all lifetime once the choice is made. The employment share of occupations will vary by age because different occupations have different levels of labor market attachment. To simplify the problem, I assume that occupational choice only applies to women while men are employed in one occupation.

Wage income The logged wage is simply additive in the wage premium of occupation α_k, human capital h and incomes shocks ζ:

$$\ln w_j = \alpha_k + h_j + \zeta_j$$

[12] This captures all unobserved characteristics that affect the decision of initial occupation choice, including factors like regional or time variation in working opportunities, or any pre-labor market opportunities that may affect the decision of occupational choice. An alternative but more complicated way to introduce an occupational choice problem will involve educational choices and human capital formation before the labor market. I leave this direction for future research.

[13] An extreme case is that when the variance is infinitely large, the choice probability will be completely independent of labor market returns to occupations.

Human capital Human capital h is normalized to be 1 for all women entering the labor market. Human capital of young female evolves following:

$$h_{j+1} = (1 + \rho(k, n, j))h_j$$

where human capital growth ρ is a function of women's occupation k, age j, and employment status n:

$$\rho(k, n, j) = \begin{cases} \rho_{k,1} + j\rho_{k,2} & \text{if } n_j = \bar{n} \\ \rho_{k,0} & \text{if } n_j = 0 \end{cases}$$

When a woman of age j is employed, her human capital grows by $\rho_{k,1} + j\rho_{k,2}$. Occupations differ in both the intrinsic learning speed $\rho_{k,1}$ and the age slope of learning speed $\rho_{k,2}$. Occupations with a faster learning speed are expected to have higher wage returns with the same length of employment history. When $\rho_{k,2}$ is negative, human capital accumulation is faster at the beginning of career thus non-employment in early career is more costly in those occupations. Additionally, the human capital depreciation rate of non-employment $\rho_{k,0}$ is also different across occupations. Modeling occupation- and age-dependence of human capital growth helps me to match paths of wage growth for women employed in different occupations and at different life stages, which allows me to capture the trade-off at the choice of occupations and the coordination between young and old generation.

2.8 Recursive formulation

Given period j, states $\mathbf{x} = (a, \pi, \mathbf{s})$, household members jointly choose $\mathbf{d} \equiv \{k^{\text{yf}}, r^{\text{of}}, \mathbf{n}, \mathbf{l}, \mathbf{q}, q^n, a', \mathbf{c}\}$, subject to the household monetary budget constraint, each household member's individual time budget constraint, child care time allocation constraint, and the household borrowing constraint. The value function can thus be formulated recursively as

$$
\begin{aligned}
& V_j(\mathbf{x}) = \max_{\mathbf{d}} \{u(\mathbf{c}, \mathbf{l}, \mathbf{q}) + \beta \mathbb{E}[\hat{V}_{j+1}(\mathbf{x}')]\} \\
& s.t. \quad c^y + c^o + p^n q^n + a' = (1+r)a + y_j(\mathbf{s}, \{n^i\}_{i \in \mathcal{I}}; \mathcal{T}) \\
& \qquad l^i + q^i + n^i \leq 1, \quad l^i \geq 0, \quad q^i \geq 0, \quad n^i \in \{0, \bar{n}\} \qquad \forall\, i \in \mathcal{I} \\
& \qquad \sum_{i \in \mathcal{I}} q^i + q^n \geq \kappa_\pi \\
& \qquad a' > \underline{a}
\end{aligned}
\tag{8}
$$

The expectation is taken over exogenous processes of income, mortality, and the age of children, and

$$
\hat{V}_{j+1}(\mathbf{x}') = \begin{cases} V_{j+1}(\mathbf{x}') & \text{for } j = 1, ..., 11 \\ \max_{k^{\text{yf}} \in \{1,\dots,K\}} \{V_1(a - \psi_k, \pi, \mathbf{s}) + \varepsilon_k\} & \text{for } j = 12 \end{cases}
$$

Period T differs from other periods in two main aspects. First, a new household is formed, the old in the current household leave forever, the young in the current household become the old in new household, and the children in the current household enter as the young in the new household. The state variables evolve as the household member identity changes. Second, the household jointly choose the occupation for the young woman in the new household, subject to both an unobserved labor market shock and training cost.

2.9 Definition of equilibrium

Let $\Lambda = (j, a, \pi, \mathbf{s})$ denote the vector of states for households and $\mu(\Lambda)$ be the distribution of households over the state space. Given interest rate r, child care supply function, and a set of government policies $\{\tau, R_1, R_2, \tau_b\}$, a stationary recursive competitive equilibrium for this economy is a collection of (i) value functions $V_j(a, \pi, \mathbf{s})$; (ii) formal child care price q^n; (iii) policy functions $\mathbf{d}_j(a, \pi, \mathbf{s})$ such that:[14]

1. Given prices and the government policies, the policy functions solve the problem described in

[14]Detailed equilibrium definition is given in Section 5 of the Technical Appendix.

Equation (8) and $V_j(a, \pi, \mathbf{s})$ is the associated value function.

2. Formal care market clears with $Q^{n,S} = Q^{n,D}$.

3. Government budget is balanced every period.

4. The distribution of households is stationary.

2.10 Role of social security entitlement age

In this model, the social security program insures households against stochastic shocks such as productivity shocks, fertility shocks and uncertain length of lives. Why would changing social security entitlement age affect women's employment and human capital accumulation? In this subsection, I summarize the channels through which the policy works and provide qualitative prediction on the policy effects. To set the idea, I consider a specific form of implementation that removes social security benefits completely for women between age 50 and 60 and reimburses the extra government revenue to households via proportional wage tax cuts.

Wealth effect Removing benefits for 10 years in general will reduce the present discounted value of social security incomes. Women between age 50 and 60 will work longer due to the reduction in insurance. In anticipation of collecting wage earnings for longer year, they may want to work high-skilled occupations and accumulate more human capital.

Intergenerational time transfer effect When women with grandchildren return to work, they will reduce the amount of child care transfer to children's mothers. Younger women will act strategically in response to the reduction in grandparental child care support by either taking care of children by themselves or purchasing child care service from the market. Apparently, this effect will depend on the price of child care relative to young women's wage since this determines how easily young women can make the substitution between grandparental care and market formal care. Additionally, this channel may have dynamic effects due to its interaction with human capital accumulation process. If human capital accumulation is significantly faster at early career, non-employment in early career may lead to persistent losses in human capital and earnings in later life.

Substitution effect Government runs a social security surplus under the same tax rate when women have a longer average working year. When government reimburses revenue via a proportional tax cut, women are encouraged to supply more labor and accumulate more human capital.

As can be seen from the above analysis, although the policy change only targets women between 50 and 60, it may have an impact on women at younger ages as well through the channels of dynamic human capital accumulation and intergenerational time transfer. Meanwhile, these channels affect the incentive to supply labor and accumulate human capital in opposite directions, making the overall effect ambiguous. The quantitative importance of each incentive can only be justified with the numerical experiments.

3 Data

The analysis in this paper is based on two main sources: UHS of China for information on employment, occupations, and wages, and CTUS for child care time use.

3.1 Employment, occupations, and wages

I classify the original occupational codes in the UHS into low- and high-skilled occupations following the task-based framework introduced by Autor et al. (2003). The low-skilled occupations include those that involve more intensively the routine and manual tasks and the high-skilled occupations include those that involve more intensively abstract task.[15]

[15] High-skilled occupations include mangers, officials, engineers, professional workers, technical workers, artists, and teachers. Low-skilled occupations include clerical works, sales workers, production workers and operators.

Table 1: Descriptive statistics by occupation

	Low-skilled	High-skilled	All
Employment share in age [24,30]	72.9 %	27.1%	100%
Employment share in age [24,60]	76.0 %	24.0%	100%
Log wage at age 24	9.03	9.24	9.07
	(0.69)	(0.67)	(0.69)
Log wage at age 50	9.24	9.75	9.37
	(0.75)	(0.63)	(0.76)
Wage growth, age $\in [25, 35]$	5.0%	3.4%	3.7%
	(0.199)	(0.194)	(0.197)
Wage growth, age $\in [40, 50]$	0.6%	0.2%	0.3%
	(0.173)	(0.185)	(0.182)

Note: (1) Employment share is defined as the fraction of women in a given occupation in all employed population. (2) Wage growth is evaluate for population continuously employed in the consecutive years in the age group. (3) Wage loss for 1 year of interruption is defined as the wage growth of population going through an employment – non-employment – employment(ENE) relative to those who are continuously employed. (4) Measures of wage change are truncated at 50% in absolute values.

Table 1 presents descriptive statistics of employment share and wage growth by occupation. As can be seen from the table, the low- and the high-skilled occupations differ in important ways. The low-skilled occupations account for over 70% of employment. However, the employment share of high-skilled is higher at the younger age. At the beginning of career(age24), the low-skilled make 0.21 log points less wages that the high-skilled. By age 50, this gap widens to 0.51 log points. The occupational wage gap is also reflected in the wage growth rates. The bottom 4 rows of Table 1 present by occupation the mean and standard deviation of wage growth for a younger group of age between 25 and 35 and for an older group of age between 40 and 50. As can be easily seen from the table, the high-skilled occupation features higher wage growth in both age groups. Additionally, the wage growth gap is as large as 1.6% per year for the younger group and decreases to 0.4% for the older group.

Knowing these facts is important for policy analysis. First, choosing a certain occupation implies a particular path of lifetime earnings thus occupational choice may be important channel for women to act in response to the policy change. For example, if the incentive to develop human capital dominates when women expect to have a longer career, they may choose the high-skilled occupation at a higher probability. Second, wage growth exhibits strong life cycle patterns. In particular, wage growth is faster at younger ages, during which women are typically associated with young children. If women anticipate that they will reduce labor supply at early career due to the reduction in grandparental child care thus are not able to develop human capital on the job, the expected return of choosing high-skilled occupation is lower.

3.2 Time use

Data source The main data source about time use is the first wave of CTUS conducted by the National Bureau of Statistics of China in May 2008. CTUS interviews each individual on a weekday and a weekend of the same week and record time diary on activities in these two days into a weekday and a weekend module accordingly. I construct the total child care hours from the weighted average of time spent on child care as the primary activity in two modules.

CTUS also contains information about individuals' age, relationship to the head, marital status, education, and employment status, which allows me to explore the distribution of child care hours across different groups. In the next section, I focus on grandparental child care by employment status to highlight the intercorrelation between retirement and child care provision from grandparents. The interested readers are referred to Section 2 of the Technical Appendix for more details on the dataset and additional results.

Employment status and grandparental child care Table 2 documents intensive and extensive margins of primary child care hours by employment status for population above age 50.

In the previous sections, I document that Chinese women typically retire between 50 and 55, while men tend to retire around 60. Additionally, the non-employed account for only a small fraction of the population. When documenting the differences across employment groups, the cells which contain

Table 2: Extensive and intensive margin of grandparental child care, by employment status

Age	Men E	Men R	Men N	Women E	Women R	Women N
Intensive margin						
50 – 54	6.56	9.13	8.87	8.01	17.84	24.05
55 – 59	8.29	12.13	8.43	7.67	15.00	27.36
60 – 64	11.46	11.01	–	11.08	13.26	–
65 – 70	9.60	8.36	–	8.57	9.71	–
Extensive margin						
50 – 54	0.14	0.17	0.18	0.22	0.39	0.63
55 – 59	0.21	0.42	0.50	0.23	0.41	0.49
60 – 64	0.17	0.38	–	0.30	0.30	–
65 – 70	0.15	0.23	–	0.24	0.20	–

smaller sample size introduces some additional noises. In this case, I draw conclusions based on the cells (in yellow) with largest amount of observations, i.e. grandfathers and grandmothers employed before age 60, grandmothers retired before age 60, and grandfathers and grandmothers retired after age 60.

The main findings of Table 2 are as follows: first, the employed provide less grandparental child care in terms of both extensive and intensive margins compared with the other two groups (retired and non-employed) ; second, contingent on employment status and age group, grandmothers provide only slightly more child care in terms of the intensive margin, while the relationship in terms of the extensive margin is not quite clear. When drawing conclusions on the gender difference, I abstract away from the number and age distribution of grandchildren for grandparents in each cell. In the next section, I show that the distributions of both the probability and the mean number of grandchildren shift to the right for around two years for grandfathers, which partially explain why grandfathers are more likely to provide child care for the retired than grandmothers between age 60 and 70 .

Age profile of grandchildren I end this section with Figure 3, which documents the age profile of grandchildren distribution for population above age 50.

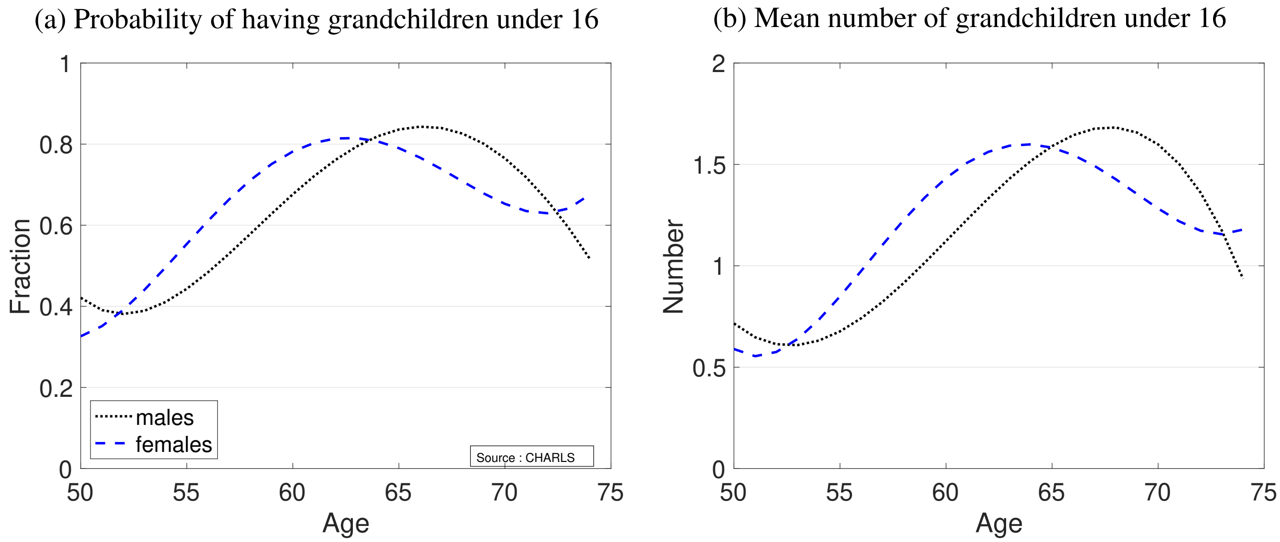

Figure 3: Age profile of grandchildren in urban China

The age profiles are constructed with a fourth-order polynomial in age using data from CHARLS in year 2011. Figure 3(a) documents the age profile of the probability of having at least one grandchildren under 16 and Figure 3(b) documents the age profile of the mean amount of grandchildren under 16. The figures clearly show that the amount of grandchildren under age 16 increase sharply for the population between age 50 and 65. The increase in the amount of grandchildren for women between age 50 and 60, together with the sizable grandparental child care hours documented in the previous sections, implies that the potential policy change may have a sizable impact on the provision of grandparental child care.

4 Calibration

In this section, I describe the procedure how I parameterize the model. I take some parameters externally and estimate the others using the method of simulated moments(MSM). The MSM allows me to combine information on employment, wages, and time use from different data sources. I solve the model by backward induction of value functions and simulate the economy with 50,000 household dynasties until convergence of distributions as an approximation of the model steady state. The simulated data provides a panel data set to construct moments that can be matched to moments constructed from data.[16] After calibrating the model, I check the performance of the model by comparing the non-targeted moments with the data.

4.1 Functional specification

Following Fuster et al. (2007), I assume that household's period utility u is separable in utility of generations $\tilde{u}$:

$$u(\mathbf{c}, \mathbf{l}, \mathbf{q}; m^o) = \tilde{u}(c^y, l^{yf}, l^{ym}, q^{yf}, q^{ym}) + m^o \tilde{u}(c^o, l^{of}, l^{om}, q^{of}, q^{om}) \tag{9}$$

The instantaneous utility function $\tilde{u}$ is defined for a generation with two genders m and f:

$$\tilde{u}(c, l^f, l^y, q^f, q^m) = \frac{(c^{1-\nu}(H^f)^{\frac{\nu}{2}}(H^m)^{\frac{\nu}{2}})^{1-\gamma}}{1-\gamma}$$

where c is the pooled consumption of this generation, H is a linear transformation which aggregates leisure and child care of an individual. I assume that individuals in the same generation have the same utility weight on child care, but individuals in different generations weight child care differently. To be more specific, young male (ym) and young female (yf) have utility weight ω^y and old male (om) and old female (of) have utility weight ω^o, i.e.

$$H^i = \begin{cases} l^i + \omega^y q^i & \text{if } i \in \{\text{ym}, \text{yf}\} \\ l^i + \omega^o q^i & \text{if } i \in \{\text{om}, \text{of}\} \end{cases}$$

Child care time q not only directly affects utility but also enters as an input to relax the child care

[16]See Section 6 of the Technical Appendix for a description about the numerical solution of the model.

time constraint. I also assume $\omega < 1$ to guarantee there is a solution.[17] A higher utility weight for the young generation would imply more child care hours and less working time for young women relative to old women. Varying the preference parameters ω^y and ω^o allows me to match the child care hours allocation.

With this setup, young male and young female have the same preference over child care hours. However, young males have higher wages and inelastically supply labor, while young females have lower wages and can choose non-employment. These modeling assumptions attributes to the gender difference in childcare hours.

4.2 External parameters

In this section, I present my parameterization of the preference, government policies, hours allocation, child care processes and other external parameters. I restrict my analysis to the urban population to build a more clear mapping between the model and data.[18] Table 3 summarizes the external parameters.

Environment and preference A model period is equivalent to two years. An individual starts life at age 22 and live through the young and the old generations, each lasting for 24 years. I set the discount factor $\beta = 0.90$ and a fixed interest rate $r = 8\%$ on a two-year basis. I take a standard value of 2.0 for the coefficient of risk aversion γ.

Government policy In the benchmark economy, I set the wage income tax to be 28% and the exogenous public expenditure to be 5.38, which is the value that balances the government budget at the steady state when other moments are matched.

I set the women's social security eligibility age to 50 and men's social security eligibility age to 60. In the benchmark, I set the social security to be 75% of personal average lifetime earnings up till social

[17] See Section 6 of the Technical Appendix for algebra.

[18] The rural population mostly work in agriculture sector, whose labor supply displays a significantly different pattern from those who work in other sectors. In addition, the rural population receive much lower amount of social security income. See Section 3.2 of the Technical Appendix for more details.

Table 3: External parameters

	Parameter	Description	Value
Environment	A	Age turning adulthood	22
	n	Model periods	2
	T	Periods of young/old generation	12
	r	Interest rate	0.08
	g	Population growth	0
Government	τ	Social security tax rate	0.28
	R_1	Social security eligibility age of women: 50	2
	R_2	Social security eligibility age of men: 60	7
	τ^b	Social security replacement ratio	0.75
	G	Exogenous public expenditure	5.38
Demographics	$\{\delta_j^o\}_{j=1,...,12}$	Mortality rate of grandparents	See Appendix
	$\{\delta_j^c\}_{j=1,...,8}$	Fertility rate	See Appendix
Preference	β	Discount factor	0.90
	γ	Risk aversion	1.5
Wage process	α_0^m	Intercept: men (normalization)	0
	α_1^m	Age linear: men	0.054
	α_2^m	Age quadratic: men	– 2.5e-3
	ρ_ζ	Persistence of income shock: women	0.77
	σ	Std. of income shock: women	0.35
Time allocation	$\{\kappa_\pi\}_{\pi=2,3,4}$	Child care hours : daily 10 hours	0.42
	q^{school}	School hours: daily 8 hours	0.33
	$\underline{q_n}$	Minimum child care provision: daily 2 hours	0.09
	$\bar{n}$	Working hours: daily 8 hours	0.33

security entitlement age. Social security is paid until the death of the individual.[19] Lee et al. (2019) and He et al. (2019) consider a more general social security rule that is partial indexed to economic growth.

Children and child care I take the fertility rates from the 2000 China National Population Census and adjust the values in the beginning and the ending period of the potential fertile periods to simplify

[19]Technically speaking, this only applies to the social account, while the remaining individual account will be reimbursed to the children or spouse of the individual when the old dies before the individual account runs out.

the computation. Mortality rates are also taken directly from the 2000 China National Population Census.[20]

Instead of keeping track of children age directly, I divide children age into several groups and allow age groups to evolve following transition matrix generated by fertility process and duration in each age group bin. With the assumptions on the fertility process, in any period, households belong to one of the five categories in Table 4.

Table 4: Child care requirement by children age groups

π	Age group	κ_π in daily hours
1	never give birth	0
2	child age $\in [0, 2]$	10
3	child age $\in [3, 6]$	10
4	child age $\in [7, 16]$	2
5	child age > 16	0

Children need child care for 10 hours per day. Children under age 6 can only purchase formal child care hours at given price p_n. Children over 6 attend compulsory public schooling for 8 hours per day. In practice, I also impose a 30 minutes of minimum child care hours per day. The price of formal child care is important in determining how much households change labor supply and child care hours in response to the social security policy and will be calibrated internally. When formal care price is low enough that the reduced grandparental hours are largely absorbed by an increase in purchase of formal care, mothers will be able to stay on their jobs and the aggregate labor supply may be reduced little or even increase. In the benchmark, I set $\xi_1 = \infty$. In this case, child care price is insensitive to the market demand.

Working hours In the benchmark, I assume that working hours are the same for both men and women and for all ages, except for women in the period of child birth to allow for maternal leave policy. I assume that each individual spends 8 hours per day on sleeping and has at most 16 hours of total dispos-

[20]More details on the demographic process can be found in Section 7 of the Technical Appendix.

able time for working, leisure and child care. I thus set the working hours to be $\frac{1}{3}$, which corresponds to 8 hours per day of working on full-time jobs.

Wage processes I estimate men's wage process directly from the data. I use a second-order age polynomial approximation to the wages of men between age 24 and 60 in the UHS. I assume that income shocks is 0 for men at all ages.

Women's income shock ζ follows an AR(1) process:

$$\zeta_j = \rho_\zeta \zeta_{j-1} + \epsilon_j, \epsilon_j \sim \mathcal{N}(0, \sigma^2)$$

In Section 1.4 of the Technical Appendix, I present estimation results of income shock processes by gender, and by occupation for women by matching the variance and up to 2 lags of auto-variance of the residuals of wage regressions.[21] The results show that the variance of transitory shocks is slightly larger for high-skilled women, while the persistence and the variance of the permanent shocks are very similar across low- and high-skilled women. In the benchmark, I set the income shock processes to be the same for women in both skill types. Without a good prior on the correlation between income shocks, I assume that income shocks for individuals in the same household (mother and grandmother) are independent.

Women's human capital accumulation parameters $\{\rho_{1,k}, \rho_{2,k}, \rho_{0,k}\}_{k=1,2}$ and occupational wage premia $\{\alpha_k\}_{k=1,2}$ will be calibrated internally using wage growth moments by age-occupation-employment status groups, as will be clear in the next section.

Occupational choice probability I assume that the unobserved shocks to occupational choice are independent and identically distributed across individuals and occupations and follow the extreme value type I distribution with mean zero and variance σ_e^2. This assumption allows me to obtain a simple

[21]The estimated shock processes are consistent with Yu and Zhu (2013) and He et al. (2019), who document the labor income and household income processes with moments constructed from various waves of China Health and Nutrition Survey (CHNS).

formula of the choice probability which can be written as:

$$\mathbb{P}(k^{\text{yf}} = v) = \frac{\exp(\text{EV}_v/\sigma_e)}{\sum_{k=1,\dots,K} \exp(\text{EV}_k/\sigma_e)}$$

where EV_v is the expected value function of choosing occupation v, after adjusting for the training costs but before the realization of unobserved labor market shocks in period 1, i.e.

$$\text{EV}_v(\mathbf{x}, \pi, a) = \mathbb{E}V_1(\mathbf{x}, \pi, a - \psi_v | k^{\text{yf}} = v)$$

4.3 Internally calibrated parameters

Table 5 presents three main blocks of parameters that are calibrated internally to match the key moments of the economy. As in many other structural models, these moments are jointly determined by the whole set of parameters, but each moment may convey relatively more important information on one of the parameters.

The first block includes parameters about preference and child care price, which are set to match moments about time allocation of employment and child care. ν controls the relative utility weight on leisure to consumption, thus is chosen to match the aggregate female employment rate of 77$\%$ between age 24 and 50. ω^y and ω_2 control the taste for child care of the old and young generations, and child care price p_n affects the incentive to use market formal care. A larger ω^y would imply more child care hours of mothers when ω^o and p_n are controlled the same. I thus choose ω^y and ω^o to match the mean child care time of 18 weekly hours from the young women and 12 weekly hours from the old women conditional on the provision. I set p_n to be the mean wage of women employed in low-skilled occupation in steady state when other moments are matched.

The second and the third block of parameters are related to occupational choice and human capital evolution processes. The role of training cost of high-skilled occupation and the variance of the unobserved labor market shock and their identification is described in Section 7.2 of the Technical

Table 5: Internally calibrated parameters

Parameter	Description	Value
	Preference & child care price	
ν	Intensity of leisure	0.42
ω^y	Utility weight on child care: young	– 0.10
ω^o	Utility weight on child care: old	– 0.30
p^n	Child care unit price	4.0
	Occupational choice	
ψ_2	Training cost of high-skilled occupation	1.50
σ_e	Standard deviation of unobserved shock	0.10
	Wages and human capital evolution	
$\rho_{1,1}$	High-skilled: intrinsic learning speed	0.055
$\rho_{1,2}$	High-skilled: age-slope of learning	– 4e-3
$\rho_{1,0}$	High-skilled: depreciation in non-employment	– 0.10
$\rho_{2,1}$	Low-skilled: intrinsic learning speed	0.025
$\rho_{2,2}$	Low-skilled: age-slope of learning	– 2e-3
$\rho_{2,0}$	Low-skilled: depreciation in non-employment	– 0.04
α_1	High-skilled: wage premium	– 0.42
α_2	Low-skilled: wage premium	– 0.50

Appendix. I set the training cost of the low-skilled occupation to 0 and choose the training cost of the high-skilled occupation to match the aggregate employment share of high-skilled occupation. The estimated training cost $\kappa_2 = 1.50$ which is equivalent to around 5 years of women's average income at age 24. The variance of the unobserved shock is estimated to match the data pattern that women with children at age 24 are 7.0$\%$ more likely to choose low-skilled occupations than those who do not have children.

The parameters of human capital evolution are chosen to match the wage growth moments for young and old women and by employment history in Table 1. Without selection, the mean wage growth by age will be equal to the model-implied age-specific human capital growth rate for the continuously employed. The estimation shows at early career, high-skilled women accumulate human capital at 5.5% annually and low-skilled women accumulate at 2.5% annually. In both occupations, learning-through-employment dies out at around 24 years of career (age 48).[22] In Section 11.4 of the Technical Appendix, I show that a model without age-dependence of human capital accumulation would predict a lower opportunity cost of non-employment at the beginning of the career, thus predicts a lower employment for early career and an increasing profile of employment rate by age 50. The fact that the constant learning model fails to generate the empirically plausible employment rate over the life cycle justify my choice of age-dependent human capital growth. The (relative) wage loss of non-employment relative to the continuously-employed in the model is a combination of human capital depreciation of non-employment and the lost human capital accumulation on-the-job, thus is used to identify the depreciation of human capital in periods of non-employment. I find that human capital depreciates at 4% annually in the low-skilled occupation and depreciates at a faster speed of 10% annually in the high-skilled occupations. Since wages of men are set externally, I choose wage premium of low- and high-skilled occupations to match the gender wage premium and skill premium of the high-skilled women.

4.4 Model fit of aggregate employment

In the previous section, I show model fitness at the micro-level in term of young and old women's labor supply. In this section, I show that the model also matches the aggregate employment rate and the employment share of the high-skilled occupation.

Employment rate by age Figure 4 presents the model fit of female employment by age. The model does a good job in fitting the employment of both young and old women. To be more specific, the model generates a drop in the employment rate around the age of social security entitlement to a similar

[22] Researchers find evidence of a declining learning speed by age in other countries as well. For example, using matched employer-employee data from Germany, Gregory (2019) find that the learning speed declines by 4% yearly as workers age.

degree in the data, which shows that my model captures the labor supply incentives to value of non-employment – a combination of monetary value social security benefits relative to wages and value from taking care of children.

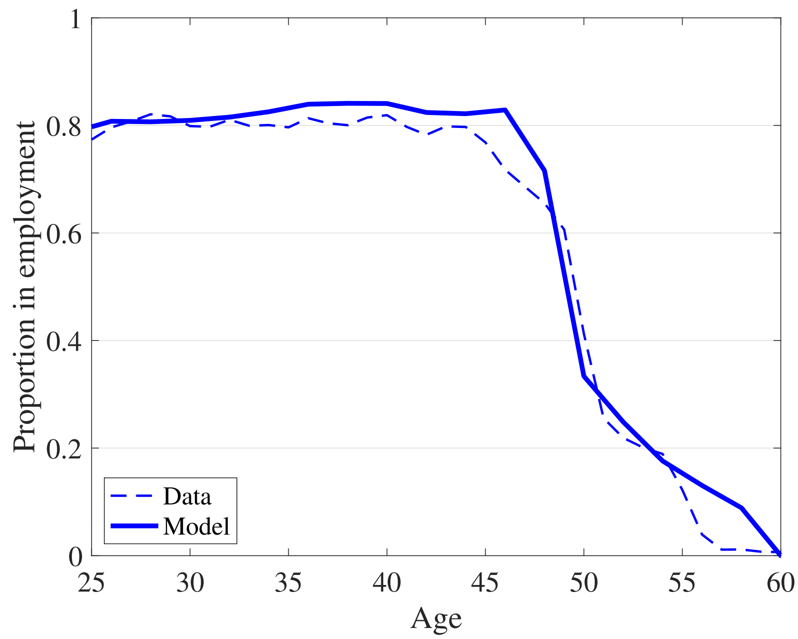

Figure 4: Model fit: female employment over the lifecycle

Two features of the model allows me to match the employment of young women under age 35, both qualitatively and quantitatively. First, the model features grandparental child care, which allows mothers to use child care from the old generation so as to supply more working hours. Second, human capital accumulation is faster at the beginning of career, which implies a higher opportunity cost of non-employment at younger ages than older ages. In the Section 11.4 of Technical Appendix, I consider an alternative model featuring constant learning speed over the life to isolate the concerns of dynamic human capital accumulation. The alternative model predicts that employment rate starts at around 70% at age 25 and monotonically increases to 85% up till age 50, which is apparently inconsistent with data patterns shown in Figure 4 .

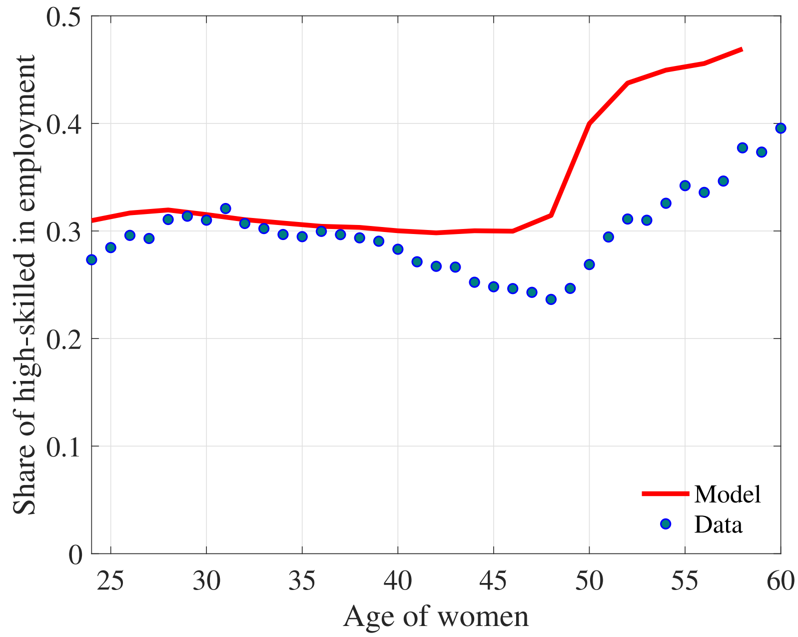

Figure 5: Model fit: fraction of high-skilled in employment

Share of high-skilled employment by age Figure 5 compares the employment share of high-skilled occupations over the life cycle in the data and in the model. In the data, the employment share of high-skilled occupations increases at the beginning of career and drops gradually between age 30 and 50. After age 50, employment share of the high-skilled occupation increases again. My model generates a similar pattern. In the model, the low-skilled are less attached to the labor market thus will drop out the labor force when they give birth to children, which explain the increase of employment share of high-skilled before age 30. When children grow up, the low-skilled women return to work, which brings down the share of high-skilled as a fraction of employment. Upon age 50, women are eligible to retire. However, the high-skilled women would face a larger income cut to retirement since they have more human capital and earn higher wages, thus will drop out of the labor force more slowly than the low-skilled old women. Table A27 of the Technical Appendix shows that the model-generated gender- and occupational-wage gaps are also consistent with the data.

In the Section 8 of the Technical Appendix, I also present the fitness of child care allocation by provider and by children age to show that my model correctly captures the costs of child care in female labor supply decisions.

4.5 Model validation

In this section, I validate my model as to the fitness of empirical evidence of labor supply and child care. I first present the model fitness of an empirical estimate about the marginal effect of the presence of old household members on young women's labor supply. I next show that my model reproduces the results from a literature of using the social security eligibility age policy as regression discontinuity experiment to estimate the impact of retirement on child care provision. These exercises validate my model at the micro-level decision-making and also informs the magnitudes of policy impacts.

Marginal effects of grandparents on young women's labor supply Labor supply elasticities are informative about the goodness of fit in terms of child care incentives in determining mothers' and grandmothers' labor supply. Equation (10) presents a Probit regression model to estimate the marginal effect of determinants of female labor supply:

$$\text{emp}_i^{\text{m}} = \mathbb{1}[\beta_0 + \beta_1 \text{GP}_i + \beta' \boldsymbol{X}_i + \epsilon_i > 0] \tag{10}$$

and I apply the above specification to the model-generated data for women between ages 24 and 40. In Equation (10), emp^{m} is the binary indicator of young women's employment status, GP refers to the presence of old, and $\boldsymbol{X}$ includes control variables of the linear and quadratic of experience, and women's occupation. The care of interest involves the coefficient of variable GP, which measures how much the probability of employment changes for young women when the women's parents or parent-in-laws are alive compared to those who have the same states except for losing parents or parent-in-laws. In the structural model, this coefficient summarizes the effects from intergenerational time transfer and added income.

In Table 6, I report the marginal effects for women by presence of children estimated from the

Table 6: Marginal effects of presence of the old generation

	Model	Data
Women with children aged [0,6]	0.244	0.261
All women with children	0.074	–
All women	0.038	0.066

model-generated data to those using data from various empirical literature. Li (2017) estimates that the marginal effect of variable GP in determining employment of young women to be 0.261 for women with children younger than 6, the model generates a coefficient of 0.241. Maurer-Fazio et al. (2011) estimates the marginal effect with samples of all women (including those with older children, or without children) to be 0.066 with samples from the 1 percent Micro Samples of the Population Censuses of China. Hare (2016) obtains a similar estimates of 0.061 using samples from 1991 – 2011 Waves of China Health and Nutrition Survey (CHNS). However, my model falls short of this estimate and generates 0.038. Table 6 shows that the model achieves relatively good job in matching the marginal effects, especially for women with young children. A naive extrapolation of this marginal effect would predict that under the new policy change, when the old women return to work, the employment rate change of women(mothers) would decrease by this change in the old women's employment times the corresponding marginal effects.

Retirement and child care provision There is also a literature exploit the difference of old around the social security eligibility age to estimate the casual effect of retirement on child care provision. The empirical specification is as in Equation (12)

$$y_i = \beta_0 + \beta_1 R_i + \beta_2 r_i + \beta_3 R_i \times r_i + \mathbf{X}_i \boldsymbol{\beta} + \epsilon_i \tag{11}$$

in which r_i refers to an individual's age to the age of retirement eligibility. R_i is the retirement status, which is instrumented with eligibility E_i in a first-stage regression of the retirement decision:

$$R_i = \gamma_0 + \gamma_1 E_i + \gamma_2 r_i + \gamma_3 E_i \times r_i + \mathbf{X_i}\boldsymbol{\gamma} + \epsilon_i \tag{12}$$

with

$$E_i = \begin{cases} 1 & \text{if } r_i \geq 0 \\ 0 & \text{if } r_i < 0 \end{cases}$$

Table 7 presents the estimated results in Feng and Zhang (2018) and the coefficients generated by my model about the casual effects of retirement on the incidence and hours of child care provision from old women.

Table 7: Model fit: retirement and child care provision

	All		Low-skilled		High-skilled	
First stage						
Data	0.476*** (0.052)		0.475*** (0.062)		0.415*** (0.084)	
Model	0.413		0.423		0.380	
Second stage						
	Provision	Annual hours	Provision	Annual hours	Provision	Annual hours
Data	0.296*** (0.083)	621.648** (254.561)	0.371*** (0.176)	585.903 (512.079)	0.287*** (0.097)	581.337* (307.029)
Model	0.504	658.741	0.472	667.392	0.642	610.446

Note: (1) Source: Feng and Zhang (2018).

My model does a good job in fitting the patterns observed in the data. In particular, in the first stage estimation, reaching entitlement age leads to 47.6% of increase in retirement in the data and the model generates 41.3%. The model fits the overall impact by slightly overshooting the impact for the low-skilled group and underestimating the impact for the high-skilled group. One thing that is noticeable in this table is that both the model generates similar level of labor supply elasticity to the social security entitlement for low-skilled and high-skilled, as is consistent with the data.

In the model, both the preference for child care of the old and the benefit level of social securities determine the old's retirement decision. In the benchmark, I set the replacement ratio to be 75%. A less generous replacement ratio of 60% would predict 0.282 and 0.137 for low-skilled and high-skilled in stage 1 regression, respectively. This generates a gap of 0.145, which is larger than 0.043 in the benchmark.[23] The intuition is that a less generous social security system brings out a reduction of monetary income of retirement. The high-skilled old women earn more wages on the job and will be less likely to quit. Section 11 of the Technical Appendix provides more detailed information on the sensitivity to these parameters.

5 Experiments

In this section, I consider a policy counterfactual that raises women's social security eligibility age from 50 to 60. Non-employed women between 50 and 60 are no longer eligible for social security incomes. In the policy counterfactual, I assume that the government pays social securities with the same benefit accrual formula, and human capital evolves according to the same functional specifications. Additionally, exogenous shocks, such as the birth/death shocks of household members and incomes shocks to individuals, are assumed to follow the same stochastic processes. As the social security revenues will change under the new policy, I consider allow the government to reimburse the revenues

[23]The exercise is conducted by solving the model using the new replacement ratio and simulate the households using the stationary distribution from the benchmark economy to redo the same regressions. See more details in the Technical Appendix.

to households in proportional tax cuts, with a new tax rate τ^{CF} such that

$$\tau^{CF}\sum_i w(x,\mathcal{T}^{CF})^i \mathbb{1}_{\{n(x,\mathcal{T}^{CF})^i=\bar{n}\}} - \sum_i b(z^i)\mathbb{1}_{\{r^i=1\}} - G = 0$$

5.1 Impact on female careers

Figure 6 presents the main results by occupation. Figure 6(a) plots the deviation of employment rates from the baseline. The employment rate of high-skilled women barely changes until age 45, after which, the employment rate rises since under the policy reform, old women can no longer receive social securities between age 50 and 60. Low- and high-skilled women behave differently in important ways. First, the employment rate of young low-skilled women drops by 13 % on average before age 45, a larger scale than the high-skilled women. This gap is more significant for women at early career. Low-skilled women make lower wages and accumulate human capital at a slower speed, thus having lower opportunity cost of non-employment. Low-skilled women has a larger labor supply elasticity and drop out of labor force at a higher probability when they receive less child care support from the old generation. Second, the policy brings a more persistent drop in the employment rate of low-skilled women between ages 35 and 45, up to around 7%. This is due to the fact that human capital growth is faster at early career, thus the reduction in early career employment implies large losses of human capital. The alternative model with constant learning speed would predict a recovery of employment rates after age 35, which again justify my modeling choice of age-dependent human capital accumulation. Lastly, low-skilled women also have a lower increase in the employment rate for ages above 50. The old low-skilled women have lower wages and are more likely to stay non-employed to take care of grandchildren.

The change in share of high-skilled women as a fraction of employment is also reflected in the change of share of high-skilled women in employment, as shown in Figure 6(b). The share of high-skilled labor increases at the beginning since women choosing the low-skilled occupation are less at-

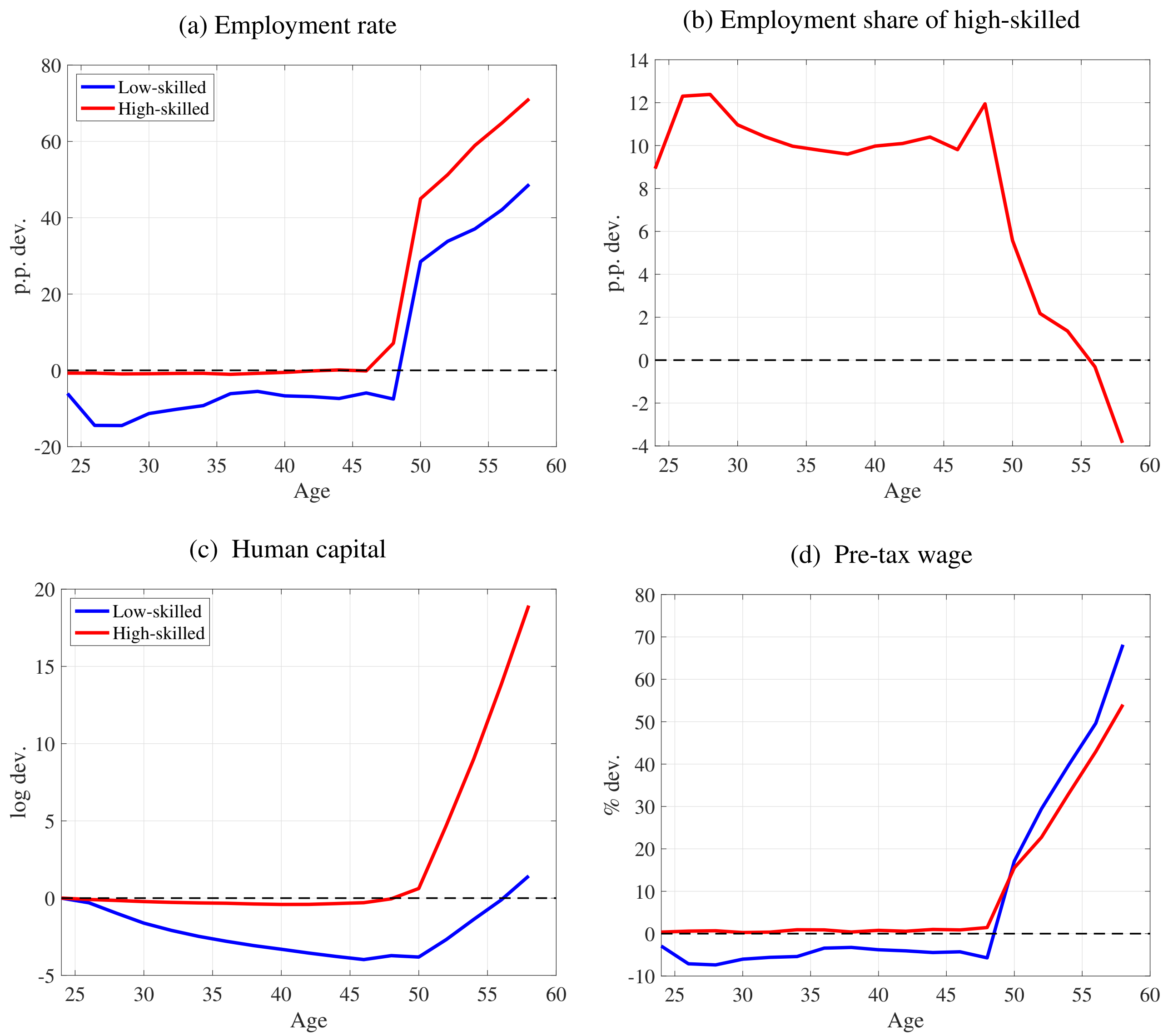

Figure 6: Policy impact by occupation

tached. As the low-skilled return to work when children grow up, the employment share of high-skilled drops as a fraction of employment. For age above 50, the employment rate of high-skilled increases more in absolute values as shown in the left top panel, it however drops as a fraction of employment.

Figure 6(c) plots log deviation of human capital from the baseline. As can be seen from the figure, since the employment rate of high-skilled women does not change, their human capital does not change either. The employment rate of low-skilled drops at all ages before age 45, thus human capital loss accumulates in this age range. After age 50, the employment rates for both low- and high-skilled women increase, thus both have higher average human capital relative to that in the baseline. In particular, due to human capital losses at younger ages, low-skilled women's human capital catches up only after age 56.

Figure 6(d) plots the log deviation of wage earnings, i.e. the product of employment rate and the mean wage conditional on employment. To make it comparable between the baseline and the counterfactual, I use the pre-tax wages. Without the selection of employment, the drop in wage earnings will be the combination of the drop in employment rate and the drop in human capital. As a result, the change in wage earnings for the high-skilled is close to 0 at all ages, while the low-skilled have a larger loss of wage earnings, and the loss is higher up to 15% at the beginning of career and continues at around 12% till age 45. After age 50, due to the increase in employment rate, the wage earnings also exceed that in the baseline, and the low-skilled have a slightly larger increase.

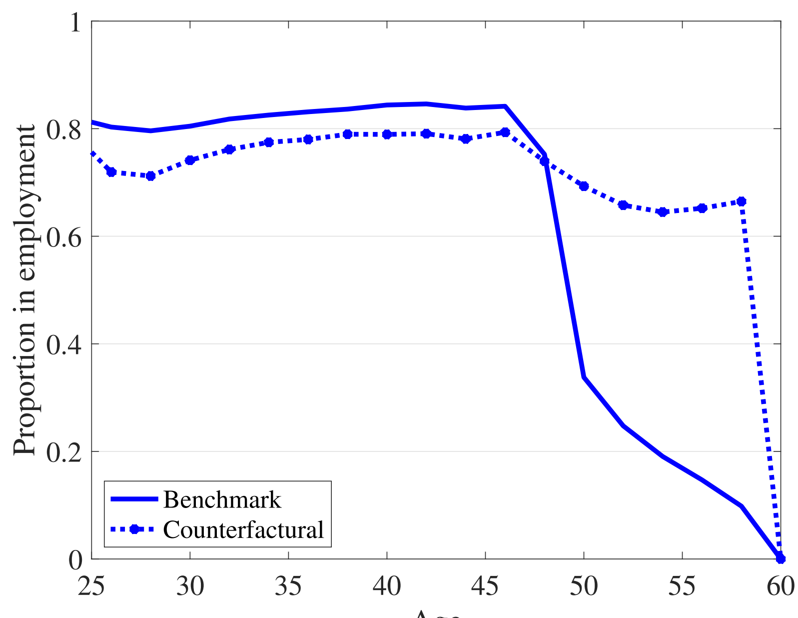

Figure 7: Policy impact on aggregate employment rate by age

Figure 7 presents the impact on aggregate employment. The aggregate employment rate drops by 9% before age 30 and by around 5% between 35 and 45. The employment rate between ages 50 and 60 rises to around 65%. Note that this response is larger than the estimates of policy impact of delaying social security entitlement in many other countries. The reasons are as follows. First, I look at a relatively younger group of population between ages 50 and 60. I abstract away from health shocks that will typically be an issue for older population. Second, in developed countries, there are other types of social insurance programs that the old can claim in response to the reduction in social security benefits. For example, people can apply for disability insurance as substitute for social security.[24] In China, people mainly rely on social security for insurance.[25]

In the Section 10.1 of the Technical Appendix, I further present the impact on human capital and wages. As shown in Figure 6(c), human capital of low-skilled women decreases relative to that in the benchmark while human capital of high-skilled women remain the same. However, the share of high-skilled women increases, making the aggregate human capital close to that in the benchmark. In a model without occupational choice, women do not have the option to choose high-skilled occupation to insure themselves against the reduction in social security incomes, and the effect of reduction in employment dominates, which leads losses of aggregate human capital to a larger degree.

Lifetime impacts Table 8 summarizes the overall impact on employment and earnings over the life cycle and by age 40. The net PDV of sequence of earning flows of type w_t for a individual i from period S to T is defined as:

$$PDV^i = \sum_{t=S}^{T} \beta^{t-S} w_t^i \mathbb{1}_{\{n_t^i = \bar{n}\}}$$

I compute the PDV for pre- and after-tax wage earnings and labor earnings, which is the summation of wage earnings and social security benefits.

Although it is a policy that increase the entitlement age by 10 years, women's average total working

[24]See, for example, Li (2018) for the United States and Díaz-Giménez and Díaz-Saavedra (2009) for Spain.

[25]Note also that in the model women transit from the young to the old generation at age of 48 and there is a sharp increase of grandchildren once becoming the old. This leads to an additional drop of employment. In reality, the process of having grandchildren will be more smoothed and the employment effects may take longer to happen.

Table 8: Summary of overall impacts on women

		Lifetime	By age 40
Total working years (yrs)		+3.1	-1.0
Emp. share of high-skilled (p.p.)		+7.9%	+10.4%
PDV of	pre-tax wage earnings (log)	+2.5%	-2.6%
	after-tax wage earnings (log)	+5.4%	+3.9%
	labor earnings (log)	+2.2%	+3.9%
Household savings rate (p.p.)		+ 7.1%	

years only increase by 3.1 years, this is due to the reduction in employment rate of young women. Pre-tax increases to a smaller level, implying that the reduction in human capital may play a role besides the movements in employment rate. In fact, the pre-tax wage earnings Labor earnings refer to the summation of wage earnings and social security earnings, which increases by a smaller scale than the wage earnings since in the baseline, women tend to receive social securities for more year.

5.2 Impact by presence of children

Figure 8 validates that the drop in employment rate mainly happens to those with children, especially children under age 7. Further conditional on having (young) children, the drop in employment rate is higher for mothers younger than 35. This is because the old now continue to work till age 60, which is corresponding to age 36 for the children of the old when a generation is set to be 24 years in the model. Additionally, at later ages, women tend to rely less on grandparental child care due to the mortality shocks of the old, thus the deviation from baseline is slightly lower. For women without children, the employment also drops by around 4% between 24 and 46, especially since age 35, this is because the average human capital is lower at the same age than that in the baseline economy.

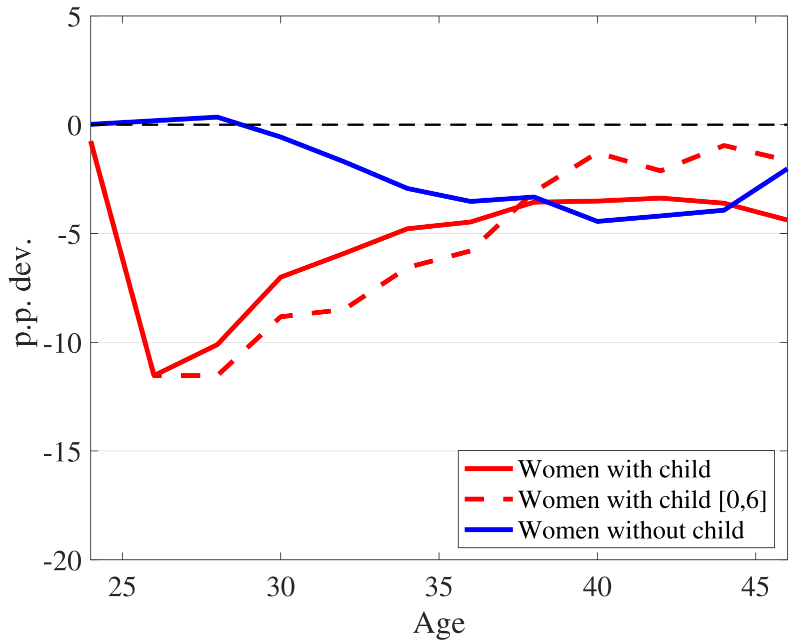

Figure 8: Policy impact on employment by presence of children

5.3 Impact on welfare

Welfare calculation I measure the welfare change as the additional lifetime consumption to be endowed to households under the benchmark economy so that the average welfare will be the equal to that under the policy change.

Let value $V_j(s, \lambda; \mathcal{T})$ be the value of a household when the household is at the state $\mathbf{x}$ under government policy $\mathcal{T}$, and the young generation in the household is at age j if all future consumption flows of the household are multiplied by λ :

$$V_j(\mathbf{x}, \lambda; \mathcal{T}) = \mathbb{E} \sum_{s=j}^{\infty} u(\mathbf{c}_s(\mathbf{x}; \mathcal{T}) \times (1 + \lambda), \mathbf{l}_s(\mathbf{x}; \mathcal{T}), \mathbf{q}_s(\mathbf{x}; \mathcal{T}))$$

where $\mathbf{c}_s(\mathbf{x}; \mathcal{T}), \mathbf{l}_s(\mathbf{x}; \mathcal{T}), \mathbf{q}_s(\mathbf{x}; \mathcal{T})$ refers to the policy functions under policy $\mathcal{T}$.

As for the aggregate economy, we can measure the welfare change $\bar{\lambda}$ as the λ such that

$$\int_{j,\mathbf{x}} \sum_j V(\mathbf{x}, \bar{\lambda}; \mathcal{T}_{CF}) d\mu(\mathbf{x}) = \int_{j,\mathbf{x}} \sum_j V_j(\mathbf{x}, 0; \mathcal{T}_{BM}) d\mu(\mathbf{x})$$

where $\mathcal{T}_{CF}, \mathcal{T}_{BM}$ refers to the benchmark economy and counterfactual economy, respectively.

The overall welfare change is estimated to be slightly negative -0.1%. However this masks a lot of heterogeneity across households. To see this, I computer for conditional (ex-post) welfare for any household with state $\mathbf{x}$ and with the young generation being age j by calculating $\lambda(j, \mathbf{x})$ that solves

$$V_j(\mathbf{x}, \lambda(j, \mathbf{x}); \mathcal{T}_{CF}) = V_j(\mathbf{x}, 0; \mathcal{T}_{BM})$$

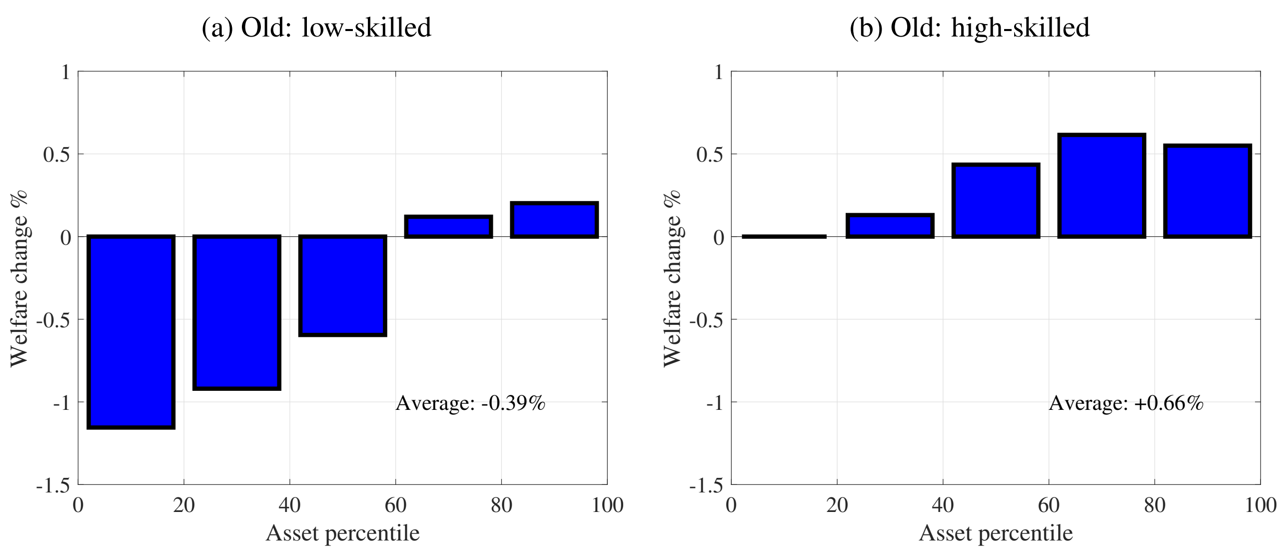

Figure 9: Policy impact on welfare by old's occupation and household assets

Figure 9 plots the welfare change for the cohort that the young generation is going to enter the labor market in the stationary distribution of the benchmark economy by occupation of the old women and household asset. As can be seen from the figures, households with old employed in high-skilled occupations typically gains from the policy change, this is because these households can always afford formal child care as the old earn more wages than the market formal care. In this case, it is the young women are more likely to choose a high-skilled occupation, and the human capital mechanism dominates. The households with low-skilled women have to substitute young women's employment for the old when the young make less wages than the market formal care. This, as shown in the previous section, brings persistent loss of human capital and leads to welfare losses. This also explains why the overall welfare change increases as the household assets increase for both groups.

6 Robustness

6.1 Population aging

In this section, I present the policy impact in an economy with population aging. I consider a case in which the death hazard is half of that in the benchmark at all ages. This increases the life expectancy by around 2.5 years, which reaches the life expectancy of the population in the United States in 2020. Population aging affects the economy in two main ways. First, the share of households with old increase, which affects the monetary and time transfers across generations. Second, the old are expected to collect social securities for longer time, having an impact on the government budget.

Table 9: Policy effects in the economy of population aging

		Lifetime	By age 40
Total working years (yrs)		+3.2	-1.0
Emp. share of high-skilled (p.p.)		+9.2%	+12.5%
PDV of	pre-tax wage earnings (log)	+2.8%	-0.8%
	after-tax wage earnings (log)	+4.6%	+1.0%
	labor earnings (log)	+1.4%	+1.0%
Household savings rate (p.p.)		+ 5.5%	
Household welfare		-0.04%	

Table 9 summarizes the impacts. Employment drop for younger women slightly decreases since more households can use grandparental child care. Combined with the fact that more women are incentivized to choose high-skilled occupations, the average lifetime working years increase more than that in the case without population aging. Households have to finance retirement for longer years, which should lead to more savings. Interestingly, since more women are employed in high-skilled occupations, households don't increase savings as much as in the case without population aging. The overall welfare impact is still slightly negative.

6.2 Alternative social security entitlement ages

In practice, the policy change may be conducted in a gradual increase in the entitlement, which potentially takes several years to happen. In Figure 10, I plot the impact on employment, incomes and welfare by raising the entitlement age to every two years. Again the policy impacts on employment and incomes are evaluated at the steady state and the welfare change is evaluated with the stationary distribution under the benchmark economy.

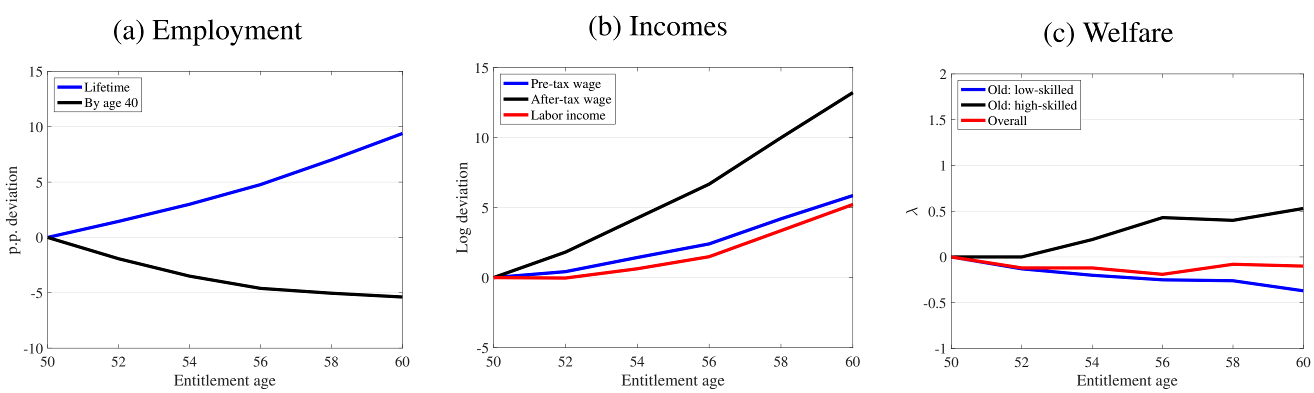

Figure 10: Policy effect by alternative social security ages

Several interesting points rise in the comparisons. Despite the overall pattern of increase in total working years and decrease in working years up till age 40. The drop in employment for young women slows down after the entitlement age is raised to 56. Three measures of PDV of earnings grow faster when entitlement age is raised to smaller years and more slowly when raised to longer years. The overall welfare change is smaller, less than 0.2% for all cases. However, as I highlighted in the previous section, this small overall change masks large heterogeneity that household with high-skilled old women gains and households with low-skilled old women loses. And the welfare change for each subgroup moves monotonically to the years of delaying entitlement.

6.3 Formal child care supply

In this subsection, I relax the assumption in the main text to allow the supply elasticity of child care to be at different levels. Recall that I specify the formal care supply function

$$p^n = \xi_0 + \xi_1 Q^n$$

$\xi_1 > 0$ refers to the case where child care supply is elastic with supply elasticity $\frac{1}{\xi_1}$ to formal care price. When $\xi_1 = 0$, the economy features perfectly elastic formal care supply.

Table 10: Sensitivity to formal care supply elasticity

Supply elasticity $\frac{1}{\xi_1}$		∞ Benchmark	1.2	0.5	0.1
Child care price (log)		0	+1.8%	+3.8%	+11.3%
Frac. using grandparental care (p.p.)		-15.5%	-15.0%	-14.4%	-12.9%
Frac. using market formal care (p.p.)		+6.8%	+6.0%	+5.2%	+3.3%
Choice prob. of high-skilled (p.p.)		+7.5%	+6.7%	+6.0%	+3.1%
Total working years	Lifetime (yrs.)	+3.1	+3.0	+2.8	+2.4
	By age 40 (yrs)	-1.0	-1.0	-1.1	-1.3
Lifetime PDV of earnings	pre-tax wage (log)	+2.5%	+2.2%	+1.6%	+0.8%
	after-tax wage (log)	+5.4%	+5.1%	+4.8%	+3.7%
	labor (log)	+2.2%	+1.9%	+1.9%	+0.5%
Household savings rate, (p.p.)		+7.1%	+6.8%	+6.7%	+5.7%

Table 10 summarizes the policy effects by varying the level of formal child care supply elasticity. In the benchmark, I assume that the formal child care supply is perfectly elastic. Blau (1993) reports that the supply elasticity of formal care is between 1.2 and 1.9 in the United States. I experiment 0.5 and 0.1, low levels of supply elasticity, along with Blau's estimate of 1.2.

The main conclusion is that the policy effects change monotonically with the assumption of supply elasticity. The results are robust in a wide range of elastic environments. The results is more different when the formal care supply is extremely inelastic. When formal care supply is less elastic, formal child care price increases more. Under the new policy, less households will use grandparental child care and more households will use market formal care. When formal child care price increases more, choosing formal care is less profitable, households will alternatively use parental or grandparental care. Women below age 40 have a larger reduction in employment and the overall increase in lifetime employment is smaller. Reduction of employment will bring about less gains of earnings. Lastly, when child care price is higher, household savings rate also decreases.

7 Concluding remarks

In this paper, I develop a dynamic OLG model to quantitatively investigate the impact of a potential policy reform in China to delay women's social security entitlement from age 50 to 60 on their employment, human capital, wages and welfare over the life cycle. Under the new policy, employment rate of women between age 50 and 60 increases to around 65%, while employment rate of women under 40 drops by around 6%. Reduction in early career employment leads to persistent loss of human capital and earnings. Intergenerational time transfer and age-dependent human capital accumulation are the key elements to drive the results.

As for the methodology, I calibrate and validate my model by matching the empirical evidence of labor supply, such as Maurer-Fazio et al. (2011), Li (2017), and Feng and Zhang (2018).The estimated model also enables me to go beyond Bratti et al. (2018), who estimate the policy effect on young women by extrapolating directly from the current stats. My results show that these empirical coefficients provide reasonable bounds of policy effects but will in general overestimate the impact on young women.

The angle provided by the model is that the young and the old coordinate to make decisions and the young may adjust in margins like occupational choice other than simply employment in anticipation of the child care costs.

This paper takes China, a country featuring sizable intergenerational time transfer from old to young generations, to highlight how the time allocation and dynamic incentive to accumulate human capital would affect policy effects. İmrohoroğlu and Zhao (2018) shows that a dynastic model with intergenerational monetary transfer will lead to different predictions on impact about household savings and aggregate output than a life cycle model without the intergenerational transfer. My paper further shows that incorporating intergenerational time transfer is important to evaluate how the policy will affect women over the life cycle.

There are several potential avenues for future research to enrich the understanding of the policy effects. Firstly, in this paper, time is perfectly substitutable across child care provider and ignores the policy impact on the quality of children. Besides large literature on documenting the impact of maternal care on children's cognitive development, Del Boca et al. (2018) further examine the impact of grandparental child care on children's cognitive skill development using UK data. Incorporating children skills will help us better understand the long-run effects of the policy change.

Secondly, throughout the paper, the collection of household members will only be thought as making economic decisions together, while I do not make any assumption on whether the household members are physically living together or not. Large literature has been documenting the relationship between the need of child care and intergenerational co-residence of parents and grandparents (see, for example, Compton and Pollak (2014) and Garcia-Moran and Kuehn (2017)).[26] Future work may also take the location choice into account.

Lastly, I consider the difference of grandparents only up to their gender differences. Using data from Italy, Bratti et al. (2018) documents that the labor supply of woman is more elastic to the child

[26] Garcia-Moran and Kuehn (2017) develops a model with the endogenous jointly decision of intergenerational co-residence and labor supply of mothers.

care availability of their mothers than of their mothers-in-law (and fathers and fathers-in-law). I do not take into account the gender of children into account either. By extending the model to allow for more types of household members and group-specific preferences to match group-related moments, I will be able to speak to these issues and obtain more accurate policy effects.

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