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POPULATION AGING, FISCAL SUSTAINABILITY AND POLICY REFORMS

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ABSTRACT

This paper investigates the impacts of population on the economy of Taiwan with a computable overlapping generation (OLG) model. The simulation results indicate that population aging yields adverse impact on economic growth, deteriorates government budget soundness, distort factor prices in the factor market, and weakens the protection function of social security system. To investigate fiscal sustainability of the aging economy, this paper performs four reform schemas of income tax reform, consumption tax reform, reforms aims to constraint government financial outlays, and consolidated income and pension reforms. With respect to tax reform, the simulation results imply that increasing in the consumption tax would be less beneficial than broaden the direct tax base. Income tax reforms are the least harmful measures to economic growth and yield no noticeable effect on budgetary improvement. Consolidated reform in pension and public fiancé systems can generate beneficial effect on public finance yet this improvement is obtained at the cost lower economic growth and per capita consumption.

KEYWORDS: Fiscal Sustainability, Overlapping Generation, Pension, Population Aging, Tax Reform

INTRODUCTION

Population aging signifies the phenomena that the proportion of people aged 65 and over to the total population exceeds 7%. This demographic phenomenon is the results of declined fertility and extended longevity. As a result, the age composition of population shifts toward older ages and the proportion of working age population are shrinking. The presence of shrinking working age population yields considerable adverse impacts on national economic growth, national savings; it also jeopardizes the sustainability of the national pension system, health care system, and government budgetary condition. Various studies have investigated the macroeconomic impacts of population aging. For example, Sheiner et al. (2006) discussed the consequences of population aging in the United States from a macroeconomic perspective and concluded that population aging caused a decline in per capita consumption and significant implications for social programs, social security and Medicare, for the elderly. Muto et al. (2016) applied overlapping generation (OLG) model to explore the effects of Japan's population aging on the macroeconomy and concluded that population aging had adverse impacts on Japanese GNP and return on capital. However, the decline in the domestic capital return encourages investment in foreign capital, mitigating the adverse effects of population aging on GNP. Mühleisen and Faruqee (2001) discussed the effects of population aging in Japan from a macroeconomic perspective and noticed that Japanese public pension schemes have come under pressure to raise contribution levels or cut the size of benefits. Mühleisen and Faruqee also noticed that, as aging demographic shock unfolds, Japan will face substantially greater fiscal challenges than other countries and Japan's fiscal situation deteriorated dramatically following the government's efforts to resuscitate the economy. Lee et al. (2016) used a simple stylised model and the National Transfer Accounts (NTA) data to simulate the effect of demographic changes and economic growth in selected Asian economies of Japan, Korea, and Taiwan.

The conclusion is that rapid aging of these economies are likely to suffer a tangible deterioration of fiscal sustainability under their current tax and expenditure system.

This paper uses the economy of Taiwan as the subject of investigation. Taiwan has become an aging economy since 1994 and is expected to phase into "super-aged" economy, with the ratio of population aged 65 and over to total population exceeds 20%, in 2025. The medium variant population projection made by the National Development Council in Taiwan predicts that the aging ratio in Taiwan will be 20.1% in year 2025 and 30.7% in 2056. Figure 1 illustrates key demographic scenarios in Taiwan. In all three panels in Figure 1 the scenarios to the right of the vertical dashed line in 2016 signify the series are forecasted ones. With the evolution of demographic aging in Taiwan, total population is projected to start decline around year 2025 (Panel A, Figure 1). Working aging population has started to decline roughly around year 2015 (Panel B). The falling rate of the workforce is faster than that of the total population. In the meanwhile the potential support ratio, defined as the ratio of population aged 15-64 per population 65+, keeps falling (Panel C) and is expected to be 1.32 at year 2060. That is, in 1980 there were approximately 14.82 working age adults supports one old-aged retirees whereas in 2060 this figure drops to 1.32. These scenarios lead to a speculation about imbalance between the number of tax and social security contributors and the number of beneficiaries in the future. As a result, one may afraid that the current social security and fiscal system may not be viable in the long run in Taiwan, given the ongoing demographic aging trend.

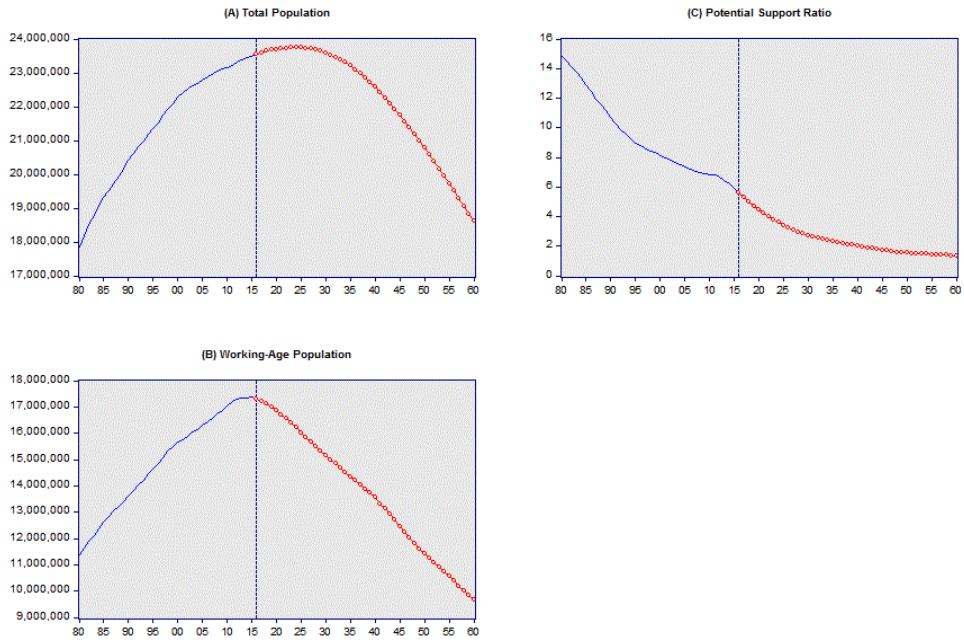

Figure 1: Population Scenarios in Taiwan, 1980-2060

Data Sources: Ministry of Interior (Taiwan) and National Development Council (Taiwan).

Recent study on the macroeconomic effects of population aging apples intensively the framework of overlapping generation (OLG) model. Samuelson (1958) introduced the first overlapping generation (OLG) model with life cycle consumption and pay-as-you-go (PAYG) pension system. Diamond (1965) extended Samuelson's model and introduced production and endogenous interest rate into the model. Thereafter, various extensive literatures with finite life-time agents

who left no bequests have been incorporated into the OLG model. With respect to public financing, Auerbach and Kotlikoff (1987) used OLG model to examine the effects of various fiscal policies, including deficit finance, dynamic tax reform, social security, and their interactions with demographic change. Blanchard and Fisher (1989) extended the model of Auerbach and Kotlikoff (1987) and incorporated population aging and pay-as-you-go (PAYG) or fully funded system into the model. Kudma et al. (2014) incorporated the main features of the two-pillar pension system used in Australia into the OLG model and Beetsma and Bucciol (2011) assumed a similar pension system. Recently, several studies have used the OLG framework to investigate the effect of government social welfare expenditure, such as pension and health care, using tax-based revenue (Kudma et al. 2014; Lisenkova et al. 2013; Muto et al. 2012, and others).

This paper aims to investigate the impacts of population aging on the macroeconomy of Taiwan, with special interest on its impacts on the sustainability of fiscal and social security system. In order to explore demographic aging impacts and policy reform effects on the economy, this study develops a computable general equilibrium overlapping generation (OLG) model and uses it to examine the aging effects and policy reform outcomes.

METHODS

The paper builds an OLG model with four sectors in the economy; namely, households, firms, the government, and a pay-as-you-go (PAYG) pension system. Considering the fact that the average life expectancy for Taiwanese people is roughly 80 years old, this paper assumes that each individual household in the model lives up to age 80. Each individual with physical age less than 20 is natured by his/her parents and receives education without working. The individual starts working at age 21 and retires at the mandatory retirement age of 65. Each household earns wage income and build up savings for use in old age. The representative household maximizes his/her intertemporal utility with respect to consumption. Firms maximize profits. The government collects taxes and social security contributions and runs a balanced budget. The model is a one-country closed model, where both the goods market and factor markets are assumed to be perfectly competitive.

Demographics

A period, t, corresponds to one year. At each time period, a new generation of households is born. Newborns with real life age of 21 corresponds to age 1 ($s=1$) in model. All generations retire at biological age 65 and lives up to a maximum age of 80. Therefore, at each time period there are 60 different generations coexist in the model. At time *t*, all agents of age *s* survive until age *s+1* with probability ϕ_s where $\phi_0 = 1$ and $\phi_J = 0$ for $J > s$, $s = 0, 1 \ldots 60$.

Let N_t^s be the number of agents of age *s* at *t*. This paper assumes that population grows at the exogenous rate n = 1.5‰ in the first instance and then drops to -0.01‰ per annum thereafter. The number of population at time *t* is given by

$$N_t = \sum_{s=1}^{60} \phi_t^s \left(1 + n_{t-1}\right) N_{t-1}^s \qquad \textbf{(1)}$$

Where ϕ_t^s is the survival probability of generation *s* at time *t*, N_t is the aggregate population at time *t*.

Households

Each household has one unit of time and supplies a fixed amount of labor inelastically for which he/she earns the market wage to finance current consumption, saving and tax payments. Households maximize his/her intertemporal utility at the beginning of age 1 in period *t*:

$$Max\sum_{s=1}^{J}\beta^{s-1}\left(\Pi_{j=1}^{s}\phi_{t+j-1,j-1}\right)u\left(c^{s}_{t+s-1},l^{s}_{t+s-1}\right) \quad \textbf{(2)}$$

The instantaneous utility $u(c, l)$ is a function of consumption c and labor supply l:

$$u(c,l)=\frac{\left(c^{\gamma}(1-l)^{1-\gamma}\right)^{1-\eta}}{1-\eta},\quad \eta>0,\ \gamma\in(0,1),\ \beta>0 \quad \textbf{(3)}$$

Where $u(c,l)$ satisfies the usual concavity requirement; β denotes the discount factor, γ describes the trade-off between leisure and consumption and $1/\eta$ is the elasticity of intertemporal substitution.

All households are homogenous in their productivity. A household's wage earning ability corresponds to his labor efficiency (e^s) and an agent's efficiency e^s depends on his age, $s\in S \cong \{1, 2... 60\}$. The age-efficiency profile is estimated based on the reported income tax data in Taiwan.[1]

The net wage income of working age population in period *t* of an *s*-year old is given by

$$(1-\tau_w-\tau_b)w_t e^s l_t^s \quad \textbf{(4)}$$

Where w_t the wage is rate per efficiency labor unit in period *t;* τ_w is the wage income tax rate; τ_b is the workers' pension contributions rate.

The new born generation does not possess any assets at the beginning of age *s*=1, hence $a_t^1=0$. Parents do not leave bequests to their children. The household with age greater than 1 (equivalent to physical age 21) earns interest income with his wealth saved in previous periods. The interest rate on assets is r_t, $r_t\in$. Capital income is taxed at rate τ_r. Households receive lump sum transfers Tr_t from the government. The physical wealth accumulation of individual household is given as

$$a_{t+1}^{s+1}=b_t^s+(1-\tau_w-\tau_b)w_t e^s l_t^s+\left[1+(1-\tau_t)r_t\right]a_t^s-(1-\tau_c)c_t^s+Tr_t \quad \textbf{(5)}$$

The aggregate wealth accumulation is: $W_t=\sum_{s=1}^{60}N_t^s a_t^s$ **(6)**

Where W_t denotes aggregate wealth which is the sum of all age cohorts' wealth at time t. For the working age

[1] Since age-income profile corresponds to age-efficiency, this paper use age-income profile to infer age-efficiency of a typical agent in the model. The estimated age-efficiency profile is: $e(S) = 0.984299 + 0.262403\times s - 0.004371\times s^2$.

population, we have $b_t^s = 0$ if s < R (where R=45, the beginning of retirement age). The budget constraint of an *s*-year old household at *t* and wealth a_t is:

$$b_t^s + (1-\tau_w-\tau_b) w_t e^s l_t^s + [1+(1-\tau_t) r_t] a_t^s + Tr_t = (1-\tau_c) c_t^s + a_{t+1}^{s+1} \quad \textbf{(7)}$$

Firms

At each *t*, firms produce output Y_t, using Cobb-Douglas type constant returns to scale production function:

$$Y_t = A_t L_t^{1-\alpha} K_t^{\alpha} \quad \textbf{(8)}$$

Where *Y* is output; αstands for capital income share and *A* is a scale variable. Productivity A_t grows at the exogenous rate g_A. The firm decides the demand for physical capital and effective labor to maximize profits with the given factor prices, wage (w_t) and interest rate (r_t), determined in the perfect competitive markets. Profit maximization gives rise to the first-order conditions:

$$\frac{\partial Y_t}{\partial K_t} = r_t + \delta = \alpha k_t^{\alpha-1} \quad \textbf{(9)}$$

$$\frac{\partial Y_t}{\partial L_t} = w_t = (1-\alpha) k_t^{\alpha} \quad \textbf{(10)}$$

Where $k_t = K_t / A_t L_t$ denotes the capital per effective labor in period *t* and δ denotes the depreciation rate.

Pension Sector

The social security system is a pay-as-you-go system. The pension sector grants a pension to the retired generations while the pension contribution is collected from the working generations. Pension benefits are a constant fraction of average labor income of working times:

$$b_t^s = \begin{cases} 0 & s < R \\ \zeta \dfrac{1}{ret} \displaystyle\sum_{s=1}^{ret} w_t^s e^s l_t^s & s \geq R \end{cases} \quad \textbf{(11)}$$

Where *ret* denotes retirement age. The replacement ratio of net pensions, ζ , is assumed to be constant. The aggregate pension benefit at time *t* is give as

$$B_t = \sum_{s=ret+1}^{60} N_t^s b_t^s \quad \textbf{(12)}$$

The government is responsible for the provision of a portion (b_g) of the aggregate pension benefit. The amount of government's pension subsidy is

$$Gb_t^s = b_g\left(\zeta \sum_{s=ret+1}^{60} N_t^s b_t^s\right) \quad \textbf{(13)}$$

The pension contribution is collected from the working generations:

$$P_t = \sum_{s=1}^{ret} \tau_b \left(w_t^s e^s l_t^s\right) \quad \textbf{(14)}$$

Under the pay-as-you-go (PAYG) pension system, the budget constraint of the pension sector is that total pension contribution received from period *t-1* equals to the current periods', period *t*, pension benefit payments. That is,

$$B_t = P_{t-1} + Gb_t \quad \textbf{(15)}$$

The Government Sector

The government issues bonds and collects three types of taxes to finance its expenditures on government consumption (G_t) and transfers (Tr_t). The three source of revenue for the government are capital tax, wage tax, and capital tax. The government's tax revenues (T_t) are given by

$$T_t = \tau_w w_t L_t + \tau_r r_t W_t + \tau_c C_t \quad \textbf{(16)}$$

Where W_t and C_t are aggregate wealth and aggregate consumption at *t*, respectively. Government spending is a constant fraction of aggregate output:

$$G_t = \overline{g} Y_t \quad \textbf{(17)}$$

The government issues bonds to finance its budgetary deficit. Public debt (D_t) at time t is

$$D_t = G_t + Gb_t + \left(1 + r_t\right) D_{t-1} - T_t \quad \textbf{(18)}$$

Where D_{t-1} is the debt stock at the beginning of time t.

Stationary Equilibrium

The stationary equilibrium requires that both goods and financial market clear. Thus, the following two equilibrium conditions must hold for financial market and goods market respectively:

$$W_t = K_t + D_t \quad \textbf{(19)}$$

$$Y_t = C_t + G_t + Gb_t + \left(K_t - \left(1-\delta\right) K_{t-1}\right) \quad \textbf{(20)}$$

PARAMETERIZATION AND MODEL SIMULATION

Parameterization

Given the model discussed, this paper first performs model calibration to mimic steady state economy for Taiwan. Table 1 illustrates the parameters used in the computation. Household's intertemporal elasticity of substitution for

consumption (θ) is set at 0.25 as in Auerbach (1987). Following Chang *et al.* (2005), this paper sets time discount factor (β) at 0.97. The depreciation rate is set to 0.04 that are nearly in line with empirical data in Taiwan. Government expenditure to GDP ratio is set at 0.17 which is estimated from the Taiwanese data in 1974-2014. All taxes rates are assumed to be fixed at the 2012 level. The software package of Matlab is used for model calibration and simulations.

Table 1: Parameter Values Setting

Parameter	Description	Value
α	Capital's share of output	0.33
β	Time discount factor	0.97
δ	Depreciate rate	0.05
g_A	Technical progress rate	0.015
ζ	Pension-income replacement ratio	0.465
θ	Inter-temporal elasticity of substitution for consumption	0.25
τ_r	Tax rate for capital tax	0.14
τ_c	Consumption tax rate	0.04
τ_w	Income tax rate	0.135
τ_b	Worker's public pension contribution rate	0.12
g	Government consumption to GDP ratio	0.17
G_b	Government's public pension subsidy rate	0.6

Simulation Analysis

To study the impact of population aging on the economy of Taiwan, this paper first obtains solution scenarios for variables, given the parameters listed in Table 1 and exogenous demographic transition. These scenarios serve as baseline for the comparison and discussion of alternative policy reform schema. This study aims to investigate fiscal sustainability in aging economy and presents various policy reforms to investigate the outcomes. This paper considers four types of reform that are believed to enhance the viability of fiscal health of the government. The four reform schemas are income tax reform, consumption tax reform, reforms aims to constraint government financial outlays, and consolidated income and pension reforms. Table 2 illustrates the reform programs simulated in this paper.

Table 2: Policy Reform Projects

Project	Description
1. Income Tax Reform	R1A: 5% increase in wage tax rate R1B: 8% increase in capital tax rate
2. Consumption Tax Reform	R2A: 5% increase in consumption tax rate
3. Government Outlay Cut	R3A: 5% cut in government expenditure R3B: 5% cut in government pension subsidy
4. Joint Wage Tax and Pension Reform	R4A: 5% increase in wage tax rate and 15% increase in pension premium contribution R4B: 5% increase in wage tax rate and 17% cut in pension replacement ratio

Baseline Simulation Results

This paper examines the impacts of population aging on the Taiwanese economy from three different aspects, namely, the macroecomic effects, the factor market related effects, and effect on fiscal system. For the macroeconomic effect, this paper considers the effects on GDP, aggregate labour supply, and per capita consumption. For the factor market, the paper concerns the effects on capital formation and factor incomes and explores the effects by examining the performances of wage rate, interest rate, saving rate, and capital-labor ratio. For the last category, this paper investigates the effects on pension to GDP ratio and government budgetary conditions. The baseline and the counterfactual policy reform scenarios are presented in Figure 2 to Figure 5. In these figures, the solid lines depict the scenarios of the baseline model and the dashed lines illustrate the scenarios of alternative policy reforms.

The baseline model indicates that GDP will eventually fall; even though there is a moderate technological improvement every year. This fall in GDP is due to the impact of shrinking working age population. Aggregate labor supply will also fall in the long run. However, per capita consumption shows a risen trend perhaps due to declined aggregate population in the long run.

In the factor market, saving rate of the economy increases from 0.3 to 0.5 approximately in the long run. This boost in saving promotes capital formation and raise capital-labor ratio in the economy. However, the enlarged capital accumulation is detrimental to capital return. Because capital becomes relative abundant, the rate of return on capital (interest rate) declines all the way. On the contrary, remuneration to the relative scarce labor, wage rate has risen continually in the simulation horizon.

Finally, population aging leads to deterioration in government budgetary stance. This is easy to understand from Equation (18) because the contributors to both tax and pension funds have decreased while the beneficiaries have increased so that the deficiency in the government outlay enlarged and public debt increased. Given the expanding size of pension beneficiaries, government subsidy to national pension also increased and debt interest payment increased as well. The overall effect is the deterioration of government budgetary condition. The baseline simulation indicates that the government budgetary stance can only be improved 100 years later and can still experience budget deficit thereafter. With the evolution of demographic aging, pension to GDP ratio also declined in the first 50 years and will increase gradually there after. Consider pension as a mechanism of social protection, this scenario implies that the social protection in the aging economy will be deteriorated due to population aging.

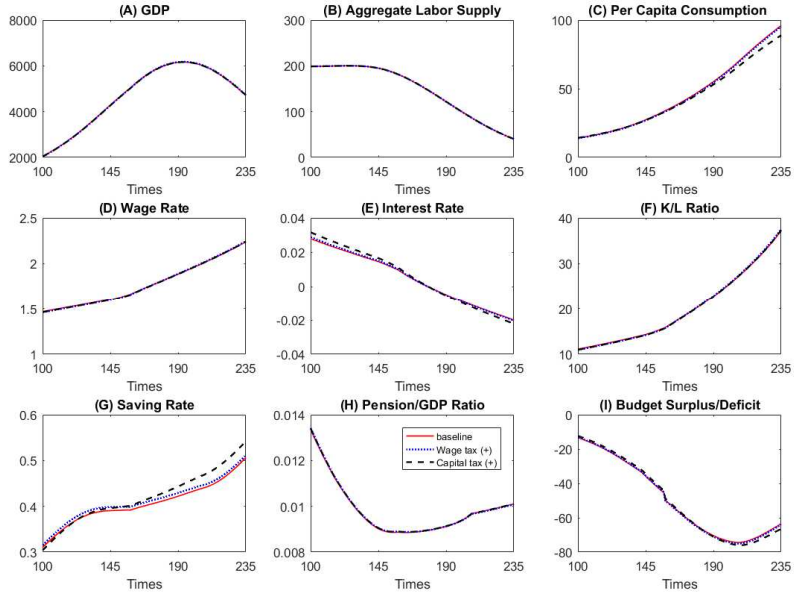

Figure 2: Simulation Scenarios for Income Tax Reform

REFORM SIMULATIONS

Fiscal Reconstruction

Figure 2 illustrates the simulation results for income tax reforms. Both increase in wage tax and income tax has little effect on GDP, aggregate labor supply, wage rate, K/L ratio, and pension-GDP ratio. Both reform measures stimulate saving rate to increase in the long run, with a more obvious effect for capital tax increase. Wage tax reform does not yield observable effect on capital return whereas raise capital tax can improve capital return in the short run and deteriorate that return in the long run. Risen capital tax also has long run adverse effect to per capital consumption. As for budgetary effect, both reforms make slightly improvement to the government budget in the short run and cause long run deterioration.

The effect of raising consumption tax from 50% to 10% has prominent negative impact on GDP, aggregate labor supply, and per capita consumption (Figure 3). This effect operates via its impact on households' work-consumption decision. Comparing to the effect of risen capital income tax, consumption tax reform has more prominent effects on every aspects of the economy. However, like that in the income reform circumstance, consumption tax reform does not improve much of the government budgetary stance.

A third reform is on cutting government expenditures (Figure 4). This cutting in government expenditure, either by a cut in general expenditure (R3A) or a consolidated reform of cutting government subsidy to the national pension and general expenditure (R3B), can yield more obvious impacts on the macroeconomic variables and factor market variables than previous two reform programs. Moreover, both reforms has significant impact on saving rate, with R3A improves saving rate whereas R3B reduces saving rate. The cut in government expenditure alone does not yield obvious improvement effect on budgetary condition. However, the joint reform project R3B can lead to noticeable improvement in the government financial condition, both in the short run and in the long run. A disadvantage effect is that it worsens the social protection function of the pension system, because it worsens the pension/GDP ratio.

Consolidated Pension and Income Reform

The last experiment in this paper is to consider consolidated reforms by an increase in the payroll tax and a joint reform in the pension system, either by an increase in pension contribution (R4A) or a cut in pension benefit (R4B). Figure 4 illustrates that both reform yield obvious adverse impacts on GDP, aggregate labor supply, and per capita consumption. Reform project R4A has more obvious effect on stimulating saving rate and K/L ratio than R4B does. However, R4B can yield more prominent improvement in the government financial stance in the long run.

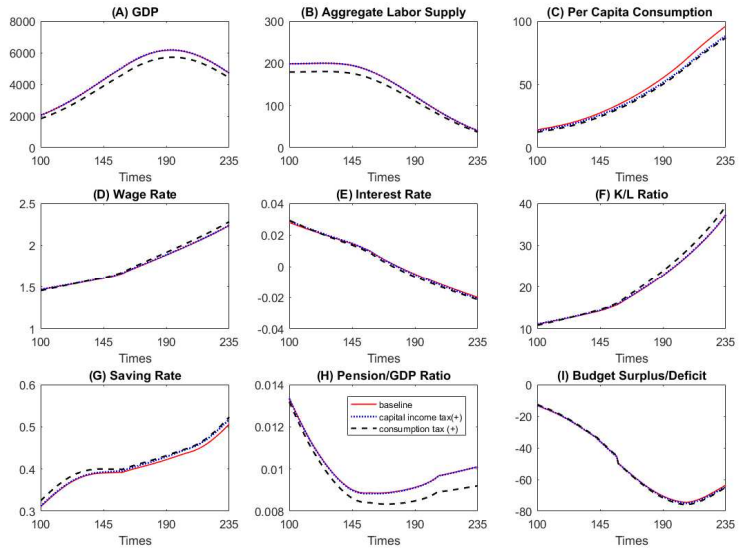

Figure 3: Simulation Scenarios for Capital Tax and Consumption Tax Reform

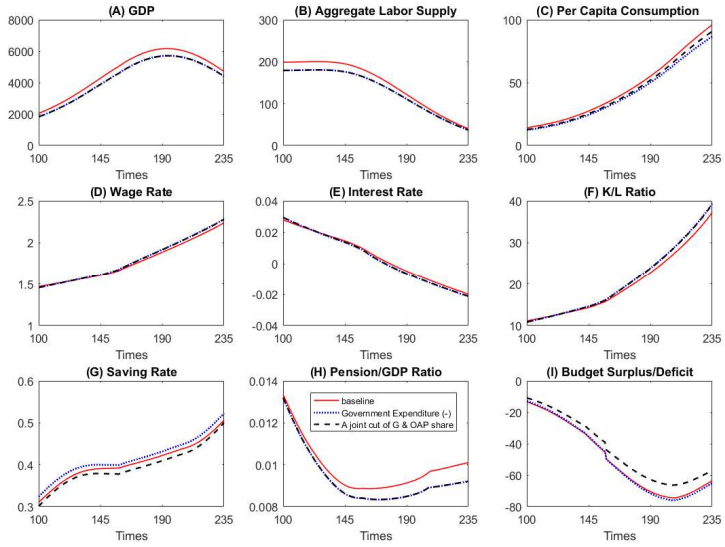

Figure 4: Simulation Scenarios for Government Outlays Cut

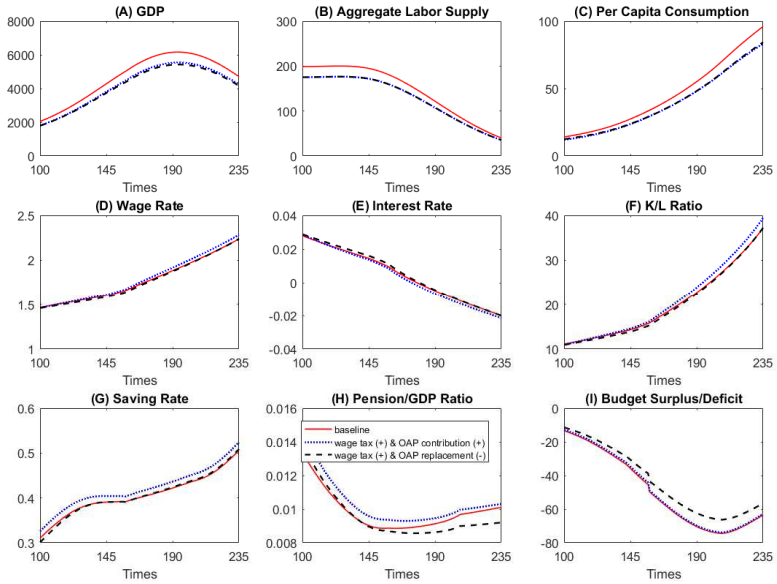

Figure 5: Simulation Scenarios for Consolidated Reforms

DISCUSSIONS AND CONCLUSIONS

Ensuring the long-term sustainability of public finances is a clamant need for the social and political stability in an aging economy. This paper investigates the impacts of population on the economy of Taiwan with computable overlapping generation model. The simulation results indicate that population aging yields adverse impact on economic growth, deteriorates government budget soundness, distort factor prices in the factor market, and weakens the protection function of social security system. This paper performs various reform simulations aiming to improve financial health of the government budgetary system. The simulation results yield a complex vision of the effects of policy reform on the sustainability of budgetary condition.

Income tax reforms are the least harmful measures to economic growth and yield no observable effect on budgetary improvement. Consumption tax reform has no significant effect on budgetary enhancement yet has obvious adverse effect on labor supply and economic growth. Cutting government expenditure alone does not improve public finance soundness yet produces negative impacts on economic growth. Consolidated reform in pension and public fiancé systems can generate beneficial effect on public finance yet this improvement is obtained at the cost lower economic growth and per capita consumption.

The demographic transition in Taiwan puts pressure on socio-economic system and presents a major challenge to long-term fiscal sustainability. The current pension system in Taiwan is based on pay-as-you-go principle, which is financial viable as long as the number of the contributors exceeds the number of beneficiaries. Given the institutional setting that the government is responsible for the provision of subsidy to the pension system, any reform program considers only increase tax revenue or reduce government expenditure can not improve public finance soundness; only joint reform of both tax and pension system can yield beneficiary effect on the budgetary problem.

The results in study also indicate that any measure aiming to improve fiscal deficit issue will not only have a direct on aggregate demand, but will also affect households' saving behaviour. In other words, reform measures will create generational welfare distribution effect which is beyond the scope of the reform program. With respect to tax reform, the simulation results also imply that increasing in the consumption tax would be less beneficial and desirable than broaden the direct tax base.

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