Understanding the Effects of Pension Reforms: A Structural Model Approach

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July 18, 2024

1 Introduction

In recent years, due to factors such as extended life expectancy and declining birth rates, pension systems in countries around the world have faced pressure for reform and Taiwan is no exception. As a consequence, the effect of pension reforms are widely investigated in many countries. However, to our knowledge, one of the major pension systems in Taiwan, named as Labor Insurance, has never been studied. What is the effect of the pension reforms of the Labor Insurance on the retirement decision and the private savings? And, particularly, how does the crowd respond to the information of the reforms?

These questions are in particular important under the institution after 2009, when the institution has been changed so that anyone who had participated in the Labor Insurance and continued after 2009 could choose to retire with two types of the pension schemes, a lump-sum scheme and a monthly pension scheme. For example, consider a person encountering an unpredictable benefit reduction and a predicted one. The former may induce a large shift in both saving and labor supply, while the later may only respond with a moderate or tiny shift. The later can even choose to retire earlier or shift his choice from a monthly pension scheme to a lump-sum scheme before the actual reform comes, lest he suffers from the possibly incoming reforms.

To answer these questions, we construct a life-cycle model of households choosing to participate the labor market, the amount of savings, and updating their believes on the chance of facing a reform. The model incorporates the heterogeneities in the discount factor, the preference of leisure and the prior believes of the occurrence of the reform. Our model also captures the complex structure of the pension schemes.

2 Background

In 2009, Labor Insurance, one of the major pension system in Taiwan, transitioned to a pension system adopting the defined benefit system. After the transition, the workers who had attended the Labor Insurance before 2009 can choose to follow the new rule or the old one while those had not can only follow the new one.

Before the transition in 2009, the conditions to determine whether one can receive the benefit is quite complicated. One can only get paid if one of the followings is satisfied: (i) Male working for at least 1 year and aging 60 (55 for females). (ii) Working for at least 15 years and aging 55. (iii) Working at the same company for at least 25 years. (iv) Working for at least 25 years and aging 50.

A worker being eligible for the benefit would receive a lump-sum transfer form the government when retiring. The amount depends on the working years and the average monthly insurance salary[1] in three years before the retirement. The benefit formula is

$$\mathrm{pb}_t = \mathrm{AMIS}_t \times \max\{\mathrm{WY}_t,\ 2\mathrm{WY}_t - 15\}, \tag{1}$$

where pb_t is the pension benefit, AMIS_t is the average monthly insurance salary and WY_t is the working years.

After 2009, the conditions for applying the benefit was canceled and the rule became a dichotomy that one may follows the defined benefit pension rule or the lump-sum payment similar to the one before 2009. To access the pension rule, one needs to work for at least 15 years. The benefit formula for the lump-sum rule and the monthly pension rule is

$$\mathrm{pb}_t = \mathrm{AMIS}_t \times \max\{\mathrm{WY}_t,\ 2\mathrm{WY}_t - 15\}, \tag{2}$$

$$\mathrm{pb}_t = \max\{\mathrm{AMIS}_t \times \mathrm{WY}_t \times 0.775\% + 3000,\ \mathrm{AMIS}_t \times \mathrm{WY}_t \times 1.55\%\}, \tag{3}$$

respectively. Also, AMIS_t is calculated with the highest 60 months' wage in the career.

Additionally, the pension benefits are influenced by the standard retirement age. Individuals who have accrued at least 15 years of working experience and opt to claim benefits before reaching the standard retirement age will encounter a reduction of 4% for each year prior to this benchmark. Conversely, those who choose to postpone retirement beyond the standard age will see their benefits increase by 4% per year. Eligibility to claim benefits spans a window of five years before and after the standard retirement age. Since 2018, the standard retirement age has been gradually increasing by one year for every two years.

3 Related Literature

Our research is connected to various papers focusing on pension, retirement, and saving. The pension system typically exerts two potentially offsetting effects on individuals' saving behavior. On one hand, pension wealth may directly substitute personal wealth; however, conversely, the pension system often provides individuals incentives to delay retirement,

[1] The average monthly insurance salary is calculated by the grades of Labor Insurance salary, which ranges from 27,470 NTD to 45,800 NTD in 2024 and is adjusted annually by the administration.

thereby extending the period of asset accumulation and increasing saving. Consequently, the impact of pension reform on retirement and private savings is of significant importance and the related literature is discussed in this chapter. Additionally, the research conducted in Taiwan is presented towards the end of this chapter.

In early work, Feldstein (1974) indicates that the Social Security pension crowded out 30 to 50 percent of personal saving using the aggregate time series data from the United States. Subsequently, Attanasio and Brugiavini (2003) observes that the reduction in pension wealth leads to an increase in the saving rate in Italy's pension reform in 1992, where the offset is about 0.35. Aguila (2011) shows that the shift from the pay-as-you-go system to personal retirement account system in Mexico's 1997 reform increases the pension wealth and crowds the private savings for the lower-income worker. In the mean time, some recent studies suggest that the crowd-out effect is minimal or even nonexistent. For instance, Feng, He, and Sato (2011) examines the reform in China from 1995 to 1997 and reports a relatively low offsetting effect ranging from 0.1 to 0.16. Similarly, Chetty, Friedman, Leth-Petersen, Nielsen, and Olsen (2014) discovers no substitution between private savings and public pensions following Denmark's 1999 reduction in retirement pension subsidies. In another study, Lachowska and Myck (2018) identifies a moderate crowd-out effect of 0.3 resulting from Poland's 1999 pension reform.

In another related branch concerning retirement decisions, early studies such as Burtless (1986) and Gustman and Steinmeier (1986) delve into the explanation of the two-peak phenomenon in retirement age. They attribute this phenomenon to the heterogeneity of workers' preferences and the varying returns of Social Security for each retirement age. Building on this foundation, Rust and Phelan (1997) developed a model where agents are unable to engage in intertemporal substitution. This work highlights that the incompleteness of the medical insurance market may compel workers to prolong their careers until getting access to Medicare. French and Jones (2011) further confirms the results in an estimated life-cycle model consisting of labor and savings decisions. Haan and Prowse (2014) calculated that in order to relieve the fiscal burden due to the increasing life expectancy, either postponing the retirement threshold age by 3.76 years or reduce the benefit by 26.8% is sufficient. Daminato and Padula (2023) estimates a life-cycle model incorporating savings, portfolio choice and retirement through a quasi-experimental variation from pension reforms in Italy for identification. The model predicts a significant social security wealth effect on retirement.

For the research conducted in Taiwan, Yang and Luoh (2009) uses data from the Manpower Utilization Survey to investigate the impact of changes in old and new Labor Pension systems on wages. The results show that, overall, there is no significant change in wages within two years of the implementation of the new and old systems. However, for workers who only enter the workforce after the changes, their wages decrease significantly, roughly in proportion to the employer contribution rate in the new system. Lai, Hsin, Liu, and Chang (2017) calibrates a general equilibrium model to investigates the reforms encompassing Civil Servant and Teacher Insurance and Labor Insurance. The simulation result shows that after the reforms, overall employment levels declined. The decrease in real wages results in the reduced labor supply, leading to an increase in the overall unemployment rate. Cheng, Lin, and Tanaka (2020) also conducts a counterfactual analysis using a calibrated general equilibrium model, finding that the pension debt can be balanced if the government increases income taxes by 5.4%, increases consumption taxes by 6.2%, increases pension taxes by 9.3%, or decreases the pension benefits by 23.5%.

4 The Model

Consider an individual who aims at maximizing his expected lifetime utility at age $t = 40, \ldots, T$, where T is one's maximum lifespan. These individuals maximize their utility by choosing their consumption c, labor supply n (in extensive margin), pension type p and their bequests b to their descendants. At period t, the utility flow is

$$u(c_t, l_t) = \frac{1}{1-\gamma}(c_t^{\eta} l_t^{1-\eta})^{1-\gamma}, \tag{4}$$

where l_t is leisure. We allow η to vary across individuals. For individuals with higher η, they value their consumption more comparing to leisure.

Leisure is normalized and determined by

$$l_t = 1 - \frac{260}{364} n_t. \tag{5}$$

When a worker dies, he obtains utility from leaving his remaining assets, a_t, as bequests. The functional form follows De Nardi (2004).

$$b(a_t) = \frac{\theta_b}{1-\gamma}(\kappa + a_t)^{1-\gamma}. \tag{6}$$

The individual faces survival risk depends on his age. Following Thatcher (1999), we model their mortality function μ as

$$\mu_t = \mu(t) = \frac{\theta_1}{1 + \theta_2 \exp(-\theta_3 t)} + \theta_4. \tag{7}$$

Note that we determine the maximum lifespan through the law of mortality. That is, $T = \min\{t \mid \mu(t) \geq 1\}$.

The worker's productivity is

$$\log(w_{it}) = \max\{X_{it}\delta + f_i + \epsilon_{it},\ \log(\underline{w})\}, \tag{8}$$

$$\epsilon_{it} = \rho \epsilon_{i,t-1} + \xi_{it}, \tag{9}$$

where X_{it} includes age and education, f_i captures the unobserved heterogeneity of productivity across individuals and $\xi_{it} \overset{iid}{\sim} N(0, \sigma_\xi^2)$. Besides, the Labor Standards Act sets the minimum wage, $\underline{w}_t$; hence the real wage that one receives is the maximum between the real productivity and the minimum wage $\underline{w}$.

Also, since the Labor Standards Act allows the employers to retire the workers aging 65, we assume that if the real productivity of a worker is lower than $\underline{w}$ and the worker ages 65, he is retired by the employers. To simplify the model, once the worker stops working after 65, he cannot return to work.

Whenever an individual is eligible for the pension, he can choose between two pension plans as (2) or (3) and retire. We denote his pension status as p_t, following

$$p_{t+1} \in \begin{cases} \{1,2\}, & p_t = 1, \\ \{4\}, & p_t = 2,4, \\ \{3\}, & p_t = 3 \text{ or } p_t = 1, \mathrm{WY}_t \geq 15. \end{cases} \tag{10}$$

Thus

$$\mathrm{pb}_t = \begin{cases} 0, & p_t = 1,4, \\ \mathrm{AMIS}_t \times \max\{\mathrm{WY}_t,\ 2\mathrm{WY}_t - 15\}, & p_t = 2, \\ \max\{\mathrm{AMIS}_t \times \mathrm{WY}_t \times 0.775\% + 3000,\ \mathrm{AMIS}_t \times \mathrm{WY}_t \times 1.55\%\}, & p_t = 3. \end{cases} \tag{11}$$

The law of motion of the AMIS_t is defined as

$$\mathrm{AMIS}_{t+1} = \begin{cases} \frac{\mathrm{WY}_t}{\mathrm{WY}_t + n_t}\mathrm{AMIS}_t + \frac{n_t \mathrm{CMIS}_t}{\mathrm{WY}_t + n_t}, & \mathrm{WY}_t < 5, \\ \mathrm{AMIS}_t + \frac{1}{5}\max\{0, \mathrm{CMIS}_t n_t - \mathrm{LMIS}_t\}, & \mathrm{WY}_t \geq 5, \end{cases} \tag{12}$$

where CMIS_t is a stair function of the wage with a ceiling and a floor, LMIS_t is the lowest salary among past 5 years and WY_t is the work year. That is,

$$\mathrm{LMIS}_{t+1} = \max\{\mathrm{LMIS}_t, \mathrm{CMIS}_t\}, \tag{13}$$
$$\mathrm{WY}_{t+1} = \mathrm{WY}_t + n_t. \tag{14}$$

An individual faces several budget constraints,

$$c_t + a_{t+1} = (1+r)a_t + \mathrm{pb}_t + w_t n_t - 0.2 \times \mathrm{CMIS}_t n_t \tau - \phi_l \mathbb{1}\{n_t - n_{t-1} = 1\}, \tag{15}$$
$$a_{t+1} \geq 0, \tag{16}$$
$$c_t \geq \underline{c}, \tag{17}$$

where ϕ_l is the transition cost of starting to work and $\underline{c}$ is the consumption floor. We assume that an individual cannot borrow against his future income including wage and pension.

In addition, the individual in our model also considers the uncertainty of reforms. We simplify this uncertainty to be a binary case, either reformed pension scheme ($R_t = 1$) and unreformed scheme ($R_t = 0$), where the reformed scheme can be in several types such as reducing the benefit, increasing the standard retirement age, or increasing the pension tax. We assume that there are two types of governments, either a high chance (p_H) or a low chance (p_L) to reform. Let π_t be the prior of the reform occurring next period. We assume that the individuals update π_t in a Bayesian manner according to the information that he receives. That is, we assume that the news is either positive or negative, following a Bernoulli distribution that is heterogeneous in different types of governments. The updating rule is

$$\begin{aligned}\pi_{t+1} &= \frac{\Pr(z_t, R_t \mid H)\pi_t}{\Pr(z_t, R_t \mid H)\pi_t + \Pr(z_t, R_t \mid L)(1-\pi_t)} \\ &= \frac{\Pr(z_t \mid R_t, H)\Pr(R_t \mid H)\pi_t}{\Pr(z_t \mid R_t, H)\Pr(R_t \mid H)\pi_t + \Pr(z_t \mid R_t, L)\Pr(R_t \mid L)(1-\pi_t)} \\ &= \frac{p(\#(z_t = 1); |z_t|, p_{z,H})p_H\pi_t}{p(\#(z_t = 1); |z_t|, p_{z,H})p_H\pi_t + p(\#(z_t = 1); |z_t|, p_{z,L})p_L(1-\pi_t)},\end{aligned} \tag{18}$$

where z_t stands for the independent and identically distributed drawn sequence of news in period t, $\#$ is the counting function, $|\cdot|$ is the length of the sequence and $p_{z,H}, p_{z,L}$ are the prbablities of positive news under the different types of governments. The reformed state is treated as an absorbing state for both types of the governments.

Let β be the time preference, we may write the individual's problem recursively as

$$\begin{aligned}V_t(x_t, R_t) = \max_{c_t, n_t, p_t} \Big\{ & u(c_t, 1 - \frac{260}{364}n_t) + \beta\mu_t b(a_{t+1}) \\ & + \beta(1-\mu_t)\Big[\pi_t \int V_{t+1}(x_{t+1}, R_{t+1} = 1)\, dF(x_{t+1} \mid x_t, c_t, n_t, p_t, t) \\ & + (1-\pi_t)\int V_{t+1}(x_{t+1}, R_{t+1} = 0)\, dF(x_{t+1} \mid x_t, c_t, n_t, p_t, t)\Big]\Big\}\end{aligned} \tag{19}$$

subject to equations (16) and (17). We also allow the time preference and the prior of reform to vary across individuals. The vector $x_t = (a_t, n_{t-1}, p_{t-1}, \mathrm{WY}_t, \mathrm{AMIS}_t, \mathrm{LMIS}_t, \epsilon_t)$ contains the state variables whose law of motions follow equations (9) to (15) and (18). The solution of the model consists of the saving rules, work rules and pension application rules. The model is solved numerically using value function iteration. Linear interpolations are used in iterations in order to approximate the continuous state variables.

5 Estimation

Due to the complexity of the model, we adopt a two-step approach. In the first step, we estimate the wage equation and the mortality law outside of the main model. To estimate the main model, we use the simulated method of moments (SMM) approach. The method consists of two loops, the inner loop and the outer loop. In the inner loop, we fix the estimated parameters and solve the policy function under the parameters to obtain the simulated moments. Next, in the outer loop, the parameters are updated to minimize the distance between the simulated moments and the real moments.

5.1 Wage Equation

The main issue in estimating the wage equation is the selection bias problem.

5.2 Mortality Law

The mortality parameters $\theta = (\theta_1, \theta_2, \theta_3, \theta_4)$ are estimated by the maximum liklihood estimation. The likelihood function is

$$\mathscr{L}(\theta) = \prod_{i=1}^{N} \prod_{t=40}^{T_i} \mu_t^{d_{it}} (1 - \mu_t)^{1-d_{it}}, \tag{20}$$

where d_{it} is the indicator of the individual i's survival status at age t.

5.3 Reform Signal

For the reform signal distributions of different types of governments, we scrawl the news and use machine learning method to rate the tendency of the news. After that, we estimate the parameters of the distributions by the expectation maximization algorithm.

5.4 SMM Target Moments

To identify the parameters in the main model, we select the following moments to be matched. Also, we use the optimal weighting matrix to improve the efficiency of the estimation.

6 Results

7 Policy Experiments

8 Conclusion

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