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**ECONOMIC IMPLICATIONS OF AN AGING POPULATION:
THE CASE OF FIVE ASIAN ECONOMIES**

by

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Abstract

This paper constructs a stylized general equilibrium overlapping generations model in which child-rearing costs are modeled explicitly to evaluate quantitatively the effects of a demographic transition in five Asian economies: Japan, China, Korea, Taiwan, and Singapore. The model looks at two key points: (i) how both aggregate variables and inter-generational welfare are affected, and (ii) the extent to which the policy reform reduces the negative effects it gives rise to. With this in mind, we simulate for two scenarios: a benchmark scenario and a policy change scenario. The simulation results indicate that population aging could have a major impact on savings rate, factor prices, and economic welfare. Especially important is the conclusion that population aging will lead to the end of Asia's high economic growth rates. But our simulation results also indicate that policy reform could reduce the negative effects.

JEL classification: C68; E27; H55; J11

Keywords: aging; policy reform; overlapping generations; Asian economy

1. Introduction

Due to a reduction in fertility rates and an increase in life expectancy, many regions of the world are now in the middle of significant demographic transitions. Though the populations of most of the developed countries have been aging for a long time, Asian countries have just recently experienced a dramatic fall in fertility rates. For example, China has seen a sharp decline in fertility over the past three decades, due to rising incomes and the coercive family planning government policies taken in the late 1970s.

Generally speaking, demographic changes have many economic effects. Bloom and Williamson (1997) calculate that demographic dynamics between 1965 and 1990 can explain between 1.4 percent and 1.9 percent of annual per capita economic growth in Asia, or as much as a third of its "growth miracle." They evaluate the relative contribution of labor force and capital input to be respectively one third and two thirds of the total demographic impacts. If this is true, population aging in these economies will lead to sharp declines in economic growth.

From the simulation results (by the Auerbach and Kotlikoff (1987) type general equilibrium overlapping generations model) of some early studies on the effects of population aging, the balance between capital and labor will be changed. Labor supply will be scarce whereas capital will be relatively abundant. This will drive up wages relative to the rate of return on capital, reducing household incentives to save (if, of course, the interest elasticity of saving is positive). In addition, some fraction of the capital stock may become obsolete due to the shrinking labor force and diminishing returns to scale, making the accumulation of capital even less attractive.

Whereas various economic and social consequences of aging have been investigated in advanced countries, very few analyses have explicitly been studied in Asian economies such as China, Korea, and Taiwan.

As such, this is, to our knowledge, the first study to employ an overlapping generations simulation framework in the context of population aging in Asian economies.

In this paper we contribute to the debate on the economic impact of the demographic transition in Asian economies in the following way. We rigorously quantify the effect that demographic changes in general equilibrium have on factor price, output, and on the welfare of the various generations. Moreover,

we consider the cost of childrearing to quantify the magnitude of not only the cost of population aging but also the benefits from the declining birthrate happening in many Asian countries. In doing so, we obtain a richer and more robust analysis of the macroeconomic consequences of demographic changes. For this purpose, we use a very stylized overlapping generations model with a childrearing cost. To focus on the main point we want to stress, we keep the model very simple. In particular, we do not consider uncertainty inclusive of longevity. We only have one type of asset, namely capital stock, as a means of transferring resources over time. And we have no monetary variables such as prices.

The rest of this paper is structured as follows. Section 2 presents some facts about the current and projected demographic trends in selected five Asian economies. In section 3, we present a stylized overlapping generations model that can be used to evaluate those effects quantitatively. In Section 4, we first explain how we parameterize and calibrate our model, and then we present the benchmark simulation results and a policy change scenario. Section 5 concludes.

2. Population Aging in Five Asian Economies: Some Basic Facts

At the beginning of 2003, the world had 6.3 billion people. While the world population has constantly grown, its annual growth rate has decreased from 2.04 percent during the period from 1965 to 1970 to 1.35 percent between 1995 and 2000. It is expected that the growth rate is projected to decrease to 0.33 percent by 2050. By then, the world's population will have increased to 8.9 billion, according to the medium variant of the United Nations' current world population projections (United Nations (2003)).

The so-called demographic transition, characterized by falling mortality rates followed by a decline in birthrates, leads to population aging. Though the patterns of population aging are similar in most countries, its speed differs. The standout feature of aging in Asian economies is that its speed is extremely fast. Let's compare the number of years that it takes the elderly population ratio—defined as the number of individuals aged 65 and over divided by the entire population—to increase from 7 percent to 14 percent: 115 years in France, 85 years in Sweden, 40 in Germany, 47 in the U.K. Japan's is just 24

years. Other Asian economies are even more dramatic: 30 years in China, 19 years in Korea, 20 in Singapore, 30 in Thailand, and 27 years in Taiwan, the speed of population aging in Korea and Singapore is much faster than that of Japan's historical experience.

We now review the dynamics of the population structure of the five Asian economies of Japan, China, Korea, Taiwan, and Singapore.

(1) Japan

The proportion of people aged under 15, according to the medium variant projection, is expected to shrink from the current 14.6 percent level (2000) to 10.8 percent in 2050. The population of the working-age group (aged 15 to 64), according to the medium variant projection, started falling in 2000 at 68.1 percent, and is expected to eventually fall even further, to 53.6 percent in 2050. The percentage of those aged 65 and over, 17.4 percent in 2000, will continue to increase: it will go as high as 35.7 percent in 2050. In Japan, one in 2.8 persons will be over 65 in 2050. The population dependency ratio is used as an index to express the level of support of the working-age group, through comparison of the relative size of child and elderly populations versus the population of the working-age group. The old-age dependency ratio (calculated by dividing the elderly population by the population of the working-age group) based on the medium variant projection increases from the current 26 percent to 67 percent in 2050. In contrast, the child dependency ratio (calculated by dividing the child population by the population of the working-age group) is expected to undergo a trend from the current 21 percent to a level of 19 to 21 percent in the future.

(2) China

The proportion of people under age 15, according to the medium variant projection, is expected to shrink from the current 24.8 percent level (2000) down to 16.3 percent in 2050. The population of the working-age group (ages 15 to 64), according to the medium variant projection, started falling in 2000 at 68.3 percent, and is expected to drop to 61 percent in 2050. The percentage of those age 65 and over, 6.9 percent in 2000, will continue to increase, up to 22.7 percent in 2050. In China, 1 in 4.4 persons will be over 65 in 2050. The population dependency ratio is used as an index to express the level of support for the working-age group, through comparison of the relative

size of the child and elderly populations versus the population of the working-age group. The old-age dependency ratio (calculated by dividing the elderly population by the population of the working-age group) based on the medium variant projection will increase from the current 10 percent to 37 percent in 2050. In contrast, the child dependency ratio (calculated by dividing the child population by the population of the working-age group) is expected to drop from the current 36.4 percent to 26.7 percent in the future.

(3) Korea

The proportion of people under 15, according to the medium variant projection, is expected to shrink from the current 20.8 percent level (2000) down to 16.5 percent in 2050. The population of the working-age group (ages 15 to 64), according to the medium variant projection, started falling in 2000 at 72.1 percent, and is expected to drop to 56.1 percent in 2050. The percentage of those age 65 and over, 7.1 percent in 2000, will continue to increase, up to 27.4 percent in 2050. In Korea, 1 in 3.6 persons will be over 65 in 2050. The population dependency ratio is used as an index to express the level of support of the working-age group, through comparison of the relative size of the child and elderly populations versus the population of the working-age group. The old-age dependency ratio (calculated by dividing the elderly population by the population of the working-age group) based on the medium variant projection, will increase from the current 9.8 percent to 48.8 percent in 2050. In contrast, the child dependency ratio (calculated by dividing the child population by the population of the working-age group) is expected to decrease from the current 28.9 percent to 23 percent around the latter half of 2010s, and up to 29 percent in 2050.

(4) Taiwan

The proportion of people under 15, according to the medium variant projection, is expected to shrink from the current 21.1 percent (2000) to 13.0 percent in 2050. The population of the working-age group (ages 15 to 64), according to the medium variant projection, started falling in 2000 at 70.3 percent, and is expected to drop to 57.3 percent in 2050. The percentage of those age 65 and over, 8.6 percent in 2000, will continue to increase, up to 29.8 percent in 2050. In Taiwan, 1 in 3.4 persons will be over 65 in 2050. The population dependency ratio is used as an index to express the level of

support of the working-age group, through comparison of the relative size of the child and elderly populations versus the population of the working-age group. The old-age dependency ratio (calculated by dividing the elderly population by the population of the working-age group) based on the medium variant projection increases from the current 12.3 percent eventually up to 52.0 percent in 2050. In contrast, the child dependency ratio (calculated by dividing the child population by the population of the working-age group) is expected to decrease from the current 30 percent to 22 percent in the future.

(5) Singapore

The proportion of people under 15, according to the medium variant projection, is expected to shrink from the current 21.9 percent (2000) to 13.9 percent in 2050. The population of the working-age group (ages 15 to 64), according to the medium variant projection, started falling in 2000 at 70.9 percent, and is expected to drop to 57.5 percent in 2050. The percentage of those age 65 and over, 7.2 percent in 2000, will continue to increase, up to 28.6 percent in 2050. In Singapore, 1 in 3.5 persons will be over 65 in 2050. The population dependency ratio is used as an index to express the level of support of the working-age group, through comparison of the relative size of the child and elderly populations versus the population of the working-age group. The old-age dependency ratio (calculated by dividing the elderly population by the population of the working-age group) based on the medium variant projection, will increase from the current 10.2 percent to 49.8 percent in 2050. In contrast, the child dependency ratio (calculated by dividing the child population by the population of the working-age group) is expected to drop from the current 30.8 percent to 24 percent in the future.

3. A Stylized Overlapping Generations Model

In this section, we present a dynamic, stylized overlapping generations model that allows us to analyze the effects of population aging, and the effects of a shift from a pay-as-you-go system to a fully funded pension system. The model is based on a version of the overlapping generations model introduced by Auerbach and Kotlikoff (1987). To investigate the effects of population aging and a policy reform, general equilibrium models with overlapping

generations have been used, since they take into account the interaction of decisions of households, firms, and the government.

Since the purpose of this paper is to study the macroeconomic effects of population aging and of fundamental policy reform, we restrict the analysis to a very stylized version of the standard overlapping generations model that excludes many interesting aspects. The most significant simplifications of our model relative to existing overlapping generations models are as follows. (i) We do not include labor supply in the household decision problem, but rather assume that all households supply one unit of labor until retirement inelastically. (ii) We do not model intra-generational household heterogeneity and therefore cannot capture distributional effects. (iii) We assume perfect foresight. (iv) We do not endogenize human capital and therefore cannot account for endogenous growth. (v) We model the public pension system of each economy in a very simplified way: each is modeled as a pay-as-you-go pension system.

We believe that our stylized model is sufficient to obtain the first-order effects of population aging on the economy despite our simplifications.

Concretely, in this section, we present the OLG simulation model, which consists of four sectors: households, firms, government, and public pensions. There is a representative individual for each generation in the households sector. Each individual at age 21 maximizes his/her intertemporal utility function with consumption. The representative firm maximizes its profits under the production function. The model is a one-country closed model, where not only the goods market but also factor markets are perfectly competitive. Details of each sector follow.

3.1 Household Sector

The overlapping generations in our model is based on the life cycle theory of consumptions/savings behavior. We consider an economy in which every person lives for a fixed number of periods. Our model is populated by households whose inhabitants live up to age 80. Consequently, we distinguish up to 80 generations within each period t . The individual life-cycle of a representative agent is described in Figure 1. Between ages 0 and 20 our agents are considered children, who earn no money and who are supported by their parents. At age 21 our agents leave their parents and start working. Over a given sub-period of their adult life - between 25 and 44 -, adults are

supposed to give birth to children, according to a time distribution that tries to mimic the actual time pattern of births in each economy. Children are dependent on their parents until they turn 20, with a cost per child that is supposed to be proportional to the parents' consumption - functioning like a "consumption tax" - and exogenous¹. Our agents retire at age 64 (44th period), are granted a pension at age 65 (45th period), and die at age 80 (60th period). These are rational, forward-looking agents. His/her utility function may be specified thus²:

$$U_i = \sum_{j=1}^{60} \left(\frac{1}{1+\rho} \right)^{j-1} \frac{[c_{i,j}]^{1-\gamma}}{1-\gamma} \quad (1)$$

where i refers to the i th generation, j refers to the j th period of life, ρ is the pure rate of time preference, and γ is the reverse of the elasticity of intertemporal substitution. The arguments of the utility function are the consumption per period ($c_{i,j}$). His/her intertemporal budget equation may be described as follows:

$$\begin{aligned} \sum_{j=1}^{ret} PDV_{i,j} (1 - \tau w_t - \tau p_t) w_t (1 + \lambda)^t e_j + \sum_{j=ret}^{60} PDV_{i,j} p_{i,j} \\ = \sum_{j=1}^{60} PDV_{i,j} (1 + \tau c_t + \tau c c_{i,j}) c_{i,j} \end{aligned} \quad (2)$$

$$\begin{cases} \tau c c_j = \text{const.} & \text{if } 5 \leq j \leq 24 \\ \tau c c_j = 0 & \text{if } 1 \leq j \leq 4, j \leq 25 \end{cases} \quad (3)$$

where PDV refers to the factor of the present discounted value, w_t is the wage rate at time t , e_j is the wage profile i at age j , λ measures the rate of technical progress, τw_t is the labor income tax rate at time t , τp_t is the public pension contribution rate at time t , τc_t is the consumption tax rate at time t , ret is the retirement age, and $p_{i,j}$ stands for pension benefit of generation i at age j . And $\tau c c_t$ takes into account the direct and indirect costs of child-rearing at time t . Each generation maximizes his/her utility function (Equation (1)) under a budget constraint (Equation (2)).

¹ By incorporating the child-rearing cost and the cost of elderly people in a single framework - integrating the effects of rising elderly ratios and public pension system pressures with falling youth ratios and the implications for adult support of child consumption - we obtain a richer and more robust analysis of the macroeconomic consequences of demographic shifts.

² The value of key parameters is listed in the Table 1.

With the maximization procedure, the following Euler equations can be solved, concerning consumption per period.

$$C_{i,j} = \left\{ \frac{1+r_t(1-\tau r_t)}{1+\rho} \right\}^{\frac{1}{\nu}} \left\{ \frac{1+\tau C_{t-1} + \tau C C_{t-1}}{1+\tau C_t + \tau C C_t} \right\}^{\frac{1}{\nu}} C_{i,j-1} \quad (3)$$

$$C_t^A = \sum_{j=1}^{60} N_{t,j} C_{i,j}, \quad C_t^C = \tau C C_t \times C_t^A$$

where $N_{t,j}$ measures the number of the adult people of age j at period t , C_t^A is the aggregated consumption of adults at time t , and C_t^C is the aggregated consumption of child at time t .

We can also obtain the following physical wealth accumulation equation with the maximization procedure:

$$a_{i,j} = a_{i,j-1} \{1+r_t(1-\tau r_t)\} + (1-\tau w_t - \tau p_t) w_t (1+\lambda)^t e_{i,j} - (1+\tau C_t + \tau C C_t) c_{i,j} \quad (4)$$

$$PA_t = \sum_{j=1}^{60} N_{t,j} a_{i,j}$$

where $a_{i,j}$ is physical wealth asset of generation i at age j , r_t is the interest rate at time t , τr_t is the tax rate on interest income at time t , and PA_t is the aggregated private asset at period t .

3.2 Firm Behavior

The input/output structure is represented by the Cobb-Douglas production function with constant return to scale. The firm decides the demand for physical capital (K) and effective labor (L_e) to maximize its profit with the given factor prices of wages and rent, which are determined in perfect competitive markets.

$$Y_t = AK_t^a L_{e,t}^{1-a} \quad (5)$$

$$K_t = I_t + (1-\delta)K_{t-1} \quad (6)$$

$$r_t = aAK_t^{a-1} L_{e,t}^{1-a} - \delta, \quad w_t = (1-a)AK_t^a L_{e,t}^{-a} \quad (7)$$

where Y is output, a stands for capital income share, A is a scale parameter, δ is the depreciation of physical capital, K is the physical capital stock, and L_e is the effective labor.

3.3 Government

The government sector has three types of taxes: wage taxes, consumption taxes, and capital taxes. In our model, we omit public debt for simplicity and because of lack of data from Asian economies other than Japan. It pays consumption and investment as expenditures.

Consequently, the government decides tax rates according to temporal budget constraints to balance for each period. The budget constraint in each period is

$$G_t = T_t \quad (8)$$

where G_t stands for government expenditure at time t , T_t denotes tax revenue at time t .

3.4 Public Pension

Though the current public pension system of each economy is very diverse, we model it as a pay-as-you go pension system for tractability. The pension sector grants a pension to the retired generations while pension contributions are collected from the working generations.

$$B_t = \sum_{j=1}^{ret} N_{i,j} \tau p_t w_t (1+\lambda)^t e_{i,j} \quad (9)$$

where B stands for the aggregated pension contribution. The aggregated pension at time t is given by the product of the population of retirement age, replacement rate, and wage.

$$P_t = \sum_{j=ret}^{60} N_{i,j} \beta \sum_{j=1}^{ret} w_t (1+\lambda)^t e_{i,j} \quad (10)$$

where p is the pension, β denotes replacement rate, ret stands for retirement age, and P is the aggregated pension benefit.

In our model, we calculate the time path of the pension contribution rate (τp) endogenously to keep within the budget constraint (11).

$$B_t = P_t \quad (11)$$

We do not explicitly model the funded component of the pension system. In our model, consequently, the funded component consists entirely of voluntary, private savings.

3.5 Equilibrium Condition

To close the model structure, the following two market-equilibrium conditions must hold. The first condition is equilibrium in the financial market.

$$K_t = PA_t \quad (12)$$

The second condition is the equilibrium in the goods market.

$$Y_t = C_t^A + C_t^C + G_t + I_t \quad (13)$$

In the model simulation, private investment (I) is determined by using this equilibrium condition.

4. Simulation Results

4.1. Calibrating the Model

In this section, we first describe the choice of demographics, preferences, production function parameters, fiscal parameters, and pension parameters. For each economy, the parameters are adjusted in order so that simulated aggregated variables are realistic. The targeted variable is aggregate savings rate. The benchmark values of the main parameters of the model are presented in Table 1. We now review the choice of parameters.

(a) Demographics

The model is calibrated with the demographic projections estimated by the UN, as revised in 2002 for Japan, China, Korea, and Singapore until 2050. For Taiwan, we use the data estimated by the Council for Economic Planning and Development (CEPD) Manpower Planning Department (2002) until 2050. We have chosen the medium fertility scenario. But because we also need the evolution of population well after 2050, birth rates are fixed at replacement levels after 2050 so that population growth will stabilize in the long run.

(b) Preferences

For each of the five economies, the intertemporal elasticity of substitution (γ) in the utility function is set equal to 0.50. The rate of time preference (ρ) is chosen such that the calculations of the model match the empirical data of each economy's aggregate savings rate.

(c) Production Parameters

We set the capital income share coefficient equal to 0.25. This value is based on Japanese data estimated by Kato (2003). The rate of technical progress is set at 0.02. We model age-specific labor productivity by assuming a

hump-shaped age-earnings profile, i.e., the quadratic equation used by Miles (1999) ($e_{age} = a_0 \times age - a_1 \times age^2$ ($a_0, a_1 > 0$))³. The rate of depreciation of capital stock is 5 percent.

(d) Fiscal Parameters

For simplicity, government expenditures to GDP ratio are assumed to remain constant at year 2003 levels in each economy. In the model, any pressure on the government budget constraint is endogenously compensated by a change in the wage income tax rate to satisfy the government temporal budget constraint. The other tax rates (consumption and capital income) are set to equal to 5 percent and 20 percent respectively in each economy. These are exogenously constant.

(e) Public Pension Parameters

As already emphasized, the public pension sector in each economy is reduced to a pay-as-you go pension system, with a permanently balanced budget. The replacement rate, i.e., the ratio of average pensions to the average net-of-tax wage earned by the same individuals when employed is set to equal to 50 percent in Japan, and 20 percent in other economies, which is the same level as China's. In the model, any shocks on the current pension benefits are endogenously financed by an increase in the contribution rate.

By starting with actual fiscal, economic, and demographic realities, the model generates a much more realistic time-path of the variables, including population age structure, elderly dependency ratio, and capital deepening. The calibration results are provided in Table 3.

4.2. Simulation Analysis

We present estimates of the macroeconomic effects of aging, based on the stylized overlapping generations model with child-rearing cost described in the previous section. First, we describe the baseline simulation results on the main economic variables, which appear to be appropriate to capture the impacts of aging. We then present the results of a policy change scenario on them.

Since the model is simulated over 500 periods, we consider a sufficiently long

³ Each economy's earning profile is reported in Table 2.

period for a steady-state to be achieved. We report our analysis mostly on the period 2003-2050, which corresponds to the demographic projection of the UN.

The calibration of dynamic computable general equilibrium models usually assumes a steady state for the simulation starting year. However, since many economies including Japan have been experiencing terrible demographic changes up to now, it is very difficult to approximate the economy in 2003 in a steady state. So we begin simulations from non-steady-state initial conditions, which are based on 2003. Therefore, we assume that the economy in 2003 was not in a steady state, but was on the transition pass to a steady state in the long run.

4.3. Simulation Results⁴

The simulation results describing the macroeconomic impacts of aging are summarized in Figures 2 to 5. We present the results for economic growth rate, wage income tax rate, pension contribution rate, national savings rate, interest rate, and economic welfare measured by discounted lifetime utility of individual cohorts.

Baseline Scenario

First, we see the change in the population structure in the model. Figures 2 and 3 show the difference between the child dependency ratio and the old age dependency ratio calibrated in the model and the one from the original UN projection. As can be seen from the figures, we succeeded in approximating the projected demographic shock.

Next, we see the baseline simulation results. Figures 4(a) to 4(e) give the results for each economy. During the demographic transition, the effective wage income tax rate increases to maintain a temporal government budget constraint in all economies. The pension contribution rate also increases sharply, by the range of 50 percent to 100 percent from its 2003 level in 2050, to finance increased benefits.

Population aging puts downward pressure on national savings under the life cycle hypothesis. As mentioned above, the life-cycle theory of

⁴ Detailed data of simulation results of each economy are available from the author upon request.

consumptions/savings behavior is a key assumption of the model. According to our results, the national savings rate falls between 2003 and 2050 in all economies. In Korea, the quite rapid drop in the savings rate reflects the speed of population aging.

Aging also leads to a reduction in the growth rate of the labor force and capital stock (due to the reduction of savings rate). However, since the labor force is more negatively affected by the demographic shock than is the capital stock, the capital deepening progresses; this puts downward pressure on the real return to physical capital in all economies by the range of 1.2 basis points to 3.2 basis points between 2003 and 2050, and upward pressure on real wage rates. Thus a reduction in the growth rates of the labor force and capital stock leads to a fall in the aggregated economic growth rate. In China, the growth rate drops dramatically, from 9 percent in 2002 to 3 percent in 2050.

As the demographic shock leads to an increase in tax and pension burdens, the economic welfare of individual cohorts decreases sharply.

4.4. Policy Change Scenario

To study the impacts of the policy change against aging, we simulate a policy change scenario. We assume that policy change will be executed in 2005. Of course, we chose this year quite arbitrarily. The policy change that we consider is pension reform. We suppose that the pay-as-you-go public pension system will be entirely abolished in 2005. Agents in the model thus rely solely on private savings to support their lives post-retirement. Figures 5 (a) to 5 (e) represent the effect on the main economic variables mentioned above in terms of deviations from the baseline results. We, in turn, now see the simulation results.

The first effect of pension reform is to increase the present value of future net income. This net increase of it, in turn, has effects on increased savings rate. Thus increases in physical capital stock caused by the rise in savings make economic growth rate accelerate and rise temporary compared with the baseline scenario. As far as the interest rate is concerned, the long-run effect is negative as physical capital stock increases. Moreover, pension reform reduces the burden and increases net income. Lifetime utility level is improved, though the welfare of the cohorts who are adversely affected by the reform drops.

5. Conclusion

Aging in Asian economies is expected to progress dramatically through the 21st century. In this paper, we study the question of whether 1) aging, and 2) policy reform to cope with aging will have any quantitative impact on the Asian economies. We have developed a stylized computable overlapping generations model that explicitly incorporates child-rearing costs.

We have thus computed responses to the following two scenarios: a baseline scenario, in which economic/fiscal/public pension situations in 2003 are maintained into the future (scenario 1); and a change from the pay-as-you-go pension scheme to a fully funded pension scheme (scenario 2) in using this stylized OLG model.

We conclude that the main results of these scenarios are twofold: (1) aging decreases economic growth rates and lowers economic welfare; and (2) policy change -fundamental pension reform- re-boosts economic growth and improves economic welfare of future generations. From these results, we believe that it is important to manage policy that puts emphasis on and gives priority to the rise of the savings rate to cope with aging population, to avoid the negative impacts potentially inherent in aging, and to maintain positive sustained growth.

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Table 1 Values of Key Parameters and Exogenous Variables

		Japan	China	Korea	Taiwan	Singapore
Capital income share	a	0.25	0.25	0.25	0.25	0.25
Intertemporal elast. of subst.	$1/\gamma$	2.0	2.0	2.0	2.0	2.0
Pure rate of time preference	ρ	0.0017	0.0012	0.0015	0.0026	0.0031
Replacement ratio	β	0.50	0.20	0.20	0.20	0.20
Physical capital depreciation	δ	0.05	0.05	0.05	0.05	0.05
Gov. exp. to GDP ratio	g	16.5	11.4	12.2	11.6	11.6
Consumption tax rate	τ_c	0.05	0.05	0.05	0.05	0.05
Interest tax rate	τ_r	0.20	0.20	0.20	0.20	0.20
Rate of technical progress	λ	0.02	0.02	0.02	0.02	0.02
Retirement age	ret	65	60	60	60	62

Table 2 Earning Profiles

Japan	$e_{age} = 0.167 \times age - 0.00194 \times age^2$
China	$e_{age} = 0.273 \times age - 0.00279 \times age^2$
Korea	$e_{age} = 0.083 \times age - 0.00101 \times age^2$
Taiwan*	$e_{age} = 0.083 \times age - 0.00101 \times age^2$
Singapore	$e_{age} = 0.111 \times age - 0.00104 \times age^2$

Note: Because we lack data for Taiwan, we use Korea's wage profile as a substitute for it.

Table 3 Calibration Results

	Japan		China		Korea		Taiwan		Singapore	
	Official	Model	Official	Model	Official	Model	Official	Model	Official	Model
Savings rate	25.5	25.7	34.9	34.2	29.2	29.5	16.9	17.1	14.1	14.0
economic growth rate	2.7	2.8	9.1	9.3	3.1	3.4	3.2	3.3	5.9	5.7
interest rate	1.2	1.6	5.3	5.3	6.2	6.5	3.3	3.5	5.4	5.8

Note: China's data is from CY2002. Data for all other economies comes from CY2003.

Figure 1 The Individual Life-cycle

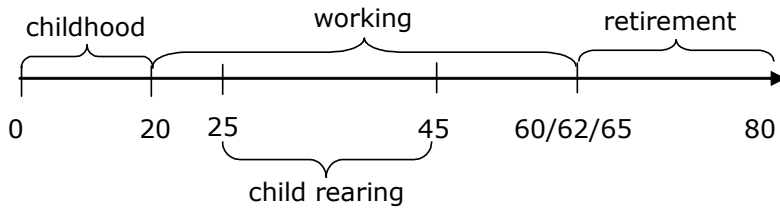
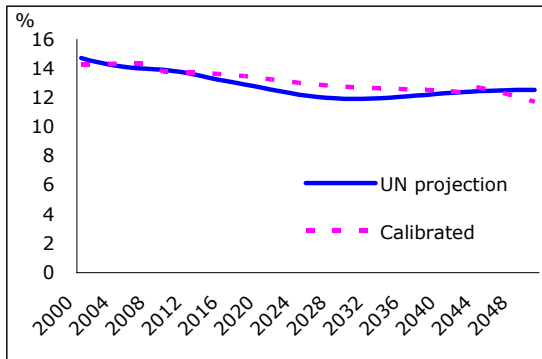
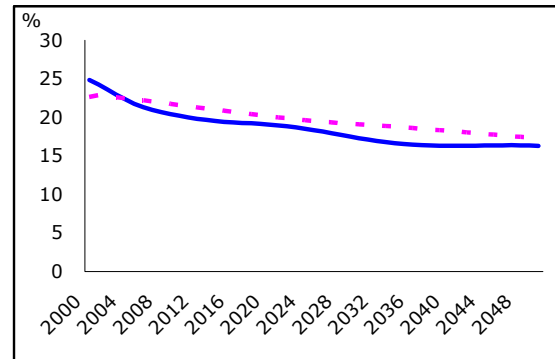


Figure 2 Youth Dependency Ratio

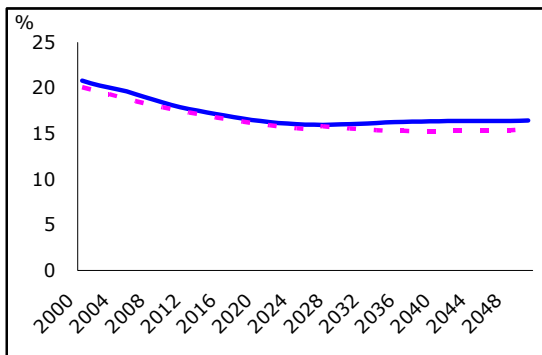
(1) Japan



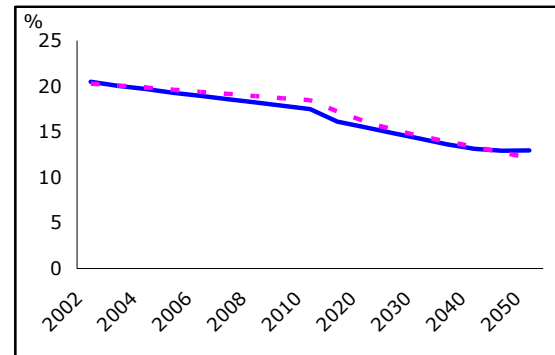
(2) China



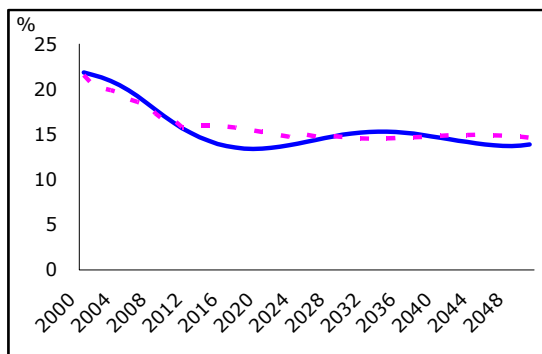
(3) Korea



(4) Taiwan



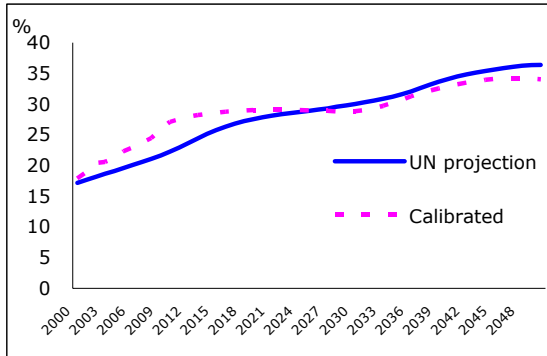
(5) Singapore



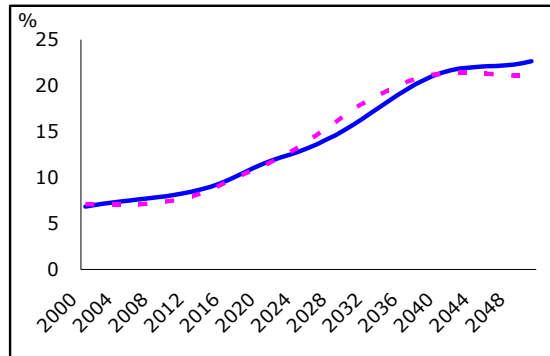
Sources: UN (2003) and author's calculation

Figure 3 Old Age Dependency Ratio

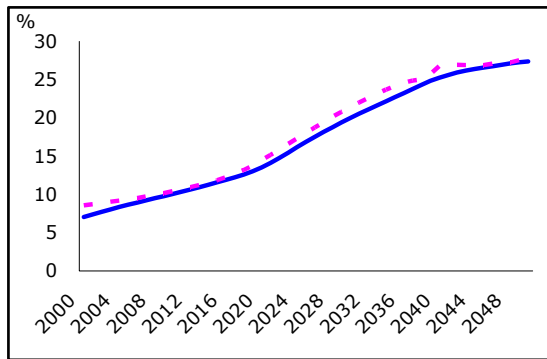
(1) Japan



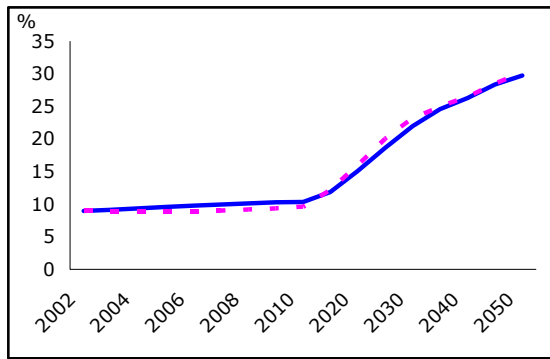
(2) China



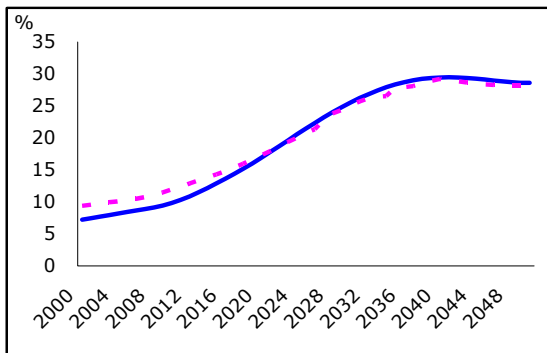
(3) Korea



(4) Taiwan



(5) Singapore

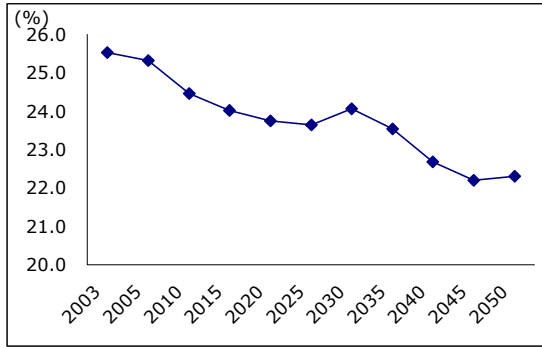


Sources: UN (2003) and author's calculations.

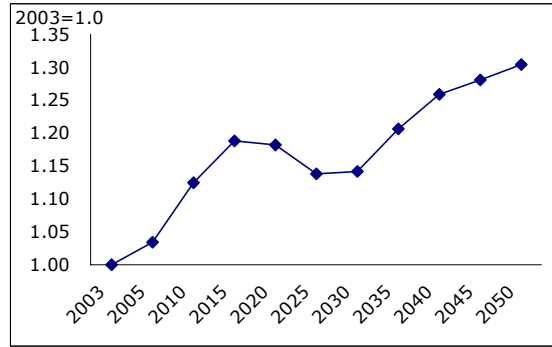
Figure 4 Benchmark Simulation Results

(a) Japan

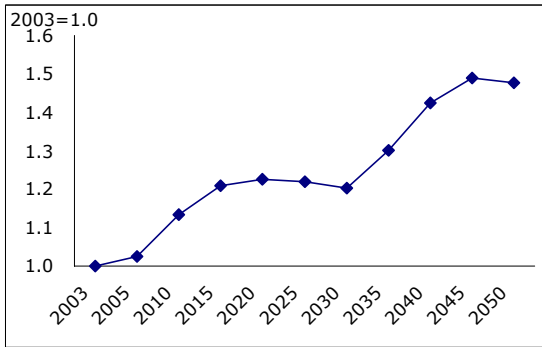
(1) Saving rate



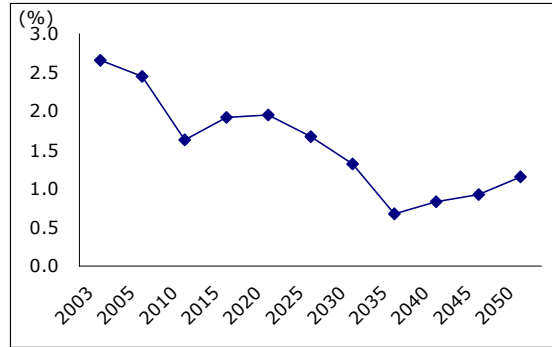
(2) Wage income tax rate(Index)



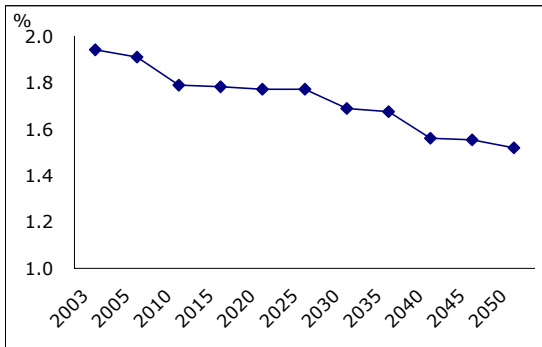
(3) Pension contribution rate(Index)



(4) Economic growth rate



(5) Rate of return on capital



(6) Economic welfare of individual cohorts

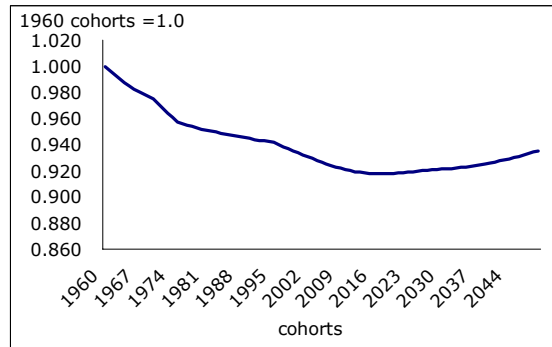
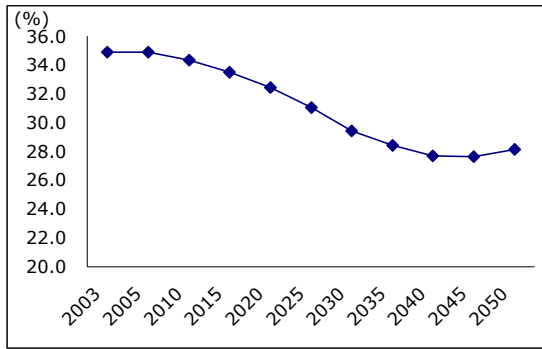


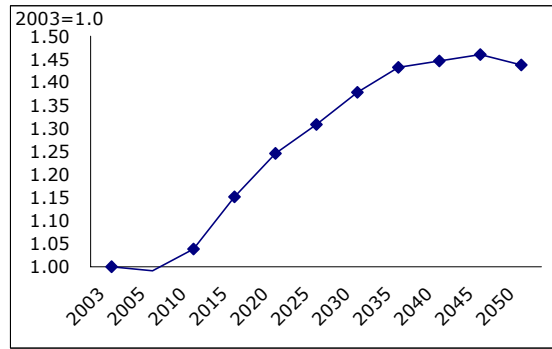
Figure 4 Benchmark Simulation Results

(b) China

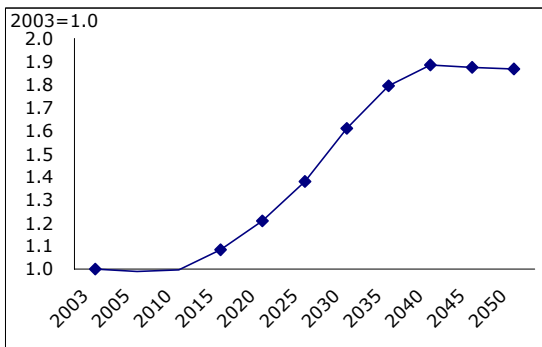
(1) Saving rate



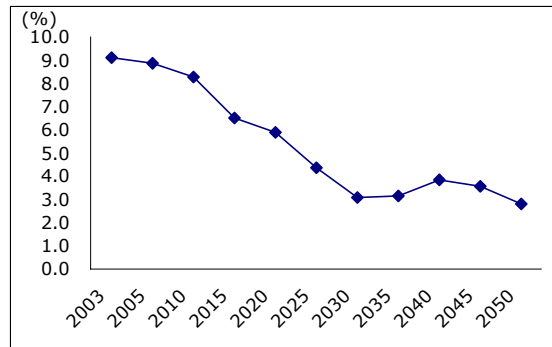
(2) Wage income tax rate(Index)



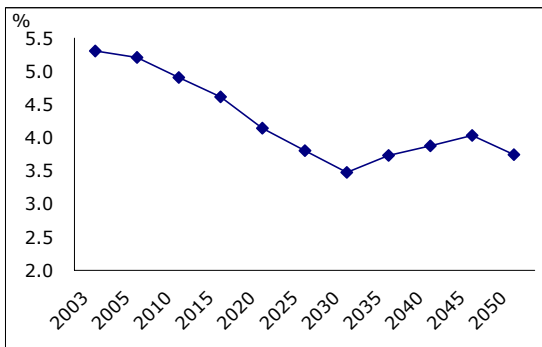
(3) Pension contribution rate(Index)



(4) Economic growth rate



(5) Rate of return on capital



(6) Economic welfare of individual cohorts

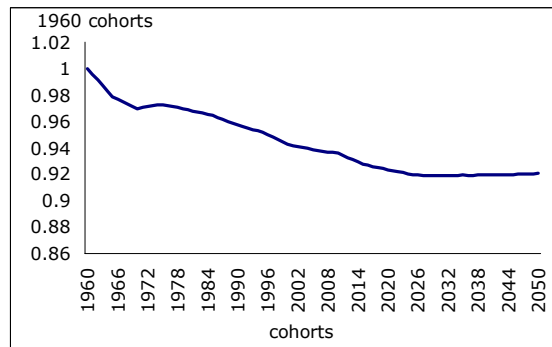
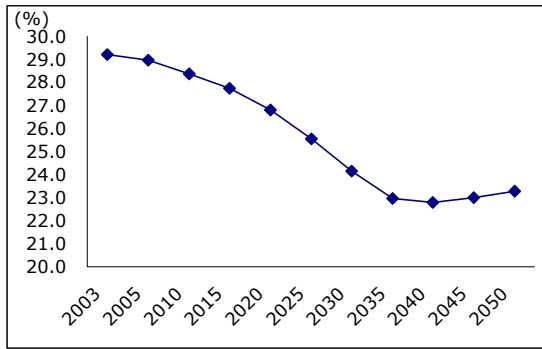


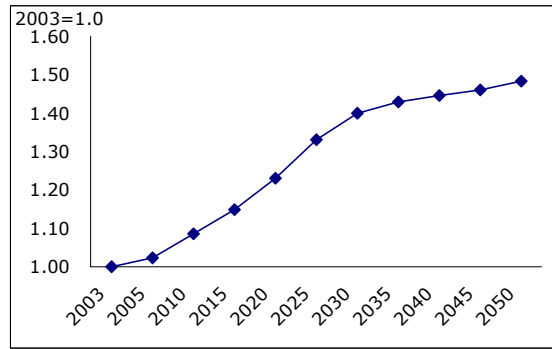
Figure 4 Benchmark Simulation Results

(c) Korea

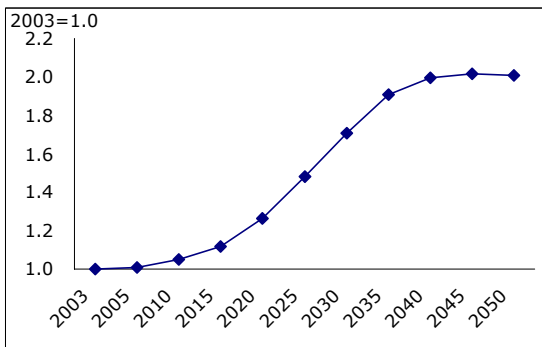
(1) Saving rate



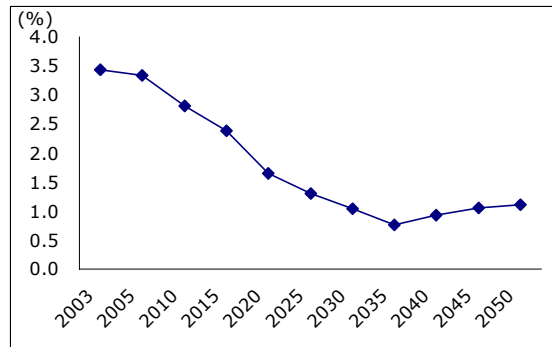
(2) Wage income tax rate(Index)



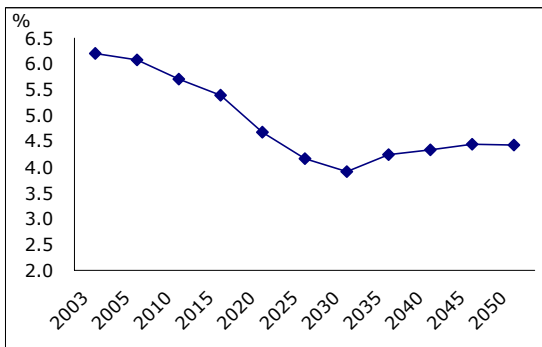
(3) Pension contribution rate(Index)



(4) Economic growth rate



(5) Rate of return on capital



(6) Economic welfare of individual cohorts

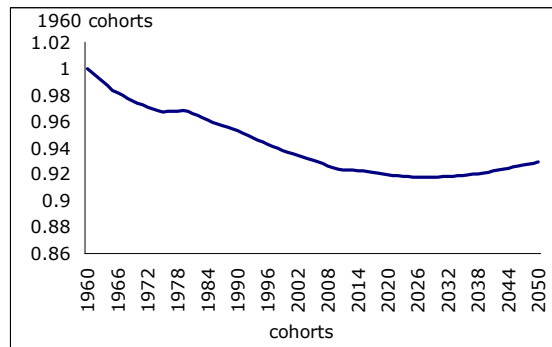
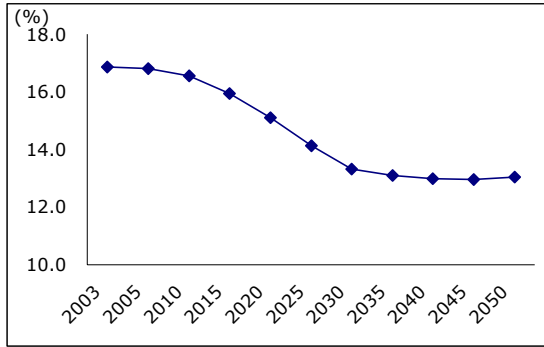


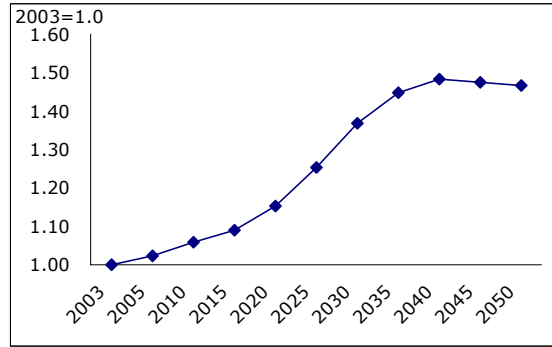
Figure 4 Benchmark Simulation Results

(d) Taiwan

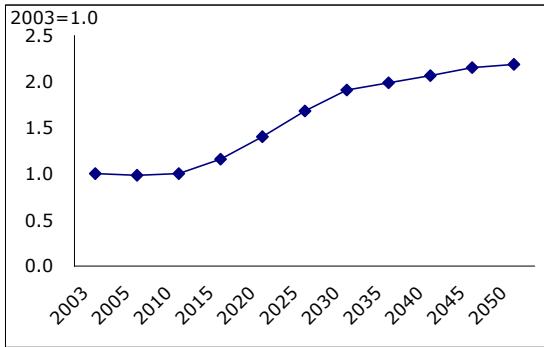
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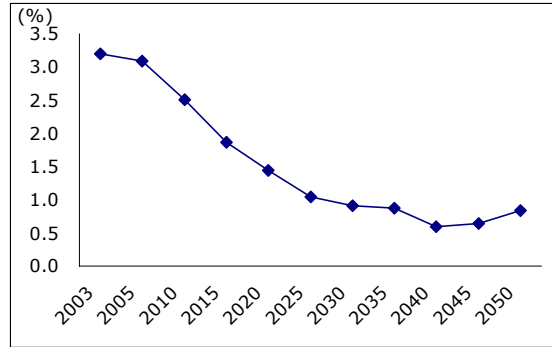
(2) Wage income tax rate(Index)



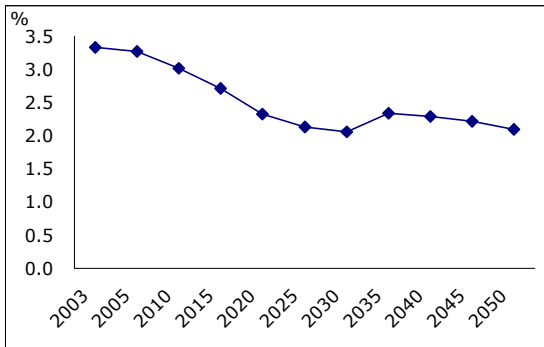
(3) Pension contribution rate(Index)



(4) Economic growth rate



(5) Rate of return on capital



(6) Economic welfare of individual cohorts

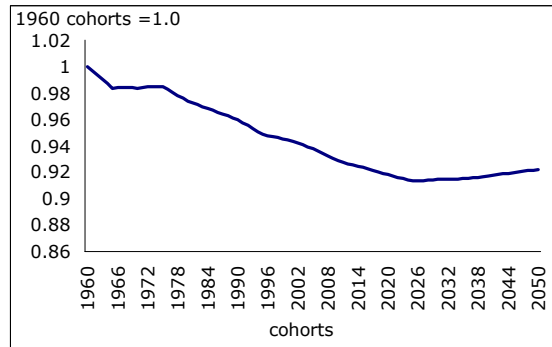
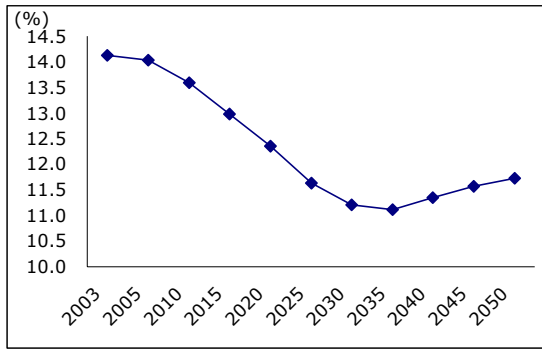


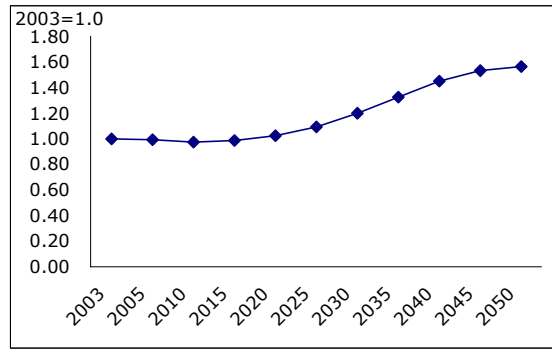
Figure 4 Benchmark Simulation Results

(e) Singapore

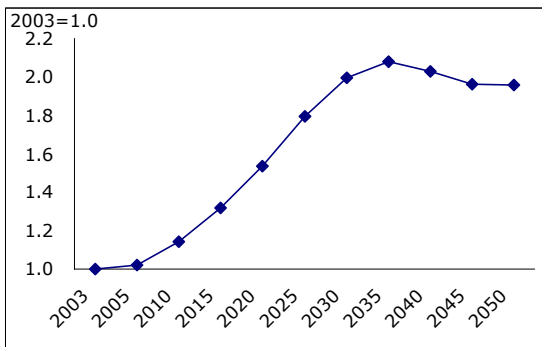
(1) Saving rate



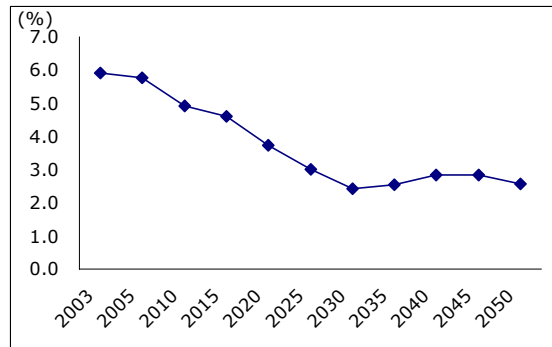
(2) Wage income tax rate(Index)



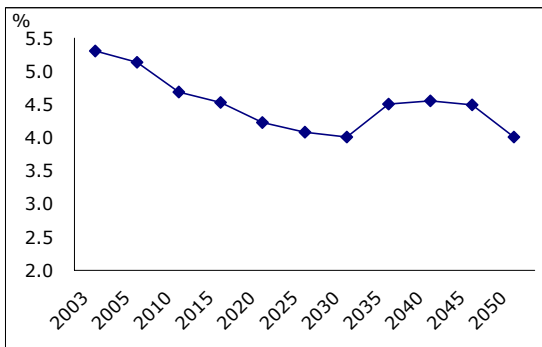
(3) Pension contribution rate(Index)



(4) Economic growth rate



(5) Rate of return on capital



(6) Economic welfare of individual cohorts

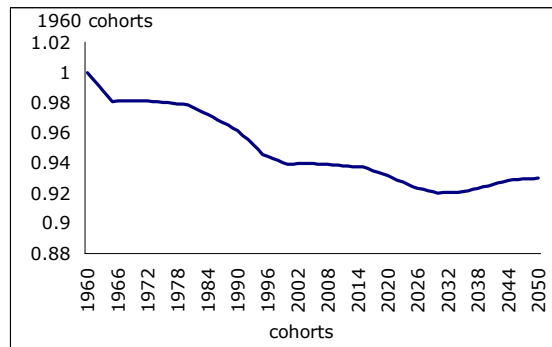
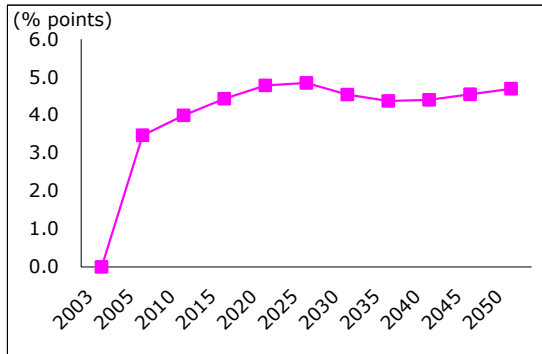


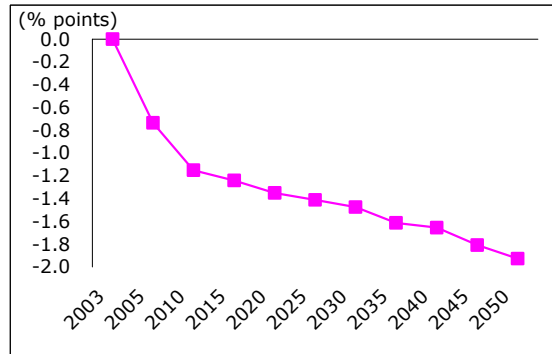
Figure 5 Policy Reform Simulation Results (deviation from benchmark simulation)

(a) Japan

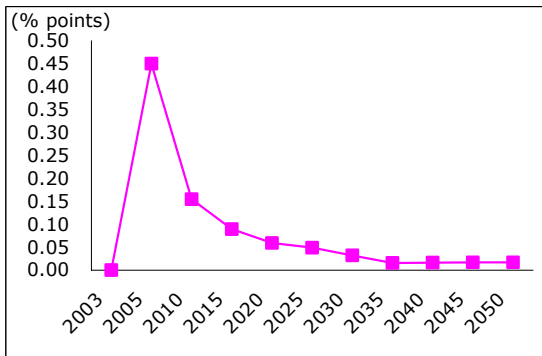
(1) Saving rate



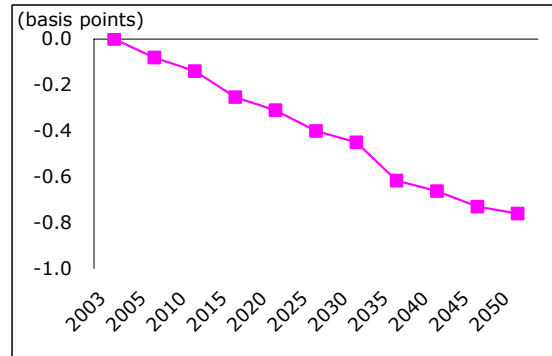
(2) Wage income tax rate(Index)



(3) Economic growth rate



(4) Rate of return on capital



(5) Economic welfare of individual cohorts

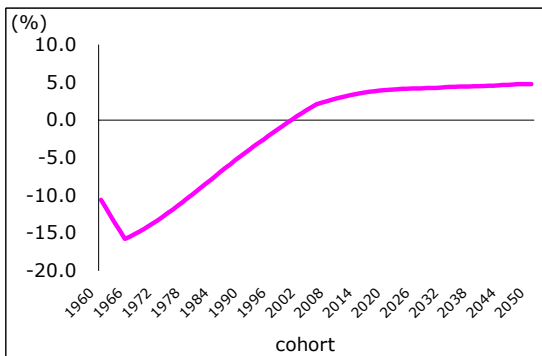
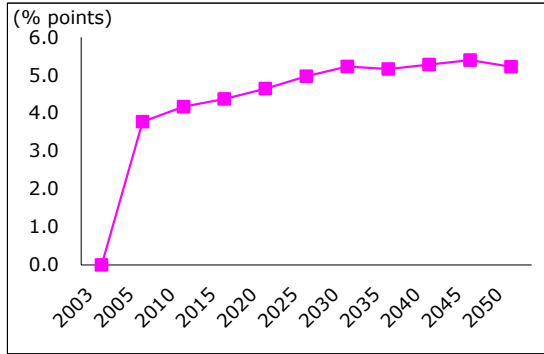


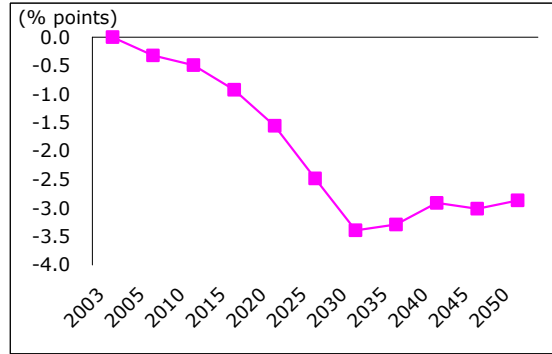
Figure 5 Policy Reform Simulation Results (deviation from benchmark simulation)

(b) China

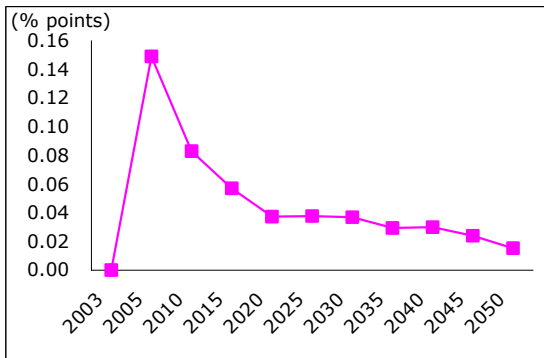
(1) Saving rate



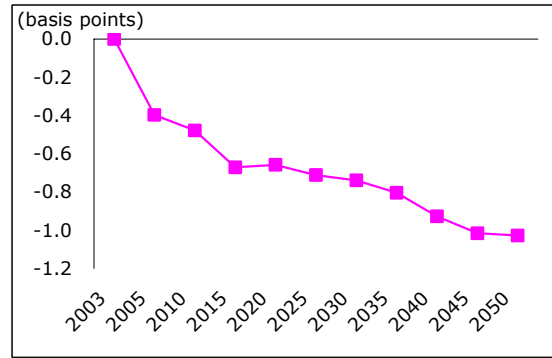
(2) Wage income tax rate(Index)



(3) Economic growth rate



(4) Rate of return on capital



(5) Economic welfare of individual cohorts

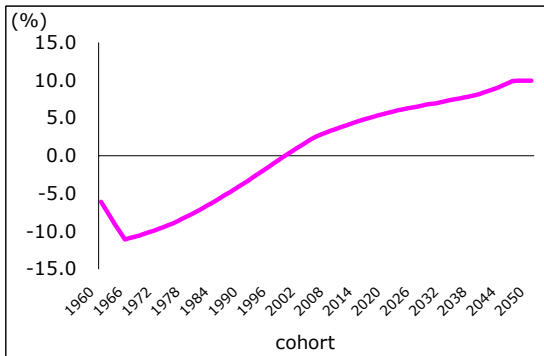
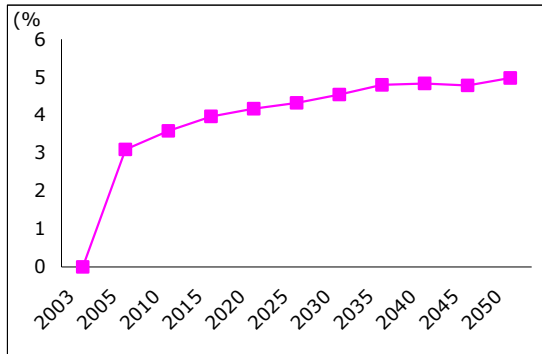


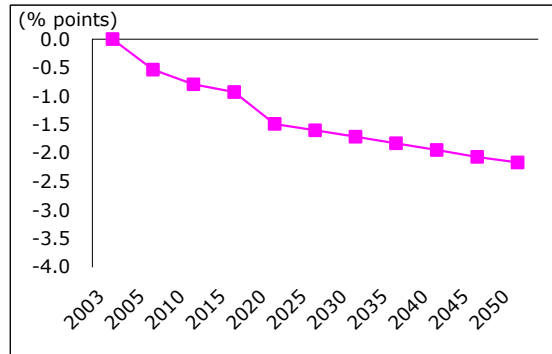
Figure 5 Policy Reform Simulation Results (deviation from benchmark simulation)

(c) Korea

(1) Saving rate



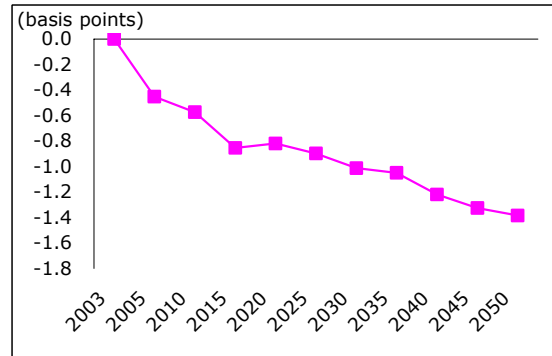
(2) Wage income tax rate(Index)



(3) Economic growth rate



(4) Rate of return on capital



(5) Economic welfare of individual cohorts

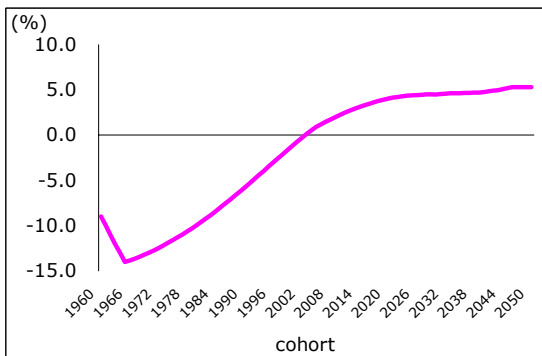
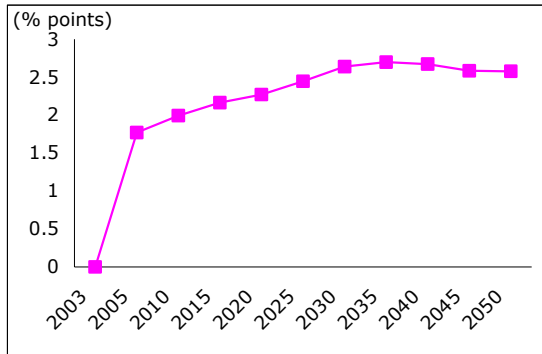


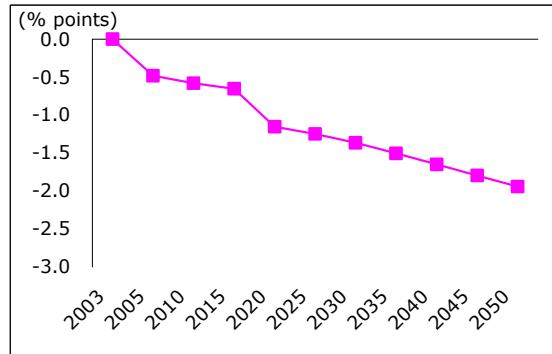
Figure 5 Policy Reform Simulation Results (deviation from benchmark simulation)

(d) Taiwan

(1) Saving rate



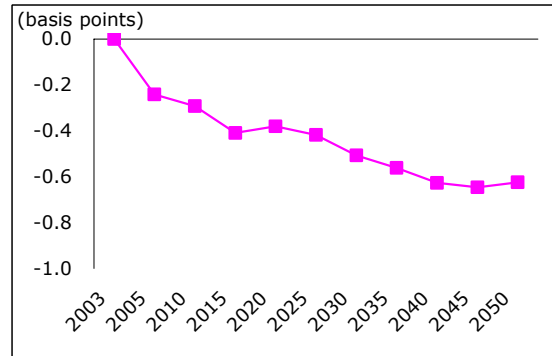
(2) Wage income tax rate(Index)



(3) Economic growth rate



(4) Rate of return on capital



(5) Economic welfare of individual cohorts

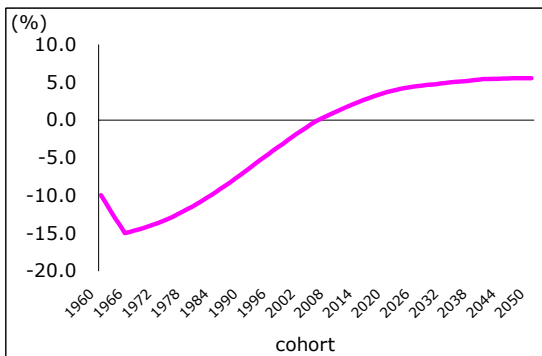
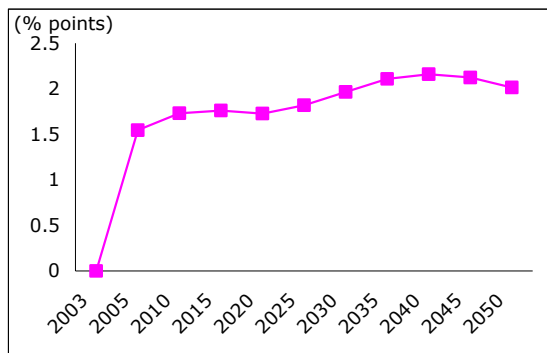


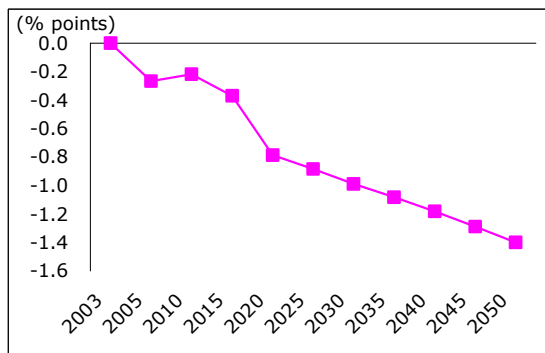
Figure 5 Policy Reform Simulation Results (deviation from benchmark simulation)

(e) Singapore

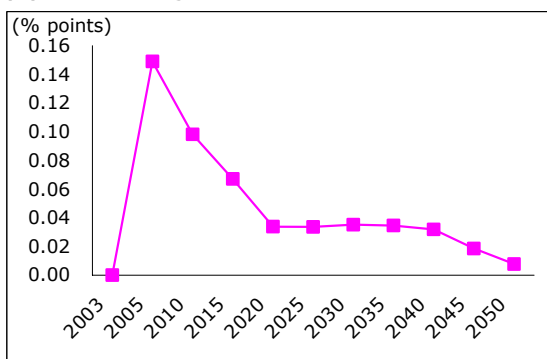
(1) Saving rate



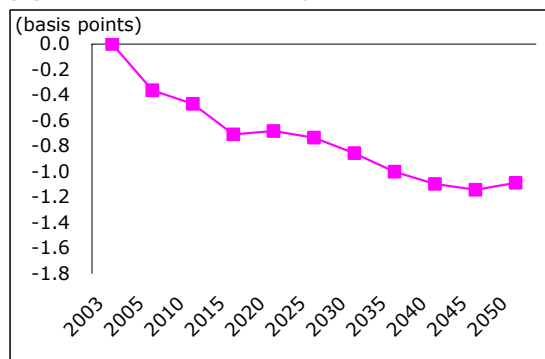
(2) Wage income tax rate(Index)



(3) Economic growth rate



(4) Rate of return on capital



(5) Economic welfare of individual cohorts

