Shifting from Pay-as-You-Go to Individual Retirement Accounts: A Path to a Sustainable Pension System*

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June 1, 2021

Abstract

With aging demographics and generous pension programs, the sustainability of the pay-as-you-go (PAYG) public pension system has been often questioned and has motivated policymakers to enact reforms in many countries. Although mandatory funded Individual Retirement Accounts (IRAs) appear to be a solution to this unsustainable system, existing reforms usually take place within the PAYG system by reducing pension benefits. This paper evaluates the effects of PAYG reforms as well as reforms that switch to the IRA system. Our analysis shows that PAYG reforms outperform IRA reforms in many aspects. In fact, PAYG reforms achieve higher GDP and yield higher welfare in the long run. The transition to the steady state is also found to be less volatile for PAYG reforms. While PAYG generally places a larger burden on future generations, the positive welfare effect of cross-subsidization dominates the welfare loss. Our findings may explain why pension reform is a controversial issue in most countries and why we rarely observe a shift to the IRA system.

Keywords: Pension Reform; Individual Retirement Account; Labor Supply; Intensive and Extensive Margin; Welfare Analysis

JEL Classification: E2, E6, H5, J2

*Declarations of interest: none. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. We thank seminar participants in Academia Sinica and the Macroeconomics Modelling Workshop for helpful discussions, comments, and suggestions.

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1 Introduction

The financial issue of pensions has received great attention in many countries over the past decade. The pay-as-you-go (PAYG) pension system is the most common pension system, and its enrollment is often mandatory for workers. Among the commonly mentioned disadvantages of PAYG are (i) financial unsustainability, (ii) burdens on future generations, (iii) distortion in the labor market, and (iv) implicit pension debt and policy uncertainty (source: OECD Pensions at a Glance). Many of these concerns are not a problem if an individual retirement account (IRA) system is implemented. Although IRAs appear to solve the unsustainability problem, replacing PAYG with IRAs has not been commonly considered as an alternative. In fact, reforms actually implemented during the past five years in OECD countries include changes in retirement age, coverage, pension benefits, and contributions, but rarely indicate switching to an IRA system.

Why do we focus on the differences between the PAYG and IRA systems? The two systems greatly differ in their expected effects on inter-generational/cross-sectional equity; whereas the PAYG system collects premiums through payroll taxation from the working population and immediately re-distributes them to retirees as pension benefits (insurance and redistribution channels), the IRA system incentivizes workers to grow their own retirement accounts (usually tax-free) so they will have enough savings as self-insurance against health/productivity shocks in their later years (tax distortion channel). Although both reforms have often been discussed in recent policy debates, few studies assess the welfare implications of reforms and the consequences of real implementation. Focusing on the aging population and transition dynamics, we provide a comprehensive evaluation of how the economy benefits from a reform both in the short run and over the long run.

This paper analyzes the transition dynamics and welfare implications of different policy reforms (PAYG or IRA). Specifically, we extend the model developed by Imrohoroglu and Kitao [2012] and Kitao [2015] and build a general equilibrium model of overlapping generations of individuals who make decisions on consumption, savings, pension benefit claims, and labor supply on both extensive and intensive margins. We then quantify the responses of macroeconomic outcomes and individuals' behavior when the government treats the new cohort and existing cohorts differently. For example, the government could implement the IRA system for new cohorts and maintain the current PAYG system for current cohorts. By analyzing different policy reforms, we investigate the implications through the insurance, tax distortion, and inter-generational redistribution channels.

To conduct the welfare analysis, Taiwan is selected as the target economy for the following reasons. First, Taiwan has experienced a drastic change in its demographics mainly due to a low

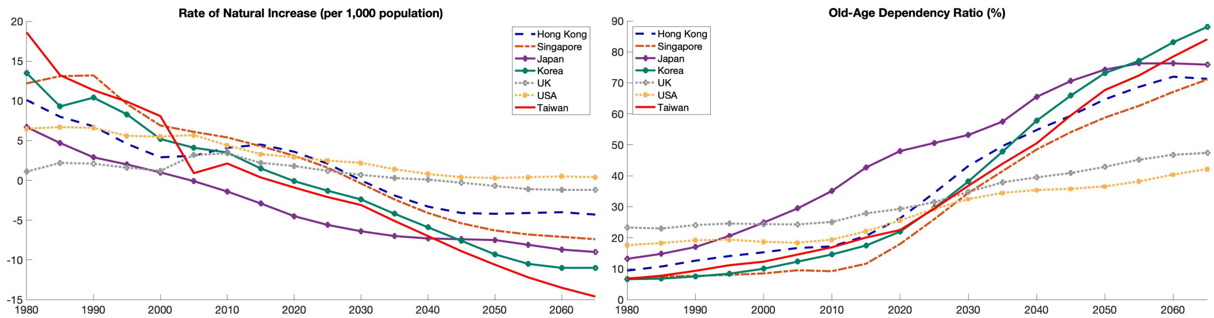

Figure 1: Rate of Natural Increase and Old-Age Dependency Ratio

fertility rate. In fact, it has been reported that Taiwan has almost the lowest fertility rate of all the developed countries. Figure 1 shows the rate of natural increase and the old-age dependency ratio over time: we observe that the absolute value of the slope for Taiwan is the steepest, implying a drastic change in demographics. Second, related to the first point, since current pension spending poses a serious threat to the Taiwanese government, in-depth pension reform is direly needed and inevitable. Based on the current estimates of pension expenditure growth,[1] pension expenditure could account for almost 50% of government spending by the year 2050. A recent article in The Economist (Asia May 20, 2017) estimates that the predicted bankruptcy date for Taiwan is 2027, which seems to make the budget problem for Taiwan the most urgent compared to other countries (2035 for China, 2035 for the USA, 2052 for Japan, and 2029 for Spain).[2] Third, as shown in Figure 2, the pension replacement ratio in Taiwan (58%) is comparable to the other OECD countries. Thus, by investigating the welfare analysis of Taiwan pension reform, important insights can be provided to countries facing pension problems that are similar to Taiwan's.

The findings of the paper consist of three parts. First, we analyze the final steady state outcomes and find that within-PAYG reforms and IRA reforms both achieve a higher GDP compared to the baseline case of no reform. The simulation results show that without any reform, the output decreases by 30.26% due to the aging population. With reforms, the negative effects of the aging population on the output are mitigated: for within-PAYG reform, GDP decreases to a lesser extent by 19.84%, and for IRA reform it does so by 29.38%. When we look at the financial burden, measured by the income tax rates required to balance the government budget, the effectiveness of reforms is more remarkable. Whereas the case without reform requires the highest

[1]We use government data from 2015–2019 (Ministry of Budget, Accounting and Statistics in Taiwan) to estimate the annual growth rate of pension spending. Currently it is around 28%, but it is increasing at a rate of roughly 1.5% per year.

[2]Source: Chinese Academy of Social Sciences, Board of Trustees of the Federal Old-Age and Survivors Insurance and Federal Disability Insurance Trust Funds, Ministry of Health, Labour and Welfare, and Agudo and Alda García [2010].

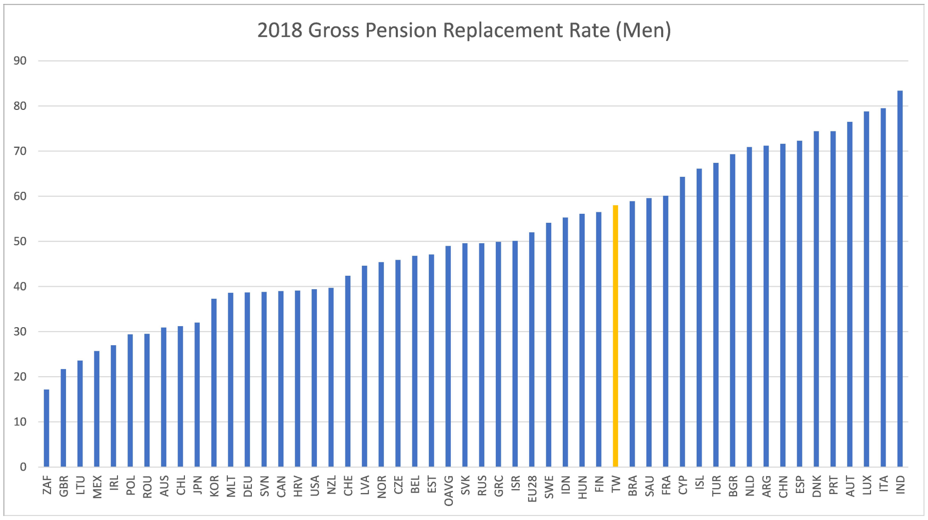

Figure 2: Pension Replacement Ratio of Taiwan vs. that of Other OECD Countries

average income tax rates of 11.77%, within-PAYG reform requires 4.63% and IRA reform requires 1.75%. Thus, this analysis indicates that reforms perform better than the case without reform in that they mitigate the output reductions and ease the tax burdens of the aging economy to a significant extent.

We next analyze the transition dynamics and the impacts on individual welfare when a given reform is implemented differently. Specifically, we consider alternative transition paths to the final steady states in the following four policy reforms: (i) IRA reform applied only to new cohorts, (ii) within-PAYG reform applied only to new cohorts, (iii) IRA reform applied to new cohorts and PAYG payments reduced to the minimum for old cohorts, and (iv) PAYG pension benefits reduced and applied to all cohorts immediately. We evaluate the transition paths of each reform in terms of both aggregate outcomes and individual welfare. Compared to the baseline transition, the output levels are found to be lower during the early transition period for reform (i), but they start to increase 60 years after implementation. The decline in GDP can be partially explained by the higher financial burdens on the younger cohorts. Under reform (i), which leaves old cohorts with the old generous PAYG system, the average income tax rate must increase from 14% to 30%. In contrast, reform (iii) has no problem of increased taxes. However, reform (iii) substantially lowers the welfare of individuals in current generations, indicating the potential difficulties in obtaining the consent to implement the reform. Furthermore, with respect to individual welfare, the within-PAYG reforms, (ii) and (iv), yield the highest long-term welfare whereas the IRA reforms, (i) and (iii), yield lower long-term welfare than the baseline scenario. This finding seems to indicate the importance of cross-subsidization from the rich to the poor offered by the PAYG system, despite its inter-generational burdens.

Lastly, we investigate the mechanism behind these welfare changes by decomposing the effects into three channels: the insurance channel, the inter-generational redistribution channel, and the tax distortion channel. The analysis shows that the insurance channel offered by the PAYG system plays an important role in the Taiwanese economy. We also find that the inter-generational redistribution channel is especially large in reform (i), which causes the welfare of future generations to be higher by 18% than the baseline transition at the beginning of the transition periods. For reform (ii), the welfare of future generations is only reduced by less than 5% than the baseline transition for the first ten years, and is higher for most of the rest of the transition period. Finally, reform (iv) yields positive welfare for all future generations, but the current generations sacrifice considerably to a great extent. Our findings imply that policymakers must take into consideration the transition process as well as the inter-generational trade-off in deciding how to improve the fiscal balance of the pension system.

This paper contributes to the literature on pension reform using a large-scale overlapping generation model. The literature in macroeconomics that uses large-scale, general equilibrium models can be traced back to Auerbach and Kotlikoff [1987] and also includes Conesa and Krueger [1999], Conesa and Garriga [2008], Imrohoroglu and Kitao [2012], Kitao [2015], Kudrna and Woodland [2011], Demange and Laroque [1999], Razin et al. [2002], Abel [2003], Boldrin and Montes [2005], De Nardi [2004] and Song et al. [2015], where the particular focus is on the general equilibrium effects of pension reforms in different countries.

Another strand of literature focuses on the OLG model with different angles. For example, Huang et al. [1997], Storesletten [2000], Rogerson and Wallenius [2009], Prescott et al. [2009], and Kitao et al. [2017] uses multi-period OLG models quantitatively address retirement decisions, welfare implications, and decisions on labor force participation. Iacoviello and Pavanb [2013] focus on the relationship between pension and the housing debt, while Makarski et al. [2017] study the effect on how the pension is funded and calculated. Heijdra and E. [2009] implement mortality process into the model, and Jacobs and Schindlerbc [2013] study the effect of tax reform and pension. Although we calibrate the model to the current Taiwanese system, the implications can be generalized to any country with an aging population and a generous pension system.

In particular, our paper is closely related to Imrohoroglu and Kitao [2012], Kitao [2015], and Song et al. [2015]. Imrohoroglu and Kitao [2012] build a general equilibrium model and focus on the interaction between work incentive and the decisions to claim Social Security in order to evaluate the effectiveness of Social Security reforms in the U.S in terms of fiscal sustainability. They simulate a reform that increases the retirement age by two years and find that such a reform significantly increases capital stock and labor supply while improving the government budget. Kitao [2015] analyzes the effects of introducing IRAs in Japan, which has an employer-based PAYG public pension system. We simulate the IRA reform in a similar fashion to Kitao [2015], but we allow individuals' retirement decisions to be endogenous and we focus particularly on the welfare implications through different channels. Song et al. [2015] focus on different sustainable reforms in China and on demographic transitions. Our analysis diverts from existing papers in that we endogenize the timing of pension benefit claims, and estimate the cost of various kinds of pension reforms, including the reforms within PAYG system. By comparing within-PAYG reform to IRA reform, we are able to illustrate different paths of transitions and analyze the costs and benefits of each reform.

The rest of the paper proceeds as follows. Section 2 describes the model. Section 3 introduces the data and how we calibrate the model. Section 4 presents a counterfactual policy analysis of sustainable pension reforms and Section 5 concludes.

2 Model

This paper takes a structural approach, using a multi-period over-lapping generation model, to evaluate quantitatively the welfare implications of pension reforms and the impacts of population aging. There is no aggregate uncertainty in the model. However, individuals face idiosyncratic production shocks and age-specific productivity shocks. Financial markets are assumed to be incomplete, but individuals can self-insure by accumulating precautionary asset holdings. Two kinds of pension systems will be considered: PAYG (current) and IRA. In this section, we describe the current PAYG system and the equilibrium condition, and then specify how individuals' behavior changes when IRA is introduced. The details on the timing and target of the policy reforms are found in Section 4.

2.1 Demographics

The economy is populated by overlapping generations of individuals of age $j = 1, 2, ..., J$, where J is the maximum possible age. The lifespan is stochastic; an individual of age j at time t survives until the next period $t+1$ with probability $s_{j,t}$. In each period, the economy has new-born agents who replace the deceased, and the population growth (or decrease) is denoted as n_t. Note that the survival probability and population growth have subscript t to reflect the fact of population aging.

2.2 Income Uncertainty

An individual enters the economy without assets, and her effective labor supply depends on the market wage rate w, the hours of work l, the idiosyncratic labor productivity shock z, and the age-specific productivity shock η_j. We assume an idiosyncratic productivity shock can be one of the $p < \infty$ values in a finish set $\mathbb{Z} = \{z_1, z_2, \ldots, z_p\}$.[3] Each individual is endowed with one unit of time in a given period, which can be used for market work or leisure. If an individual allocates l unit of time to work and is paid at the wage rate of w per unit, this person's wage is given by $wz\eta_j l$.

2.3 Production

There is a representative firm operating under constant return to scale, and its output Y is given by

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha}, \tag{1}$$

where A denotes the total factor productivity, K_t and L_t are the aggregate capital and labor inputs at time t, and α is the capital share. Capital depreciates at the rate $\delta \in (0, 1)$.

2.4 Pension System

In Taiwan, there are three major pension systems: labor insurance, public service pension, and national pension. These systems share many similarities: they are annuity-based, pay-as-you-go systems with relatively high replacement ratios and low tax rates. In addition, individuals are eligible to claim pension benefits at a relatively early age, 55, and can continue to work afterwards.[4] Due to these similarities, we focus on the largest system and the system that is closest to bankruptcy, the labor insurance system, and study the effects of different policy reforms.

Specifically, we make the following assumptions in order to capture the complexities of the pension system in Taiwan: all individuals are covered by the labor insurance system in Taiwan, and it is mandatory. Individuals can decide only whether to participate in the labor market and when to retire. They are allowed to continue working even after claiming retirement. Individuals can begin to receive pension benefit ss once they reach the earliest claiming age j^E. The retirement benefit an individual receives increases with the age of retirement. The benefit is deducted (is adjusted downward) if the individual retires before the normal retirement age of j^N, and augmented (upward) if they claim it after the normal retirement age (up to age 65). The pension tax, which is fixed as a constant proportion of the labor income, is tax-deductible.

[3] It is equivalent to assume the idiosyncratic shock follows a first-order Markov process.

[4] Detailed descriptions of the pension systems in Taiwan have been relegated to the Online Appendix.

2.5 Individuals

Preference

An individual's utility depends on consumption and work hours over the life cycle, denoted as $u(c_t, l_t)$. In addition, the individual derives utility by leaving bequests, which is denoted as $u^B(.)$. For simplicity, the government collects bequests in each period and immediately distributes them to all the living individuals as a lump-sum transfer b. The discount factor is denoted as β. We further assume that individuals cannot borrow from their future earnings.

State variables

Individuals are heterogeneous in age j, idiosyncratic labor productivity z, assets a, the amount of pension benefits e, and retirement status i, which takes a value of 1 if an individual has already claimed pension benefits and is 0 otherwise. The individual characteristics are summarized by a state vector $x = \{j, z, a, e, i\}$. An individual enters the next period with a new state vector $x' = \{j + 1, z', a', e', i'\}$.

Timing and the Household's Problem

The timing is described as follows. An individual enters the economy. If the value of the individual's assets falls below a federally established minimum consumption level, the government provides a payment to the citizen to compensate for the discrepancy. In each period, the idiosyncratic labor productivity is realized, and the individual chooses their consumption and work hours and whether to claim retirement in that year. An individual past the earliest retirement age can choose to retire and claim the pension benefit in any period after being eligible. If the individual survives till the next period, this agent enters the next period and repeats the decision process described above. The Bellman equation is given as follows:

$$V(x) = \max_{c,l,i'}\{u(c, l) + \beta E[s_j V(x') + (1 - s_j)u^B(a')]\}, \tag{2}$$

subject to

$$\begin{aligned}
tr &= \max\{0, (1 + \tau^c)\underline{c} - a\} \\
k &= a + tr - c(1 + \tau^c) \\
a' &= (1 + r)k + z\eta_j lw - T(rk + z\eta_j lw - \tau^{ss} \min\{z\eta_j lw, y^{ss}\}) - \mathbb{1}_{i=0} \cdot \tau^{ss} \min\{z\eta_j lw, y^{ss}\} + ss(x) + b \\
a' &\geq 0, \text{ and} \\
e' &= f(e, z\eta_j lw),
\end{aligned} \tag{3}$$

where $V(.)$ is the value function, k is the savings of individuals that are either rented to firms or invested in government bonds, and $f(.)$ is the pension benefit function.

2.6 Government

The government raises revenue from a consolidated income tax $T(.)$, which is based on labor income and interest return and is offset by the pension tax, a consumption tax at rate τ^c, issuance of risk-free debt D_{t+1}, and a pension tax τ^{ss} if the government operates the PAYG system. A pension tax is proportional to labor earnings at rate $\tau^{ss} \in [0, y^{ss}]$, where y^{ss} denotes the maximum pension tax rate.

The government expenditure consists of the expense of government transfer tr, the repayment of the debt D_t at the interest rate r_t, as well as the payments of the pension benefits ss if PAYG is implemented. The government transfer program follows exactly that of Taiwan, which guarantees a minimum consumption level $\underline{c}$ for any individual. The government spending is denoted as G. Hence, the government budget constraint is given by

$$\begin{aligned}&\sum_x [T(z\eta_j w_t l_t(x) + r_t k_t(x) - \tau_t^{ss}\min\{z\eta_j w_t l_t(x), y^{ss}\}) + \tau_t^{ss}\min\{z\eta_j w_t l_t(x), y^{ss}\}\\ &+ \tau_t^c c_t(x)]\mu_t(x) + D_{t+1} = G_t + (1+r_t)D_t + \sum_x ss_t(x)\mu_t(x) + \sum_x tr(x)\mu_t(x). \end{aligned} \tag{4}$$

2.7 Recursive Competitive Equilibrium

We now define the recursive competitive equilibrium. Note that since the aging population is considered, we depart from the usual definition of steady state equilibrium by focusing on the competitive equilibrium.

Given a set of demographic parameters $\{s_{j,t}\}_{j=1}^J$, $\{n_t\}$, and government policy variables $\{G_t$,D_t, ss_t,y^{ss},τ_t^{ss},$T(.)$,$\tau_t^c\}$, a competitive equilibrium is characterized by individuals' decision rules $\{c_t(x)$, $l_t(x)$,$i_t'(x)\}$, factor prices $\{r_t, w_t\}$, consolidated income taxes $\{T(.)\}$, and bequest transfers $\{b_t\}$ that satisfy the following conditions:

1. Individuals' decision rules are the solution to the optimization problem in (2) and (3).
2. Factor prices equal marginal productivity, i.e., $r_t = \alpha A(\frac{L_t}{K_t})^{1-\alpha} - \delta$ and $w_t = (1-\alpha)A(\frac{K_t}{L_t})^{\alpha}$.
3. Bequest transfers redistributed to the living individuals are equated to the aggregated amount of assets left by the deceased:

$$b_t = \sum_x a_t(x)(1 - s_{j,t-1})\mu_{t-1}(x). \tag{5}$$

4. The markets of capital, labor, and goods all clear:

$$K_t = \sum_x k_t(x)\mu_t(x) - D_t, \tag{6}$$

$$L_t = \sum_x z\eta_j l_t(x)\mu_t(x) \tag{7}$$

$$Y_t + (1-\delta)K_t = \sum_x c_t(x)\mu_t(x) + G_t + K_{t+1}. \tag{8}$$

5. The government budget constraint holds with equality as in equation (4).

2.8 Individual Retirement Account

One of the counterfactual experiments is introducing the individual retirement account as the new system. We describe the changes to the model when the IRA system is implemented. When the government implements the IRA system, all individuals are required to save a fraction τ^q of their wage earnings in their retirement accounts until they retire. Similar to the pension tax, amounts of τ^q placed in an IRA are tax-deductible. The interest earned in the IRA is also tax-deductible. Immediately after retirement, individuals can freely access their retirement savings accounts; thus, their next-period assets consist of both regular savings and the payout of the IRA balance.

The individual's problem up to two periods before retirement is stated as follows:

$$V(x) = \max_{c,l,\tau^q,i'} \{u(c,l) + \beta E[s_j V(x') + (1-s_j)u^B(a',q')]\}, \tag{9}$$

subject to

$$\begin{aligned}
&tr = \max\{0, (1+\tau^c)\underline{c} - a\} \\
&k = a + tr - c(1+\tau^c) \\
&q' = (1+r)q + \tau^q z\eta_j lw \\
&a' = (1+r)k + (1-\tau^q)z\eta_j lw - T(rk + z\eta_j lw - \tau^q z\eta_j lw) + b \\
&a' \geq 0.
\end{aligned} \tag{10}$$

If individuals claim the retirement benefit, their retirement account balance merges into their savings during the next period, and the state variable q becomes zero from that point onward.

The individual's problem one period before retirement is described as follows:

$$V(x) = \max_{c,l,i'} \{u(c,l) + \beta E[s_j V(x') + (1 - s_j) u^B(a', q')]\}, \tag{11}$$

subject to

$$\begin{aligned}
tr &= \max\{0, (1+\tau^c)\underline{c} - a\} \\
k &= a + tr - c(1+\tau^c) \\
q' &= 0 \\
a' &= (1+r)k + z\eta_j l w - T(rk + z\eta_j l w) + b + (1+r)q \\
a' &\geq 0.
\end{aligned} \tag{12}$$

In addition, the government budget constraint is represented as

$$\begin{aligned}
&\sum_x [T((1-\tau^q(x)) * z\eta_j w_t l_t(x) + r_t k_t(x)\}) + \tau_t^c c_t(x)]\mu_t(x) + D_{t+1} \\
&= G_t + (1+r_t)D_t + \sum_x tr(x)\mu_t(x).
\end{aligned} \tag{13}$$

3 Data and Calibration

In this section, we describe the data and specify the benchmark model for calibration. We first compute the recursive equilibrium defined in Section 2.7 that approximates the Taiwanese economy in the 2010s with the actual demographic structure of 2020. We denote this as the "initial steady state" and will use it as the starting point for the computation of transition dynamics. We match the moments from the Taiwanese economy in the 2010s with the simulated model moments. The income and age-specific productivity shocks are calibrated according to the micro survey data to capture the main uncertainties an individual faces.

Demographics

One period corresponds to a year. We assume that individuals enter the economy at age 20 ($j = 1$) and live up to 100 years ($J = 81$). The growth rate each year and conditional survival probabilities of the population are obtained from the National Development Council.

The National Development Council reports the population projection and conditional survival probability until 2065. According to the projection, in 2065 the old-age dependency ratio (65+/15-64) will increase to 84.1% and the population size will be 72% of the total population in 2018. Table 1 summarizes the key statistics. Since the last projection year is 2065, we will use the projected number until 2065. We use the actual demographics from 2018 for the calibration of the initial steady state. The rest of the population projection in the table will be used when we simulate the transition dynamics, the details of which will be presented in Section 4.2.

Table 1: Population Projection for Taiwan

	TFR*	Rate of natural increase	Median age	Age structure (%)			Dependency ratio (%)	
				(1) 0–14	(2)15–64	(3) 65+	(1)/(2)	(3)/(2)
2018	1.1	0.37	41.54	12.92	72.52	14.56	17.82	20.07
2020	1	-0.9	42.69	12.6	71.4	16	17.6	22.5
2025	1	-2.1	45.62	11.9	68.1	20	17.4	29.4
2030	1.1	-3.1	48.39	10.8	65.2	24	16.5	36.8
2035	1.13	-5.1	50.87	10.1	62.5	27.4	16.1	43.9
2040	1.19	-7	52.7	9.9	59.9	30.2	16.5	50.5
2045	1.2	-8.9	54.42	9.5	56.7	33.8	16.8	59.5
2050	1.2	-10.6	55.98	9.3	54.1	36.6	17.2	67.7
2055	1.2	-12.2	57.43	9.1	52.7	38.2	17.2	72.4
2060	1.2	-13.5	58.43	9	51	40	17.6	78.5
2065	1.2	-14.6	58.46	8.9	49.5	41.6	17.9	84.1

*: Total fertility rate. Source: the National Development Council.

Preference

The per-period utility is specified as follows:

$$u(c,l) = \frac{[c^{\gamma}(1-l-\mathbb{1}_{i=1}\phi)^{1-\gamma}]^{1-\sigma}}{1-\sigma}, \tag{14}$$

where γ determines the relative importance of consumption compared to leisure. We calibrate γ so that we can match the data, in which workers spend eight hours per day doing market work. We set the value of σ at 4.0, which is translated into the coefficient of relative risk aversion at 2.17. This value lies in the range of the estimates from the literature (Attanasio [1999]). The fixed cost of labor force participation after claiming retirement, ϕ , is set at 0.0583 so that average workers retire at age 58, which lies in the range of the average retirement age between 2010 and 2016.

We specify the utility from leaving a bequest a' by following Imrohoroglu and Kitao [2012]:

$$u^B(a') = \phi_1 \frac{(\phi_2 + a')^{\gamma(1-\sigma)}}{1-\sigma}, \tag{15}$$

where ϕ_1 and ϕ_2 capture how much utility can be derived from bequeathing, which also implies the saving behavior over time. We calibrate these two numbers to match (1) the ratio of wealth of those over age 75 to the wealth of the total population, which in Taiwan is around 0.15, and (2) the bequest amount each year as a percentage of GDP (around 4% to 5%); thus, we set $\phi_1 = 300$, and $\phi_2 = 27.29$.[5] Table 2 summarizes the calibrated parameter values.

Table 2: Parameters of Model (1)

Parameter	Description	Value/source
Preference		
γ	Weight on consumption	0.403
σ	Curvature parameter	4.0
ϕ	Fixed cost of working after retirement	0.0583
ϕ_1	Weight on bequest utility	300.0
ϕ_2	Curvature of bequest utility	27.29

Production

In the production function, we set the ratio to $\alpha = 0.34$, a statistic provided by the Directorate-General Budget. The subjective discount factor β is set as 0.991 to match the estimated value from Liu et al. [2014], who also study the aging population of Taiwan. The scale parameter A is set at 1.62 so that the aggregate output in the benchmark economy is normalized to 1.

Income Uncertainty

The income uncertainty over a life cycle is decomposed into idiosyncratic shock z and age-specific productivity shock η_j. Both values will be calibrated using the micro data from the Panel Study of Family Dynamics (PSFD), which contains panel survey data for Taiwanese households.

As for idiosyncratic shock z, we use household income data from 2010 and 2014 to calculate the states of labor productivity shocks and the corresponding transition probabilities. In PSFD between 2010 to 2014, we consider only these samples in which the respondents are the head of the household. We exclude samples of retired households. Household income is divided by the number of household members.

Based on per-capita income, the samples are divided into four groups: those below the 25th percentile, those between the 25th and 50th percentiles, those between the 50th and 75th percentiles, and those higher than the 75th percentile. The proportional deviations from the mean are defined as the four states of labor productivity shocks. The states are reported in Table 3. We

[5] The wealth ratio is from Lien et al. [2020], where they demonstrate the wealth distribution in Taiwan using the individual wealth register data. The bequest amount is from the 2017 Yearbook of Financial Statistics of the Ministry of Finance.

also compute the transition probabilities of labor income shocks from 2010 to 2014, presented in Table 4.

Table 3: States of Labor Productivity Shocks

State	Income range	Average	As of sample mean
State 1	0 – 25 %	11,271 TWD	27.83%
State 2	25 – 50 %	23,499 TWD	58.02%
State 3	50 – 75 %	36,726 TWD	90.67%
State 4	75 – 100 %	85,357 TWD	210.74%

Source: PSFD and author's calculation.

Table 4: Transition Probabilities of Labor Productivity Shocks

	State 1	State 2	State 3	State 4
State 1	0.7645	0.1672	0.0478	0.0205
State 2	0.3101	0.4462	0.2057	0.0380
State 3	0.0483	0.2415	0.4638	0.2464
State 4	0.0291	0.0583	0.1683	0.7443

Source: PSFD and author's calculation.

As for the age-specific productivity shocks, we follow Hansen [1993] and calculate hourly earnings for the cohorts with age j as HE_j and the average hourly earnings for all cohorts as HE. To adjust work hours across age cohorts, we compute η_j as $\eta_j = HE_j/HE$. We assume that $\eta_j = 0$ for $j \geq 51$ (70 years old) and no one works after age 70. The values are displayed in Figure 3.

Social Security

As described earlier, we model a system similar to the Taiwanese labor insurance formula. The pension benefit is calculated as a concave function of an individual's past earnings. This is an approximation of the actual formula, in which the highest five years of earnings are used as the average wage. Instead, the formula for pension benefits is given as follows:

$$\text{Benefits = Average Monthly Insurance Salary } \times \text{Coverage Years } \times 1.55\%.$$

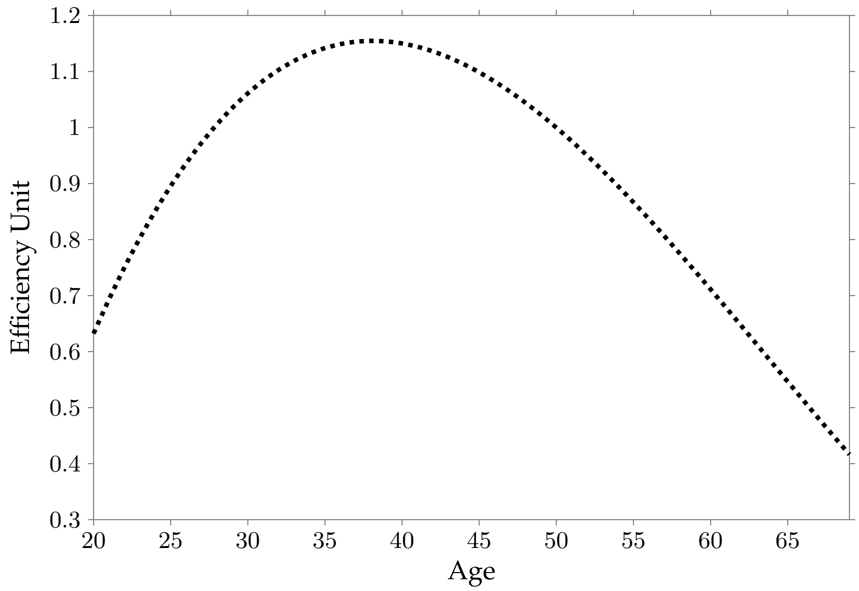

Figure 3: Age-Specific Labor Efficiency Profile. Source: PSFD and authors' calculation.

Given the above formula, we approximate the average monthly insurance salary by the following function:

$$e' = \frac{(j-1)*e + \frac{z\eta_j lw}{12}}{N} \times 12. \tag{16}$$

This formula captures how the benefit claimed during the preceding year relates to the benefit claimed during the current year. For each additional covered year, the benefits increase by $(j-1)*e$. Changes in the labor earnings are reflected by $(z\eta_j lw)/12$. In the actual pension system, we observe that the benefit during the following year increases by 1.55% if the average salary remains the same. Hence, we set $N = 60$ so that the benefit increase in the model matches the actual benefit increase for each additional covered year.

Taiwan sets an early retirement (earliest claiming) age and a normal retirement age; workers are eligible to receive pension benefits if they reach the earliest claiming age j^E. The benefits are adjusted downward if they are claimed before the normal retirement age j^N and upward if claimed within 5 years after the normal retirement age. Following the institutional setup in Taiwan, we set the earliest claiming age at 55 and the normal retirement age at 60. The adjusted ratio is 4 percent per year.

Transfer, Taxes, Expenditure, and Public Debt

The minimum annual consumption floor $\underline{c}$ is set at NT$100,000, which corresponds to the minimum monthly living standard of NT$8,000. The government debt D is set at 34.5 percent of the output, which is the average ratio from the Central Bank of Taiwan in 2015.

For income taxation, we employ a functional form proposed by Gouveia and Strauss [1994]:

$$T(y) = \lambda_0\{y - (y^{-\lambda_1} + \lambda_2)^{-1/\lambda_1}\}.$$

The values of λ_0 and λ_1 are set as the values estimated in Gouveia and Strauss [1994], and we set $\lambda_2 = 2.155$ to match the average income tax rate in Taiwan. The average income tax rate from the model is 14.4%, which lies in the range of average income tax rates in the 2010s (12% to 15%). Usually, from the competitive equilibrium the government budget constraint will not be balanced, and people must assume an additional consumption tax or income tax to balance the budget. In order to ensure that the current system reflects the real world, we assume that residuals from the government budget that are not associated with the programs are not explicitly modeled. Table 5 summarizes the calibrated parameters for the government.

Table 5: Parameters of Model (2)

Parameter	Description	Value/source
Government		
D	Government debt	34.5%
G	Government expenditure	15.8%
$\{\lambda_0, \lambda_1, \lambda_2\}$	Personal income tax	$\{0.258, 0.726, 2.155\}$
τ^{ss}	Pension tax rate	8.1%
τ^{q}	IRA contribution rate	8.1%
j^N	Normal retirement age	41 (60 years old)
j^E	Earliest retirement age	36 (55 years old)
y^{ss}	Maximum taxable earnings for pension	NT$549,600
$\underline{c}$	Consumption floor	NT$100,000 (NT$8,000 per month)

4 Quantitative Analysis

In this section, we use the calibrated model to simulate counterfactual policy experiments. Using the current system calibrated to the data as a benchmark, we compare the economic outcomes associated with different counterfactual pension reforms.

4.1 Benchmark Economy

Before analyzing the impacts of different policy reforms and the transition dynamics, we will first present the performance of the benchmark model in key dimensions of an individual's life-cycle. Since the main purpose of this paper is to conduct a welfare analysis of alternative pension arrangements, it is important to ensure a careful estimation of income risk and inequality.

Figure 4 shows the labor force participation rates, among various age groups, from the data and from the benchmark model. The data are taken from the Ministry of Labor in the year 2018. Overall, the benchmark model generates a pattern similar to that of the data. The profile in the data is concave over the life cycle: the labor force participation rate is lower at the beginning and the end of a life cycle, but a bit higher during the middle. This may be partially because we assume no savings at the beginning, we assume warm-glow agents, and the micro data is from 2010 to 2014 — but the numbers are close. We also discuss the performance of the benchmark

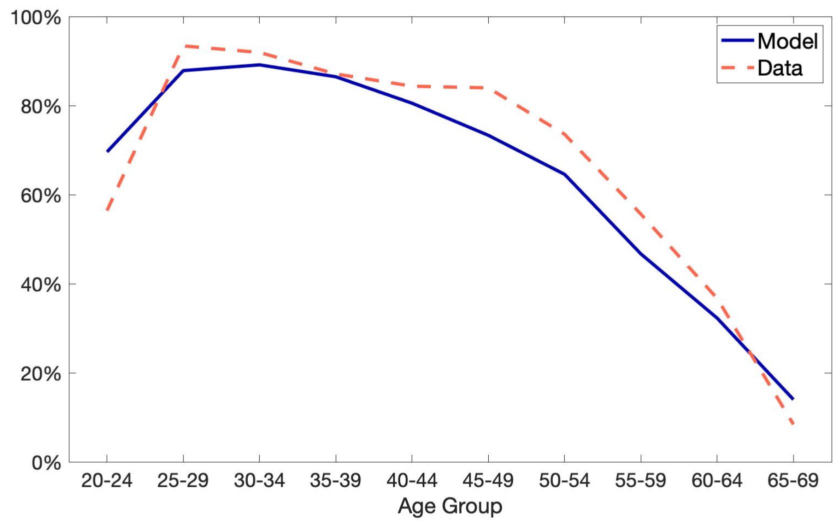

Figure 4: Labor Force Participation

model in terms of asset holdings. In the calibration, we calibrate the parameters for bequest, ϕ_1 and ϕ_2, to the proportion of assets held by those 70 years of age or older, and the bequest amount in terms of GDP. We now compare the proportions of asset holdings by cohort in Figure 5.[6] Similar to the data, the benchmark model exhibits a hump shape along the life cycle.

4.2 Policy Reforms, Transitions, and the Welfare Criterion

Policy Reforms.- The goal of this paper is to analyze the welfare implications of two main pension systems: PAYG and IRA. However, we should be more precise about how the comparisons are being implemented. For example, the timing of the reforms and how the IRA system is introduced matter substantially. Generally speaking, the PAYG system provides insurance for all workers, but the IRA system relies on individuals to self-insure. However, since the IRA is

[6]Source: Lien et al. [2020]. They use the whole population data from the Ministry of Finance from 2004 to 2014 to calculate the proportions of wealth holdings by cohort.

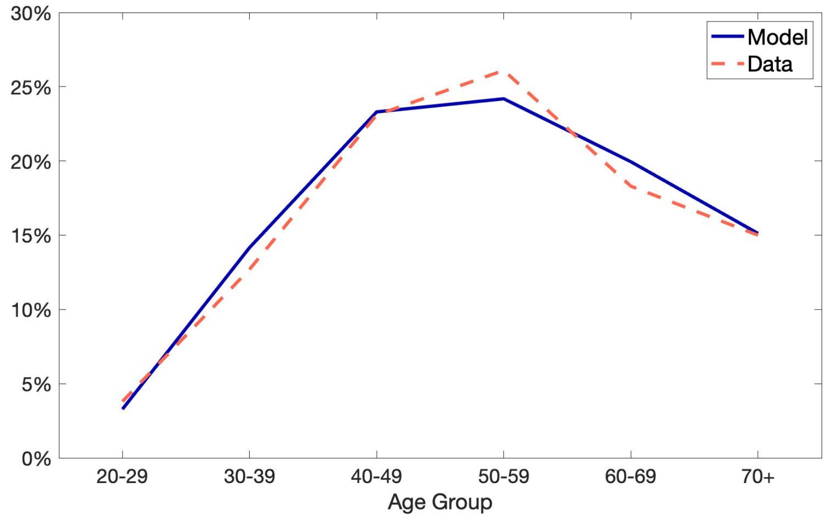

Figure 5: Asset Distribution by Age

tax-free, the tax distortion channel plays a key role in the IRA system. In addition, the inter-generational redistribution channel matters when the government implements different reforms to different cohorts.

In order to discuss the welfare implications through the insurance channel, tax distortion channel, and inter-generational redistribution channel, we consider the following four policy reforms. We also present the transition of the benchmark as a reference. Specifically, the policy reforms are as follows.

- Benchmark Transition (**BT1**): Starting from the benchmark model with the projected aging population, we assume there are no reforms of the current PAYG system.

- Transition Case 1 (**T1**): Based on the same demographic change in (BT1), the IRA system is implemented in 2020, but it only applies to the new cohort.

- Transition Case 2 (**T2**): Based on the same demographic change in (BT1), the government implements a within-PAYG reform in 2020 but only for those newly entering into the economy.

- Transition Case 3 (**T3**): Based on the same demographic change in (BT1), the IRA system is implemented for the new cohort in 2020 and the PAYG pension is reduced immediately to the basic payment.

- Transition Case 4 (**T4**): Based on the same demographic change in (BT1), the PAYG pension benefit is cut and applies to everyone immediately.

Motivated by recent policy discussions in Taiwan, the within-PAYG pension benefit cut is set as 40%. In other words, individuals receive 60% of the benefits compared to the system before reform. Also, since the pension formula has base payments of NT \$3,000 per month, the basic payment is set as NT\$36,000 per year for (T3).

Transitions.- Next, we discuss how the transitions are implemented. As discussed in the previous section, we calibrate the "initial steady state" that approximates the economy in the 2010s with the actual demographic structure of 2020. We start from the initial steady state in 2020 and simulate transition dynamics, taking the projected values of natural rate of increase and conditional survival probability from the National Development Council. Also, the benchmark model assumes the residuals from the government spending are "thrown into the ocean", and they represent 7.66% of the GDP. When balancing the government budget during the transition period, we fix this value and assume the government adjusts the income tax to balance the budget.

As for the computational methods, we describe the detailed algorithm below. We first compute the initial steady state (demography of 2020) and the final steady states (BT1, T1 to T4) by solving the recursive problems using value functions moving backwards from the last age. We then assume that the economy is in the initial steady state in period 0 and a new policy is announced and implemented in period 1. The economy transits to each of the final steady states in period T. We choose T large enough so that the transition dynamics are not affected by its value. In the reported version, T is set as 280. The detailed algorithms are as follows.

Step 1: Guess a series of values for each of the following equilibrium variable: capital, labor supply, income tax rate, and the amount of bequest.

Step 2: Assume the economy reaches the final steady state at period T. Use value functions of the final steady state and solve the agent's problem backwards from period $T-1$ to 1. Record the policy functions for the agents of each period.

Step 3: Use the distribution of agents in the initial steady state and calculate the transition distributions using the policy functions derived in Step 2.

Step 4: Then, calculate the aggregate capital, labor supply, government revenues and expenditures, and the amount of bequest transfers using the distribution derived in Step 3. Compare the aggregate values with the guess in Step 1 and check if the equilibrium conditions are satisfied for all periods. If they are not satisfied, update the guesses for equilibrium variables in Step 1 and the proceed with Step 2 to Step 4.

The Welfare Criterion.- Since the main goal of the analysis is to quantify the welfare implications of different reforms, let us now define the welfare criterion throughout the analysis. For each cohort (current generation or future generation), we calculate the consumption equivalent variation (CEV) of each alternative reform (T1 to T4) relative to the current system (BT1). Specifically, we compute the percentage changes under the current system with population aging (BT1) that would make the agents in each cohort indifferent to the alternative policy reforms (T1 to T4).

The algorithm for solving the CEV can be implemented as follows. For a cohort at year t with age j, we first calculate the welfare of the same cohort if this agent were living under a different policy (T1 to T4). Then, holding all other decisions of this agent under BT1 the same (lifetime labor supply decisions, retirement decisions, and amount of bequest remaining), we vary the percentage change in consumption in BT1 until the welfare of this agent in BT1 equals the alternative policy (T1 to T4). This way, a positive CEV means that the welfare of this agent is higher under the alternative policy, whereas a negative CEV implies that remaining in the current system is better for this cohort.

4.3 Impacts of Population Aging under Different Policy Reforms

Before we analyze transition dynamics, we first compare the features of the economy in the initial and final steady states under different policies. Note that the five scenarios laid out in Section 4.2 result in three kinds of final steady states: current PAYG system (BT1), within-PAYG reform (40% cut in pension benefits, T2 and T4), and the IRA system (T1 and T3). We compare these three different final steady state outcomes with the initial steady state to examine the overall impacts of population aging on the economy under different pension systems.

Table 6 presents the results. To illustrate what happens to the economy if the population ages at its current speed, we present the initial state outcomes (2nd column) and three future scenarios side-by-side (3rd to 5th columns). Specifically, we assume that the present rate of population aging takes place until 2065 and the demography remains the same thereafter. Column “Initial steady state" shows current economic outcomes in 2020. Columns “Current PAYG" and “Within PAYG reform" show the predicted final steady state outcomes when there is no reform and when there is a 40% cut in pension benefits, whereas column “IRA" shows the final steady state results under the IRA system.

First, note that regardless of the policies in the final steady state, the model predicts severe declines in aggregate output (measured in GDP). Without any reform, the output decreases by 30.26% due to the aging population. With reforms, the negative effects of the aging population on the output are mitigated: for the within-PAYG reform, GDP decreases to a lesser extent by 19.84%, and for the IRA reform it does so by 29.38%. When we look at GDP per capita, it is lower by 3.09% without reform, higher by 11.63% under the within PAYG reform, and lower by 1.66%

Table 6: Initial State versus Final Steady States

Variables	Initial steady state	Current PAYG	Within PAYG reform	IRA
Output (aggregate GDP)	–	-30.26%	-19.84%	-29.38%
GDP per capita	–	-3.09 %	11.63%	-1.66%
Capital	–	-28.54%	-4.42%	-21.48%
Labor	–	-31.13%	-26.79%	-33.13%
Average work hours	–	+1.89%	-1.74%	+2.53%
Wage rate	–	+1.09%	+9.49%	+5.61%
Interest rate	2.62%	2.39%	1.14%	1.68%
Average income tax rate	14.24%	+11.77%	4.63%	1.75%
IRA contribution	–	–	–	8.1 %
Pension tax rate	8.1 %	8.1 %	8.1%	–
SS balance (% of GDP)	- 9.53%	-11.15%	-3.93%	0.0 %.

under the IRA reform.

While both reforms (within-PAYG reform and IRA reform) achieve higher output levels than the case without any reform, it is remarkable to see that the within-PAYG reform system alleviates the reductions in output much more than the IRA reform. The difference is mainly due to higher capital accumulation under the within-PAYG reform. When we look at capital and labor inputs, the reductions in aggregate capital are particularly smaller under the within-PAYG reform system whereas the reductions in labor supply are similar for all three cases.

In terms of other outcomes, we observe that people work more in the intensive margin under the current PAYG system and IRA reforms (+1.89% and +2.53%), whereas people work fewer hours in the within-PAYG reform (-1.74%). The steady-state outcomes for interest rates are not substantially different across reforms. The within-PAYG reforms (T2, T4) lead to a 9.49% wage increase and a 1.14% interest rate whereas the IRA reforms (T1, T3) lead to a 5.61% wage increase and a 1.68% interest rate.

Another driving force that causes these differences in the steady state outcomes is the income tax rate that balances out the government budget: the case without a reform requires the highest average income tax rate of 11.77%, the within PAYG reform requires 4.63% and the IRA reform requires 1.75%. The level of the income tax rate reflects the financial burdens caused by different pension systems as well as how they affect individuals' incentives to work. Not surprisingly, the IRA system yields the lowest number and the current PAYG system gives the highest number. This number helps us to understand the patterns of the transition dynamics and can explain the difference in welfare, which we discuss in the next two subsections.

4.4 Transition Dynamics

Next, we analyze the transition dynamics driven by the evolution of demographics and the detailed implementations of each policy reform. To do so, we present the transition paths following a counterfactual reform which takes place in 2020 and plot the changes over time. Note that the changes are calculated by comparing the values in a given year under different policy reforms (T1 to T4) to the values if there is no reform (BT1). We track the changes until year 2180 (160 years after 2020): by then the economy is close to the final steady state outcomes.

To demonstrate the financial burden from the older cohorts to the younger cohorts, it is useful to categorize the transition periods into the following three phases:

- **Phase 1)** 2020–2055: The retirement pool consists only of the old cohorts. The new cohorts are all in their working age (age 20 to 54).
- **Phase 2)** 2055–2100: By 2055, the new generations have reached the retirement age (55). The retirement pool begins to consist both of old cohorts and new cohorts.
- **Phase 3)** 2100–2180: By 2100, the old cohorts do not exist. The population consists of the new cohorts only, reaching the final steady state.

In addition, when considering the transition paths, the reforms can be classified into two types: **gradual shifts** and **immediate shifts**. Cases T1 and T2 are gradual shifts since they leave the old cohorts under the old generous PAYG system whereas Cases T3 and T4 are immediate shifts since they also change the PAYG system for the old cohorts.

We first show the financial burdens over time. Figure 6 presents the changes in the income tax. Note that income tax is used to balance out the government budget, and facilitates investigation of the extent to which individuals bear the burden of the reform deficits. As mentioned in the analysis of the steady state cases, Case BT1, without reforms, suffers from higher taxes in the long run, Cases T2 and T4 (PAYG reforms) lead to the second highest tax rates, and Cases T1 and T3 (IRA reforms) lead to the lowest rates in the long run. When we look at the early transition periods (Phases 1 and 2), Cases BT1 and T1 exhibit substantial surges in income tax rates in the early phases, Cases T2 and T3 (immediate reforms) smooth out these changes, whereas Case T3 demonstrates the least burdens over time.

These results indicate that when maintaining the current PAYG system together with losing the supports to the pension funds from the younger generations (BT1 and T1), larger financial burdens are placed on the future generations at the beginning of the transition process. The financial burden is found to be very large for the gradual IRA transition; the average income tax rate goes up from 14% to as much as 30%, which has a similar degree to the tax increase

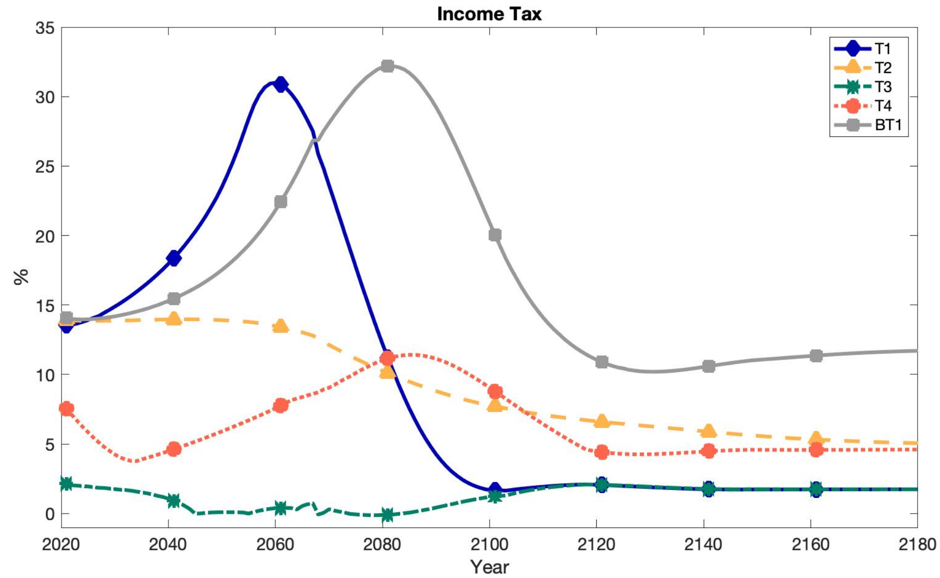

Figure 6: Transition Paths: Burdens of Reform Deficits

in the baseline transition (BT1). However, the tax rate surge for the gradual IRA reform occurs in the earlier phase for a shorter period of time compared to the baseline case. The tax for the gradual IRA reform declines to less than 2% around 2100, when all the current generations do not exist in the economy, but the tax for the baseline case is still high at 20%. All the other reforms demonstrate a smoother transition (lower volatility). To sum up, the analysis shows that each reform helps to mitigate the tax burdens of the aging economy at a faster speed to a significant extent.

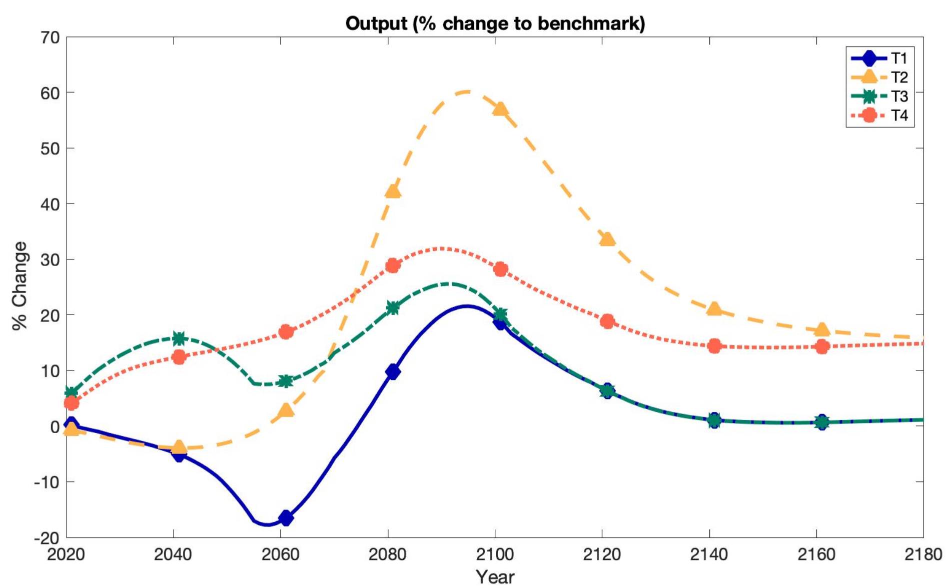

Figure 7: Transition Paths: Aggregate GDP

Figure 7 presents the changes in the total output (measured in GDP).[7] Although not drawn, Case BT1 is a horizontal line with zeros. We see that Case BT1 (without reform) leads to the lowest output (as all the lines are above zero in the long run), the IRA reforms lead to the second lowest, and the PAYG reforms lead to the highest in the long run. When comparing the IRA and PAYG that have gradual shifts (Cases T1 and T2), the qualitative patterns of transitions are similar—the output first decreases during Phase 1 (2020–2055) and then increases during Phase 2 (2055–2100) before the output reaches the steady state. However, the magnitude differs greatly. Case T1 (IRA for the new cohort) leads to a much larger decrease in the first phase (2020–2055) and consequently results in a lower long-term increase than Case T2 (PAYG reform for the new cohort). On the other hand, the immediate reforms (Cases T3 and T4) alleviate the short-term negative impacts of reforms. After going through moderate increases during all transition years, the paths reach the same steady state outcome. Note that GDP is the composition of the aggregate labor and capital, which are influenced by other equilibrium variables such as wage, interest rate, and income taxes. To see the mechanism behind the dynamic patterns, we next investigate the impact on macroeconomic outcomes and other equilibrium variables in an attempt to decompose the effects on total output.

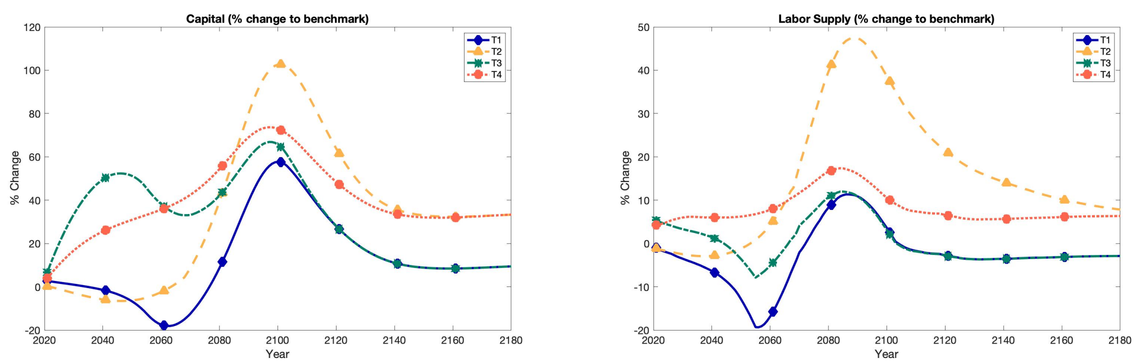

Figure 8: Transition Paths: Aggregate Macroeconomic Variables

Figure 8 presents the changes in other aggregate macroeconomic variables: capital (left graph) and labor (right graph). The transition patterns in capital accumulation are qualitatively similar to those in output outcomes. Since aggregate capital comes from individual savings, we see the transitions of individuals' saving behavior over time. Not surprisingly, gradual shifts (T1 and T2) cause individuals to dissave whereas immediate shifts encourage people to save in Phase 1. This is because of the financial burden of the pension benefits from the older cohorts; we observe that capital increases for all reforms in Phase 2 as the effects of the burden begin to diminish. La-

[7] Note that from now on we will focus mainly on the percentage change to benchmark (BT1). As a result, we will only plot transition dynamics from T1 to T4. We do not plot GDP per capita over time because relative positions in the dynamics would be the same since the aging rate is assumed to be the same under all reforms.

bor inputs also exhibit patterns similar to the output and capital outcomes for the PAYG reforms (T2 and T4), but not for the IRA reforms (T1 and T3). Both IRA reforms (T1 and T3) experience lower levels of labor inputs compared to the baseline during Phase 1 of the transition period (up to 2055). However, the driving forces behind this phenomenon are different. The decrease in labor inputs for T1 is largely driven by the increase in the income tax to balance the budget, as older cohorts remain in the current PAYG system. On the other hand, the decrease in labor inputs for T3 is because marginal productivity of labor is higher due to the increase in capital. As the burden from older cohorts is cut to the minimum and new cohorts begin to save for their retirement, economy-wide savings increase over time. As a result, labor inputs decrease because individuals do not have to provide much labor to earn sufficient income. Last, since the positive impact on capital accumulation dominates the negative impact on labor supply, the overall changes in the output are positive compared to the baseline transition, as reported earlier.

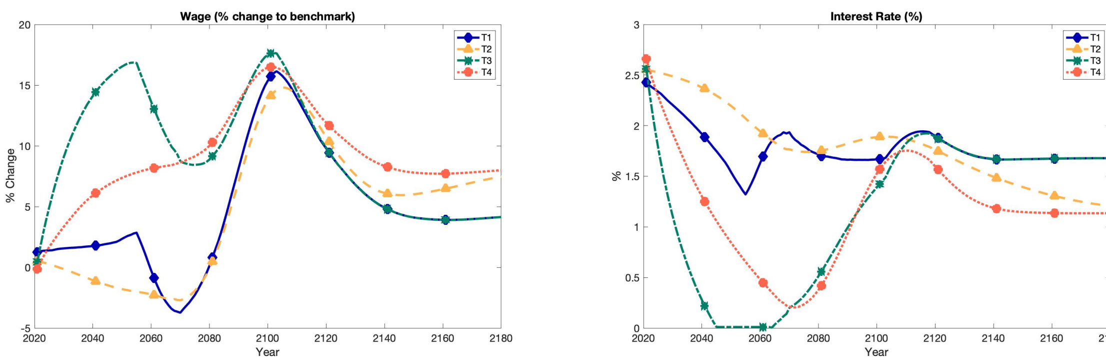

Figure 9: Transition Paths: Equilibrium Variables

Figure 9 presents the changes in wage and interest rates. The changes in the wage rates and the interest rates are equilibrium outcomes and thus highly associated with changes in the aggregate capital and labor supply. In fact, the composition changes in aggregate capital and labor supply determine the wage and interest rate, as in equilibrium wage equals marginal return to labor and interest rate equals marginal return to capital. Although the steady-state outcomes are not substantially different across reforms, the transition paths differ greatly. The immediate shift of the IRA reform (T3) results in a surge in wage rates immediately after implementation: there is a large wage increase from the within-PAYG reform for all cohorts (T4) and a gradual increase from the IRA reform for the new cohort only (T1). The gradual PAYG reform results in a lower wage rate compared to the baseline transition for Phase 1 of the transition. The differences in wages across reforms are the greatest in 2055, the year when new cohorts begin to enter the retirement pool. In 2055, the wages are higher by 16% under the immediate IRA reform and lower by 4% under the gradual PAYG reform. As for interest rates, they decrease in Phase 1, but the transitions to final steady states are relatively stable for gradual shifts (T1 and T2) and much more volatile for immediate shifts (T3 and T4). These changes in wages and interest rates provide important information on the work and saving incentives over time.

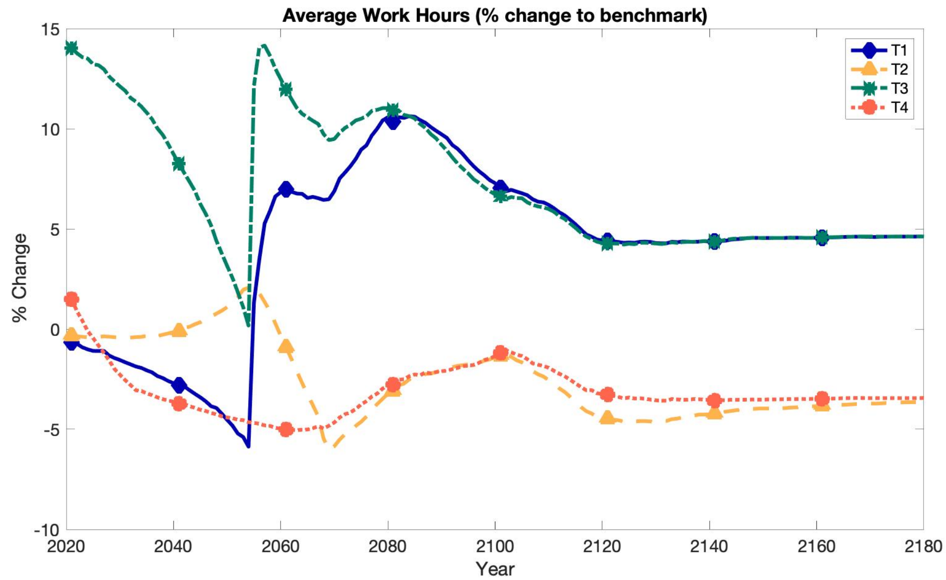

Figure 10: Transition Paths: Burdens of Reform Deficits

Figure 10 presents the changes in average work hours conditional on employment, which can be interpreted as the measurements for intensive labor supply. The IRA reforms lead to higher average work hours by 5% in the steady state compared to the baseline. During the transition, the IRA reforms first reduce work hours and then cause a jump in 2055, when the first cohort of the future generations begin entering the retirement phase. The initial declines for IRA reforms (T1 and T3) can be explained by the same arguments as the mechanism behind labor supply changes: the decreases for T1 are due to a higher income tax to balance the government budget whereas the decreases for T3 are because the marginal product of labor is higher due to higher aggregate capital. As for the PAYG reforms, T2 and T4 lead to lower average work hours by 4% in the steady state compared to the baseline, and the changes for PAYG reforms are relatively moderate. This can be explained by consistent inflows of the pension funds from the young cohorts. As a result, the changes in income tax to balance the government budget are less volatile and hence individuals do not need to change work hours substantially during the transitions.

4.5 Welfare Analysis

Another goal of this paper is to quantify the welfare implications of each reform. As discussed before, consumption equivalence variation (CEV) is our welfare criterion; that is, we calculate the welfare gain from each reform as the percentage change in consumption in the benchmark transition (BT1) that achieves the same lifetime utility as in the reform (T1 to T4). Specifically, we discuss the differences between PAYG and IRA and analyze how they differ in the across-individual welfare effects and inter-generational equity.

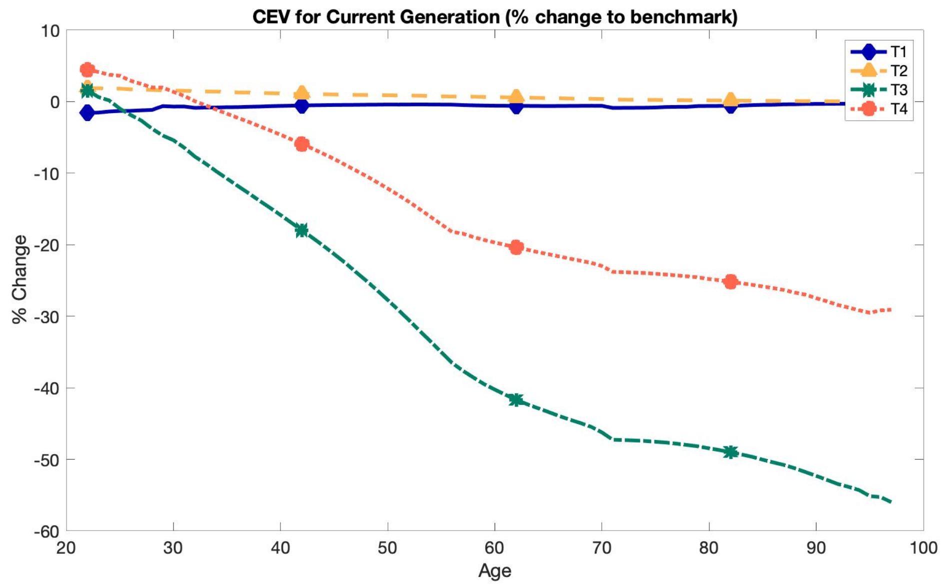

Figure 11: CEV for Current Generation

Figure 11 shows the CEV for the current generation, who are already in the economy in 2020 (ages 20 to 100). We plot changes in CEV compared to the benchmark transition for each cohort in order to illustrate the welfare effects for the current generation across age at the time of reform. A negative value implies that individuals are worse off if a reform is implemented. The graph shows that Case T2 (gradual PAYG reform) is favored by individuals from almost all ages. T1 will not be supported by the current generation although the differences are small. These scenarios are due to lower (higher) income tax rates to balance the budget for T2 (T1).

When we compare the baseline transition to Cases T1 and T2, which let the current generation stay with the old PAYG system, the welfare effects are relatively small. This implies that the re-distributional effect does not significantly affect the current generation as long as the system applied to them does not change. Large negative welfare effects are observed in Cases T3 and T4, in which the current generation is also shifted to new plans. Not surprisingly, the negative effects are larger in Case T3 (the immediate IRA reform) than Case T4 (the immediate PAYG reform). These results are intuitive because the pension benefits are reduced to base payments in T3, which are lower than the pension benefits eligible in T4. Given these findings, it can be inferred that the government may need to compensate the existing cohorts with the pension benefits to which they are entitled, if the goal is to gain support for reform from the current generation.

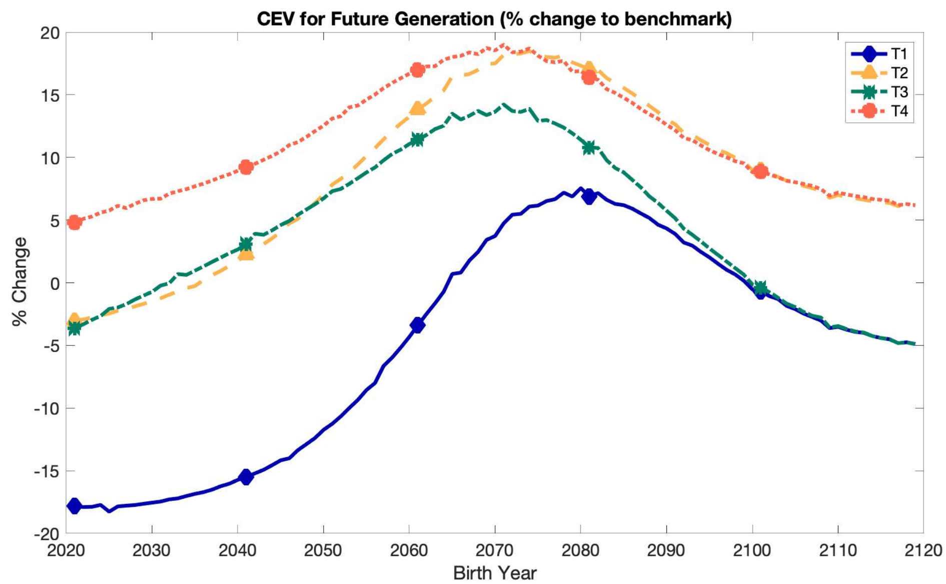

Figure 12: CEV for Future Generation

Figure 12 presents the effects of the reforms on the future generation, who enter the labor market after 2020 and thereby are under the revised social security system. We plot changes in CEV compared to the benchmark transition over time in order to illustrate the welfare effects for the future generation. In the steady state, the PAYG reforms lead to higher welfare than IRA reforms for the future generation. This may be largely due to cross-subsidization from wealthy individuals to low-income individuals. Since such re-distributional effects across individuals do not present for the IRA reforms, the PAYG reforms achieve higher overall welfare in the economy by equalizing the welfare distribution across individuals. When we observe the transition paths, we note that Cases T2 (gradual PAYG) and T3 (immediate IRA) follow similar paths for the early transition periods. These results indicate that the financial burdens on future cohorts are similar for Cases T2 and T3. Given that T2 is the PAYG reform with the larger burden on the new cohort and T3 is an IRA reform and has the smallest burden, the results show that even when an IRA reform (T3) reduces the burden by paying only the minimum to the old cohort, the welfare consequence is not significantly larger than that under the PAYG reform with burden (T2).

We further investigate welfare consequences by decomposing these three channels (i.e., the insurance channel, the inter-generational redistribution channel, and the tax distortion channel) and examine how each channel affects welfare. To tease out the inter-generational redistribution channel, we compare Cases T1 and T3 for the IRA reforms. Although both cases implement the IRA reform, Case T1 places a larger burden on the younger cohorts because this reform only applies to the new cohorts — the old cohorts are still entitled to the original PAYG benefit. The comparison between Cases T1 and T3 in Figure 12 shows that the difference in the CEV for the future generation between T1 and T3 ranges from 10% to 15% throughout the transition period. These differences are the largest at the beginning at 15% and diminishes in 2100, when all old cohorts die out. This gap can be considered the upper bound of the financial burden since we look at two extreme cases of the IRA reforms: T1 allows old cohorts to stay with the current generous PAYG payments and T3 forces old cohorts to switch to the minimum PAYG payments. Similarly, we can evaluate the inter-generational redistribution channel by comparing Case T2 with Case T4 to find the financial burden on the future generations in the case of the PAYG reform. The difference between Cases T2 (gradual shift) and T4 (immediate shift) is about 8%; the gap disappears relatively quickly by 2070. This smaller burden for the PAYG reform compared to the IRA reform (difference between T4 and T3) seems reasonable; for the PAYG system, the pension benefits for old cohorts decrease from 21,000 TWD to 14,000 TWD per month (40% reduction) and for the IRA system, the monthly benefits are reduced from 21,000 TWD to 3,000 TWD (base payment).

To evaluate the importance of the insurance channel and tax distortion channel, we compare the baseline transition (BT1) and the IRA reforms in the steady states. Whereas the PAYG reforms improve welfare for future generations, the IRA reforms lead to lower welfare levels than the baseline transition in the steady state. This result shows that for the Taiwanese economy, the current PAYG system ends up with better welfare outcomes even with generous pension benefits and a higher burden than the IRA system. A possible explanation is the low savings in their later ages. While the IRA provides individuals with an incentive to save, the Taiwanese pension tax rate is not high enough to accumulate sufficiently. In this case, a larger proportion of the older generation suffers from low levels of income. Having the PAYG system leads to higher welfare for Taiwanese people not only through the channel of cross-subsidization but also through higher levels of guaranteed fixed income after retirement. In fact, although it is not presented in this paper, when the economy does not experience a demographic change (continues with the same old dependency ratio), we observe that the IRA system is better than the baseline PAYG system. This provides some evidence that welfare gains from the PAYG systems are not only driven by cross-subsidy but also by giving more income (a safety net) to individuals who have low asset levels.

In sum, if the government is considering pension policy reform, current generations would only favor Case T2 and future generations would favor Case T4 (i.e, the immediate cut in the PAYG benefits for all cohorts), followed by Case T2. Based on these welfare analyses for current and future generations, a reform that may enjoy public support is Case T2, because it gains all the support from current generations and from generations who enter the labor market after 2035. It would be difficult to implement T1 or T3 because people in the current generation would not support such reforms, and individuals who enter the labor market before 2030 would not support them either. T4 would have the highest support from all future generations, but the current generation would be opposed to the reform.

5 Conclusion

It is true that the PAYG system benefits the economy not only by providing an incentive to save as a form of insurance against risks after retirement but also by helping to redistribute wealth across individuals. However, it has become unsustainable in countries with a growing elderly population and declining fertility rates. To analyze the sustainability of the PAYG system, we build a quantitative general equilibrium model of overlapping generations of individuals who make decisions on consumption, saving, labor supply on both extensive and intensive margins, and pension benefit claims. We focus especially on welfare and the macroeconomic effects of various policy reforms, IRAs in particular, through various channels that affect individuals' behavior. We also show how each reform affects the welfare of current and future generations.

Our analysis demonstrates that the IRA is not a panacea because transitioning to the IRA system incurs a large burden on young generations. Compared to within-PAYG reform, individuals' responses differ substantially. As a result, within-PAYG reform could outperform IRA reform in several dimensions. However, reducing pension benefits is not an easy solution, either, since it does not honor the contributions of older cohorts and substantially worsens their welfare. Nonetheless, we find that most generations support within-PAYG reform if the reduction in benefits is applied only to the new cohort. Our analysis presents possible paths under various pension systems and demonstrates the reform which best serves the government aim while minimizing the adverse effects on overall welfare.

CRediT authorship contribution statement

Hsuan-Chih Lin: Conceptualization, Methodology, Investigation, Programming, Visualization, Writing - original draft, Writing - review & editing. **Atsuko Tanaka**: Conceptualization, Methodology, Investigation, Visualization, Writing - original draft, Writing - review & editing. **Po-Shyan Wu**: Conceptualization, Methodology, Programming, Writing - original draft, Writing - review.

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