Population Aging, Labor Force Participation, and Economic Growth

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Abstract

Population aging leads to shrinking working-age population and increasing the age composition of labor force toward older workers. This paper applies growth accounting framework to evaluate the impacts of population aging on per capita output growth in Taiwan, from 2015-2060. The simulation results show that population aging has adverse impacts on future output growth. The government may take policy measures to combat this unfavorable development in output growth, including encouraging labor force participation, increasing the rate of capital deepening, promoting technological progress, and accepting productive immigrants. This study investigates the effects of these policy measures.

Keywords: Population aging, economic growth, policy simulations

JEL classification: O11, J24, E60

1. Introduction

Population aging has become one of the most significant demographic phenomena in many industrialized countries and some newly developed countries like Taiwan and Korea. Population aging has many important socio-economic and health consequences. The shrinking share of working-age population creates social and political pressures on current social support and social security programs. In addition, the increasing aged population also places great pressure on the health care systems. Increasing proportion of aged population is expected to associate with the prevalence of disability, ill-health and old-age related non-communicable chronic diseases. These developments challenge the sustainability of current public health care and social security systems. Moreover, shrinking working-age population and aging of labor force also generates adverse impact on economic growth.

This paper investigates the impacts of population aging on economic growth, using Taiwanese economy as object of investigation. Section 2 illustrates facts and prospects of demographic transition in Taiwan. Section 3 reviews various previous works on economic impacts of population aging and develops a theoretical framework for empirical investigation in this study. Section 4 illustrates the empirical findings of this study and simulates various policy scenarios to cope with the challenge of declining share of working-age population. Sections 5 sums up the findings of this study and draws policy conclusions based on these empirical and simulation results.

2. Population Aging in Taiwan: Demographic Facts and Prospects

Figure 1 illustrates the scenarios of various vital and demographic statistics for Taiwan in the past decades. The left panel of Figure 1 shows that the crude birth rate in Taiwan has been declined all the way since the 1970's, except for some minor reversing spikes in the years of dragon in 1976, 1988, 2000, and 2012. The crude death rate has been increased from 4.91‰ in 1974 to 9.1‰ in 2015. The positive gap between the birth and death rate (panel a, Figure 1) signifies that total population was still growing, in spite that the birth rate had been declining all the way and that the total increase rate of population has also been declining (panel b, Figure 1) in the past decades. Only when the death rate exceeds the birth rate then total population will start declining. This is expected to happen around year 2025. One noticeable pattern of population growth rate is that total population growth rate has gone above the natural growth rate after year 2000. The positive spread between these two growth rates can be ascribed to the contribution of net migration due to the open policy for foreign brides to Taiwanese Citizens.

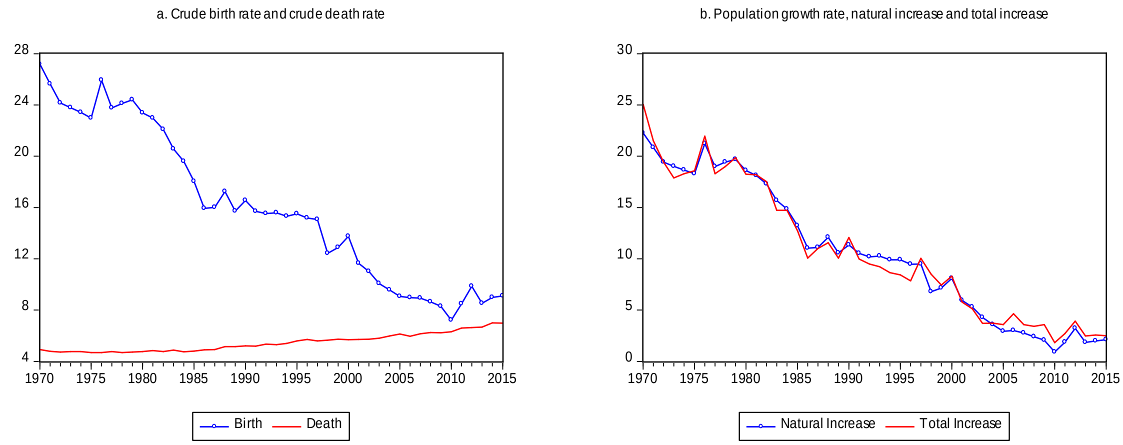

Figure 1: Demographic trends in Taiwan

Data sources: Department of Statistics, Ministry of Interior

Figure 2 and 3 illustrates historical and projected age compositions of aggregate population and various population indices of Taiwan. The data beyond 2015 in these figures are median variant population projection made by the government in Taiwan. The number of young dependents (age 0-14) has been declined since 1965 and the number of old dependents (age 65 and up) has been increased since the 1960s. Due to this dynamic demographic transition, the number of working-age (age 15-64) population has reached its peak around year 2013-2014 and was projected to show a non-stopping declining trend after 2015. Although the size of working-age population has declined since 2014, the projected total population in Taiwan is still increasing up to 2025 (Figure 2). The shares of young dependents, old dependents, and working-age population plotted in Figure 3 illustrate that the share of working-age population has peaked around 2013-14 and then descends very quickly thereafter. Meanwhile, the share of old age population shows an accelerating rate of increase. This dynamic demographic transition has important implication for economic and social security system, since it implies that there will be less working-age population to support the old dependent in the future.

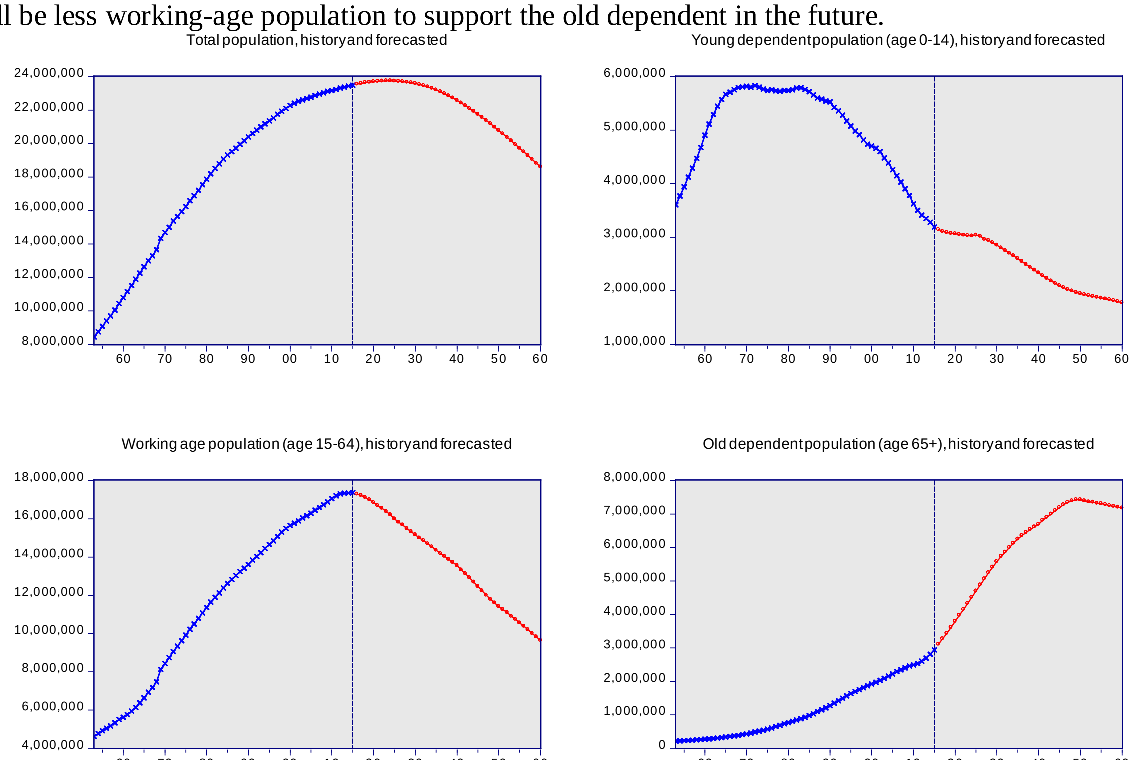

Figure 2: Population in Taiwan, history and projection (1950-2060)

Data sources: Department of Statistics, Ministry of Interior; Population Projection, National Development Council

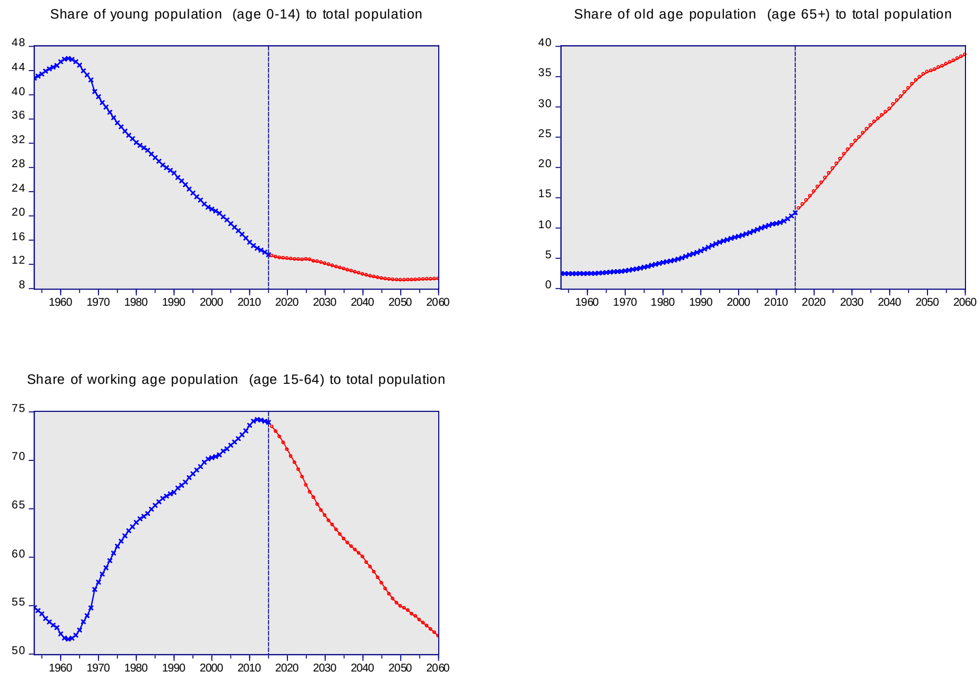

Figure 3: Age composition, history and projected (1950-2064)

Data sources: Department of Statistics, Ministry of Interior; Population Projection, National Development Council

The demographic projections of Taiwan[1] indicate that the share of working-age population is 73.6% in 2016 and is expected to drop to 51% in year 2060 (panel b, Figure 3). Meanwhile, the old age dependency ratio is 14.35 in 2008 and 18.0 in 2016, and is expected to become 79.9 in year 2060.

With respect to age specific labor force participation, the young age group (age 15-24) has shown a declining trend of participation in the past decades. The major body of the working-age labor, aged 25-44, has shown an increasing trend of participation, whereas the participation rate for the late-middle- age labor (aged 45-64) and old-aged labor (age 65 and up) has shown relative steady pattern of participation (Figure 4).

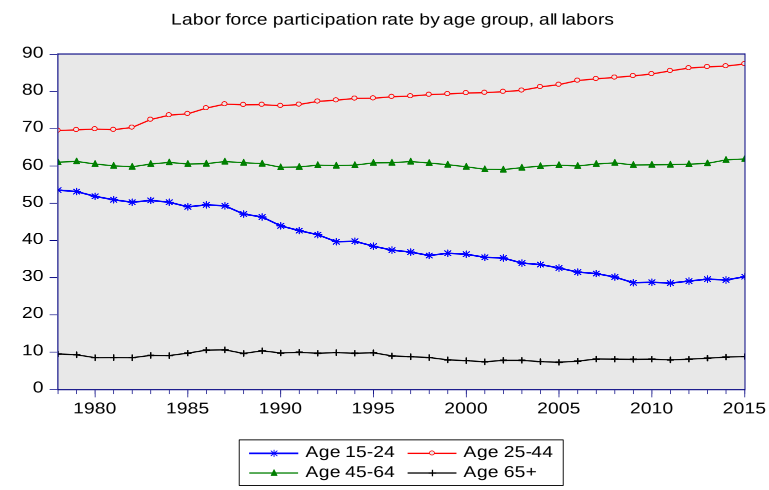

Figure 4: Labor force participation rate in Taiwan, 1978-2015

Data sources: Department of Statistics, Ministry of Interior

[1] See the website: http://sowf.moi.gov.tw/stat/Life/List.html.

Most noticeable development of demographic transition in Taiwan is the evolution in aging index.[2] The aging index evolved from 9.31 in 1974 to 61.5 in 2008, and boosted up after year 2015. This aging index is expected to become 101.2 in 2016 and increase to 303.4 in 2040 and 468.5 in year 2060. With this aging scenario, the share of old-age population, those who aged 65 and over, in 2060 is expected to be 40.6. Taiwan, like other aging economies, has to face with challenges arising from the unprecedented demographic aging. One would expect that this aging demographic transition would generate some unfavorable impacts on future economic growth.

3. Theory and Method

This section develops conceptual frameworks that link population aging with economic growth and then sets up a theoretical model to investigate the impact of population aging on economic growth. Whether population aging generates adverse impact on economic growth is an issue that requires vigilant investigation. Bloom, Canning, and Fink (2010) argue that population aging associated with declining labor force participation rates does not necessarily slow down output growth in most countries. The reasoning is that labor force to population ratio will actually increase due to lower youth dependency that is more than enough to offset the shifting share of adults toward the older ages. As a result, economic growth will continue, in spite of the phenomenon of population aging. They further claim that the effects of population aging on economic growth can be mitigated by behavioral responses of the economy to population aging, in the form of higher savings for retirement, greater labor force participation, and increased immigration from labor-surplus to labor-deficit countries. Futagami and Nakajima (2001) investigate how population aging affects economic growth in a general equilibrium model of life cycle savings combined with endogenous growth. They conclude that population aging is not necessarily a negative factor for growth. However, the simulation results of their model with pension system and postponing retirement policy suggest that policy encourages postponing retirement would cause slow-down in economic growth.

Bloom, Canning, and Fink (2010) and Futagami and Nakajima (2001) provide some answers to the question associated with population aging and economic growth. However, the conceptual linkage between population aging and economic growth is vague in these works. Foot (2007, p.182) provides a framework linking the labor market consequence of population aging to output by the identity. That is,

$$Q = (Q/H)(H/E)(E/L)(L/W)(W/P)P \qquad (1)$$

where Q = real output, H = average hours per employee, E = number of employees, L = labour force, W = working-age population, and P = population size. The identity illustrates that the annual output of any society can be decomposed into the product of various components. That is, the product of productivity performance (measured as output per hour worked, Q/H), the effort of employees (defined as average hours worked per year, H/E), the employment rate (E/L, which is 1 minus the unemployment rate), labor force participation (the share of the adult population looking for work, L/W), the share of the adult population in the total population (W/P), and the size of the population (P). It is clear from (1) that countries with better productivity, higher work effort, lower unemployment rates, higher participation rates, lower shares of children in the population and larger populations will produce more output. Output growth is the sum of growth of each of these components. Identity (1) provides very useful conceptual framework linking population aging (L/W and W/P) and real output, it omits one important determinant of real output; the crucial factor missing from (1) is the level of capital stock.

Leibfritz and Roeger (2008, pp. 36-38) show a similar framework as Foot (2007) yet make extensive discussion of the role of capital stock in the determination of per capita real output growth. Despite that Leibfritz and Roeger (2008) present good theoretical interpretation for the correlation between population aging and economic growth, it does not conduct empirical investigation on this issue. In order to bridge this theoretical and empirical gap, the current paper tries to incorporate dynamic demographic transition and Solow (1956) growth accounting to investigate the prospect effect of population aging on economic growth.

The model

Follow Solow (1956), the current paper assumes a constant return to scale of a Cobb-Douglas production technology with capital stock installed at the beginning of each time periods.

[2] Aging index = 100*(number of population aged 65 and up)/(number of population aged 0-14)

The production function is given as

$$Y_t = A \cdot F(E_t, K_t) = A \cdot E_t^{\alpha} \cdot K_t^{1-\alpha} \qquad (2)$$

where subscript *t* denotes time period; Y_t is real output at time *t*; E_t is labor input; K_t is capital stock, and "A" represents "knowledge" or "technology", which is an exogenous term. Taking logarithm of (2) yields

$$\log(Y_t) = a + \alpha \cdot \log(E_t) + (1-\alpha)\log(K_t) \qquad (3)$$

In growth rate notations, one obtains

$$\dot{y}_t = a + \alpha \cdot \dot{e}_t + (1-\alpha)\dot{k}_t \qquad (3')$$

In (3') the dot above a variable denotes percentage changes. In an economy, multi-factor productivity (MFP) growth (or, technical progress) can be measured by the Solow residual as

$$\Delta MFP_t = \dot{y}_t - \alpha\dot{e}_t - (1-\alpha)\dot{k}_t \qquad (4)$$

Rearranging (4) and subtract $\dot{e}_t$ from both sides yields labor productivity growth,

$$\dot{y}_t - \dot{e}_t = \Delta MFP_t + (1-\alpha)(\dot{k}_t - \dot{e}_t) \qquad (5)$$

Equation (5) can be manipulated to obtain the expression of output growth rate:

$$\dot{y}_t = \Delta MFP_t + (1-\alpha)(\dot{k}_t - \dot{e}_t) + \dot{e}_t \qquad (6)$$

Equation (6) shows that output growth can be decomposed into three components: the growth in productivity, the growth that attributes to capital deepening, and the growth attributed to labor input. Subtracting population growth ($\dot{n}_t$) from both sides of (6) yields the determination of output growth per capita:

$$\dot{y}_t - \dot{n}_t = \Delta MFP_t + (1-\alpha)(\dot{k}_t - \dot{e}_t) + \dot{e}_t - \dot{n}_t \qquad (7)$$

Equation (7) shows that output growth per capita can be expressed as the sum of MFP growth, capital deepening ($\dot{k}_t - \dot{e}_t$) and labor input growth minus population growth ($\dot{e}_t - \dot{n}_t$). The ratio of labor input to total population (E_t/N_t) can be written as

$$\frac{E_t}{N_t} = \frac{E_t}{LF_t} \cdot \frac{LF_t}{NWA_t} \cdot \frac{NWA_t}{N_t} \qquad (8)$$

where N_t is total population at time t; LF_t is labor force; NWA_t represents the numbers of working-age population (population aged 15-64). Taking logarithm of (8) yields

$$\log\left(\frac{E_t}{N_t}\right) = \log\left(\frac{E_t}{LF_t}\right) + \log\left(\frac{LF_t}{NWA_t}\right) + \log\left(\frac{NWA_t}{N_t}\right) \qquad (9)$$

Expanding and expressing (9) in relative rate of change, one obtains

$$\dot{e}_t - \dot{n}_t = (\dot{e}_t - \dot{lf}_t) + (\dot{lf}_t - \dot{\gamma}_t) + (\dot{\gamma}_t - \dot{n}_t) \qquad (10)$$

where $\dot{lf}_t$ is the growth of labor force, $\dot{\gamma}_t$ is the growth of working-age population. Equation (10) shows that $\dot{e}_t - \dot{n}_t$, the difference between labor input growth and population growth, can be expressed as the sum of growth of employment out of labor force ($\dot{e}_t - \dot{lf}_t$), relative growth of labor force to working-age population ($\dot{lf}_t - \dot{\gamma}_t$) and relative growth of working-age population to total population ($\dot{\gamma}_t - \dot{n}_t$).

The three terms in the right-hand-side of (10) can be conceptualized as growth of labor force employment, growth of labor force participation rate, and growth rate of working-age population in total population.

Plugging (10) into the last term in (7) one obtains the conceptual model that can be applied for empirical investigation:

$$\dot{y}_t - \dot{n}_t = \Delta MFP_t + (1-\alpha)\left(\dot{k}_t - \dot{e}_t\right) + \left[\left(\dot{e}_t - \dot{lf}_t\right) + \left(\dot{lf}_t - \dot{\gamma}_t\right) + \left(\dot{\gamma}_t - \dot{n}_t\right)\right] \quad (11)$$

Equation (11) is the model which this paper uses to evaluate the impact of population aging on economic growth. It is clear from (11) that, productivity growth and capital deepening will contribute to per capita GDP growth, if capital deepening and productivity growth accelerate to compensate for the decline in labor input due to population aging.

4. Model Estimates and Simulation Experiments

The empirical model is estimated based on the specification in equation (7) and uses annual data of Taiwan ranged from 1951 to 2014. The estimated model is

$$\left(\ln Y_t - \ln N_t\right) = \underset{(0.3187)}{1.7398} + \underset{(0.3317)}{0.7276} \times \text{TFP}_t + \underset{(0.0727)}{0.6021} \times \left(\ln K_t - \ln E_t\right) + \underset{(0.5047)}{2.0237} \times \left(\ln E_t - \ln N_t\right) \quad (12)$$

The left-hand side of equation (12), $\left(\ln Y_t - \ln N_t\right)$, is output growth per capita, where Y_t is real GDP in 2001 price; N_t is the number of population. TFP_t is the growth of total factor productivity; K_t is capital stock in 2001 price, and E_t is the number of employed labor. The numbers in the parenthesis beneath each parameter estimated are the standard errors for the coefficient estimated. The t-statistic indicates that all the coefficients estimated in (12) are significant at 5% significance level.

The estimated model in equation (12) implies that increase in factor productivity (TFP) and increase in capital deepening $\left(\ln K_t - \ln E_t\right)$ contribute to output growth. In addition, once employment growth outgrows that of total population, i.e. $\left(\ln E_t - \ln N_t\right) > 0$, there would also have a positive output growth effect.

Equation (12) indicates various factors contribute to economic growth, including factor productivity, capital formation, labor employment, and population growth. One can use this estimated equation to explore the effect of population aging on per capita output growth, given the exogenous demographic transition and it effects on labor employment, $\dot{e}_t - \dot{n}_t$. It has been indicated in equation (10) that the difference between employment growth and population growth, $\dot{e}_t - \dot{n}_t$, is the sum of three labor market momentums which are influenced by the evolution of population aging. The three momentums are growth of employment out of labor force ($\dot{e}_t - \dot{lf}_t$), growth of labor force participation ($\dot{lf}_t - \dot{\gamma}_t$), and growth of working-age population over total population ($\dot{\gamma}_t - \dot{n}_t$). In general, employment growth is determined mostly by business cycle while the other two are the results of demographic transitions. In a simple demographic transition and economic growth model, one can use this simple two-equation model, equation (10) and (12), to explain the transmission and impact of demographic transition to economic growth.

Model calibration uses median variant of population projection to obtain demographic transition for year 2015-2060. In addition, this paper also collects past economic performance of Taiwan (1951-2014) and estimated historical total factor productivity and rate of capital deepening. The estimated average values for total factor productivity (TFP) and capital deepening are 0.25 and 1.05 respectively. A baseline model is solved using these figures as initial values and plugging official median variant demographic projection. The baseline model indicates that aging demographic transition in Taiwan will have adverse effect on per capita output growth starting year 2020 approximately. If there were no counteracting force to alter the negative effect of shrinking working-age labor force due to population aging, per capita output growth in Taiwan will start sliding down consistently from after year 2020 (Figure 5).

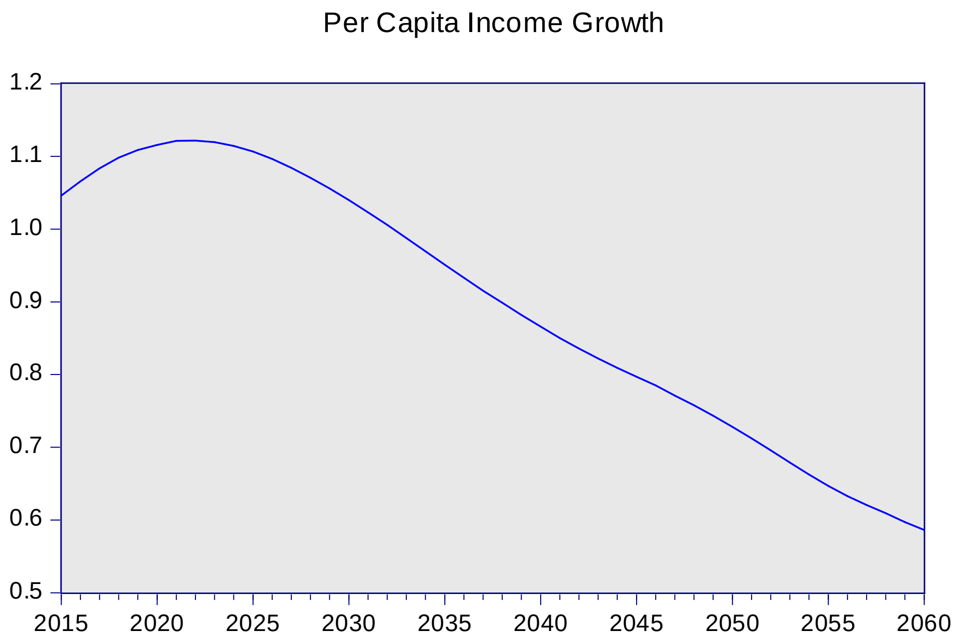

Figure 5: Baseline scenario, the effect of population on per capita output growth

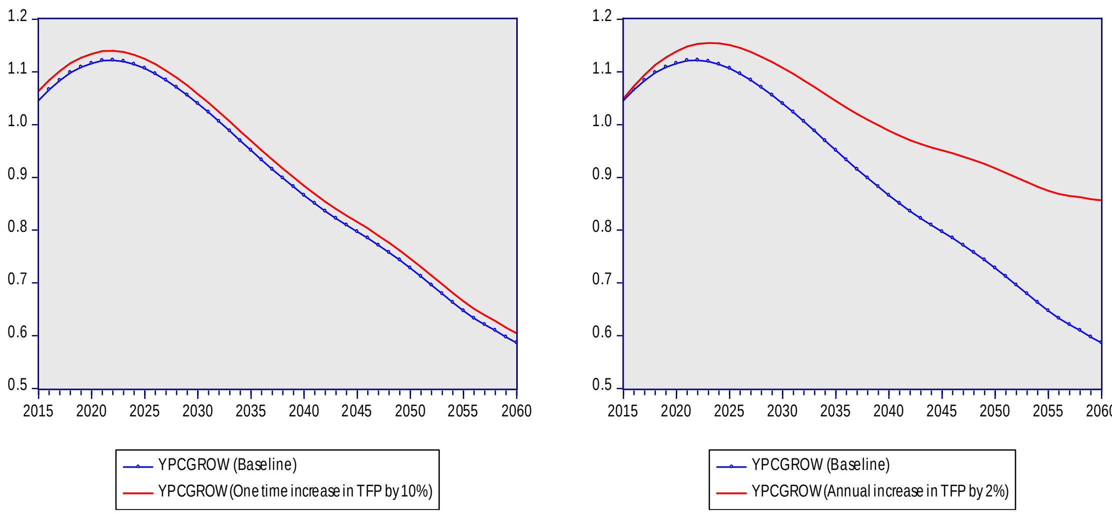

Figure 6: Baseline solution and simulated scenarios of increase in TFP

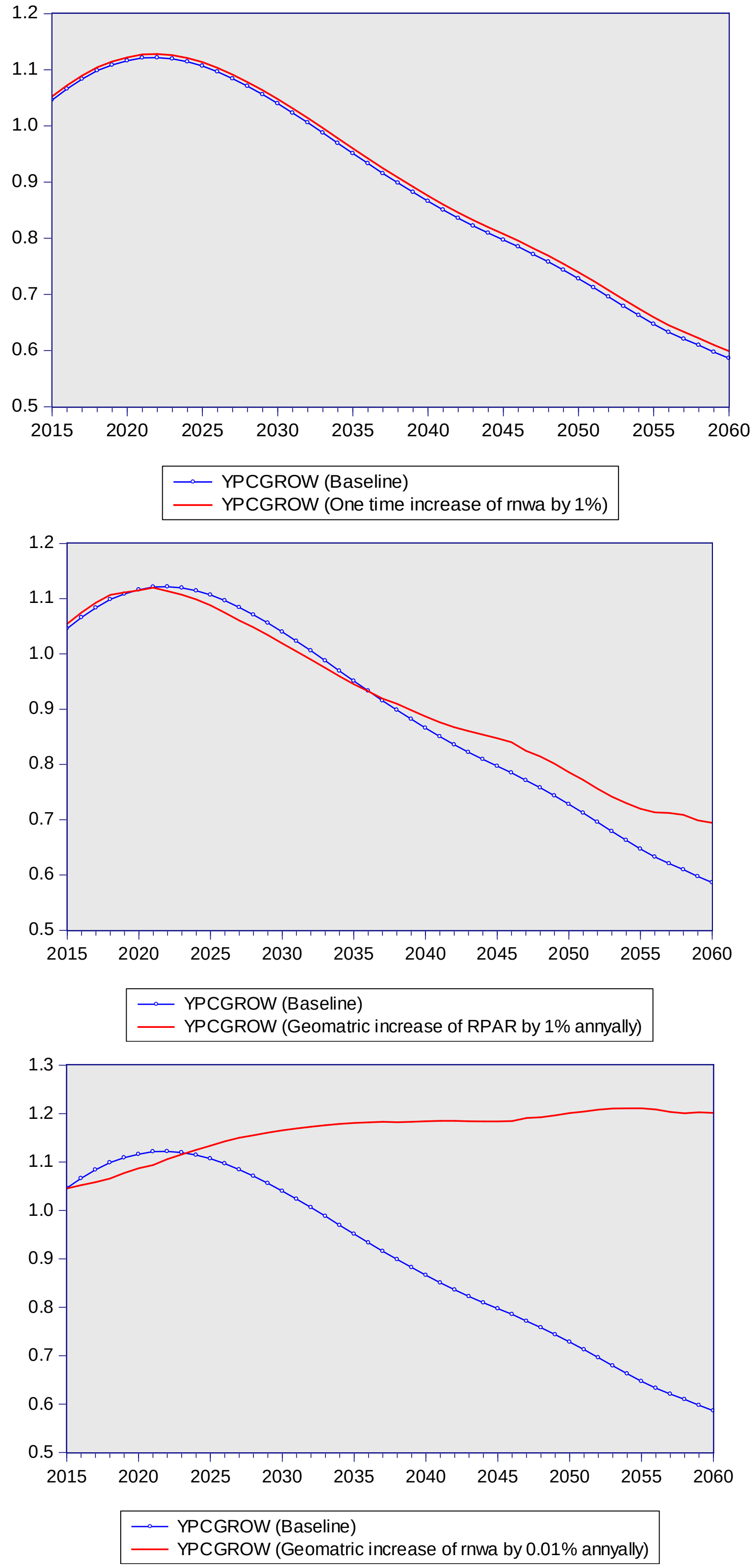

Figure 7: Baseline solution and simulated scenarios of labor market factors

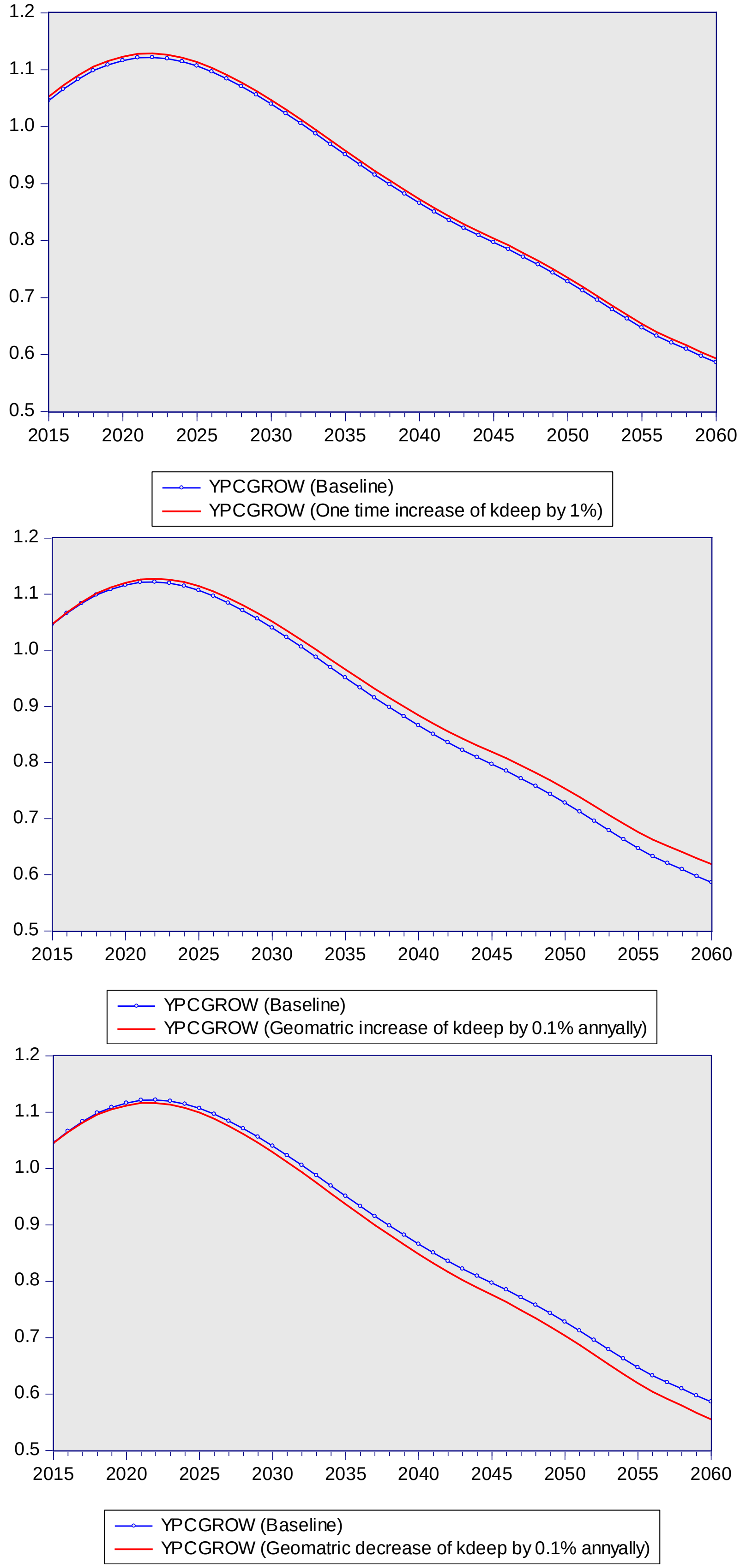

Figure 8: Baseline solution and simulated scenarios of capital deepening

Simulation on labor market and demographic factors

With the baseline model at hand, this study then conducts several simulation experiments based on some counterfactual hypothesis. The scenario for policy experiments include (1) Increase in total factor productivity, one time increase and continuous increase at fix rate each year; (2) One time and continuous increase in labor force participation rate ($\dot{lf}_t - \dot{\gamma}_t$); (3) A onetime and continuous increase in the growth of working-age population over total population ($\dot{\gamma}_t - \dot{n}_t$); (4) One time and continuous changes in capital deepening rate ($\dot{k}_t - \dot{e}_t$).

Figure 6 illustrates the results of the experiment on TFP increase. A onetime increase in TFP by 10% causes a parallel drift up of per capita output but it is unable to deter the downward sloping momentum of output growth (left panel, Figure 6). An alternative scenario assumes that TFP increases continuously by 2% each year. Apparently, this continuous increase in TFP helps to counter part of the falling rate of output growth (right panel, Figure 6). How feasible is this measure to counter the declining output growth is another issues beyond this simple experiment. Figure 7 shows the simulation results of changes in labor market factors. The most naïve scenario is a onetime increase in the ratio of working-age population, perhaps due to a one-time open-up of foreign immigration or due to the surge of a biologically "productive" injection of population in the Chinese years of dragon[3] which causes a one-time injection in labor force 15 years later. The simulation result shows a similar scenario to that of one-time increase in TFP (top panel of Figure 6.) That is, a onetime injection of working-age population shifts the output growth up a little bit but is unable to deter the falling trend. Another experiment is to promote annual labor force participation rate by 1% continuously. This continuous increase in labor force participation dilutes the amount of capita capital per worker can uses, so that it has an adverse effect on output growth in the short-run. However, per capita output starts to grow faster than that of the baseline model. The simulation indicates that encouraging continuous labor force participation can ameliorate the declining trend in output growth in the long run (middle panel in Figure 7). Again, the feasibility of encouraging continuous labor participation is a matter of practical challenge.

An alternative scenario in simulation is to allow for a geometric increase of ($\dot{\gamma}_t - \dot{n}_t$) by 0.01% annually, by allowing for the adoption of productive new immigrants every year. The new immigrants entering into the economy are assumed to have the same productivity as the average working-age residents. The political and social tensions of assimilating new immigrants are assumed to be exogenous to the current research framework. The simulation result of this experiment is the most promising one in this study. It indicates that a constant annual injection of productive immigrants does not only counter the declining trend in per capita output but also contributes to the promotion of long-run economic growth. However, to gain this long-run benefit of continuous adoption of immigrants, the economy has to sacrifice its short-run output growth (bottom panel in Figure 7).

Simulation on the effect of capital deepening

Population aging leads to a shrinking working-age population. However, the adverse effect shrinking working-age labor force on output can be offset partly by the increase in capital deepening. Capital deepening augments capital-labor ratio, increases labor productivity, and hence compensates part of the adverse effect of shrinking size of working-age labor. This paper considers three scenarios of capital deepening: (1) A one time increase in capital deepening ($\dot{k}_t - \dot{e}_t$) by 1%; (2) A continuous annual increase capital deepening by 0.1%, and (3) a continuous annual decrease of capital deepening by 0.1%The effect of one-time increase does not differ much from that in the previous section of one-time increase cases (Figure 8, top panel). However, a continuous increase in capital deepening works to counter the declining rate in output, whereas a continuous decrease in capital deepening hastens the declining trend in per capita output (middle and bottom panel Figure 8). Even though it is recognized that an increase in capital per worker improves productivity, the effect of continuous increase in capital deepening by 0.1% is not so prominent as that in a continuous increase in adopting immigrants.

[3] This is a Chinese Zodiac effect on the birth rate. Every year of the Chinese calendar corresponds to a sign in the zodiac cycle; dragon is one of the 12 representative animals of this zodiac cycle. According to Chinese astrology, the dragon's quality of power, courage, honesty, and magnanimity would manifest in the individuals born in year of dragon. Many people in Chinese culture prefer the quality of the dragon and consciously arrange timing of pregnancy for the year of dragon. As a result, there is an increase in the birth rate around the year of dragon.

5. Conclusions and Policy Implications

The author investigates the impact of population aging on economic growth in Taiwan. The analytical framework of this paper is developed based on Cobb-Douglas production function, the Solow's growth accounting, and Leibfritz and Roeger (2008) notion of demographic effects on labor market. A simple two-equation model is used in the investigation. The data for Taiwan, ranged from 1951 to 2014, was used to estimate the empirical model. Model calibration and validation is then performed with hypothetical initial conditions and exogenous population projections made by the government in Taiwan. Various simulation experiments are then conducted and the results are compared with that of the scenario of the baseline model. The simulated results indicate that increase in total factor productivity (TFP) and capital deepening can improve the deteriorating condition in per capita output due to population aging. However, one-time increase cannot check the declining rate of change in output; only continuous increase in TFP and capital deepening can make things differ. In addition, given the population aging momentum in Taiwan, any measure that can increase labor force participation or increase the share of economic active population does improve the haze situation ahead.

Several policy implications can be drawn from the current research. In order to fight against the future declining trend in output growth, the government should encourage R&D to increase production efficiency and factor productivity. Moreover, aged retirees tend to rely on savings made in early working-ages for living. As more and more elders withdraw their savings, it decelerates capital formation and capital deepening. Therefore, the government should implement some persistent measures to encourage capital formation in the aging economy. In addition, persistent measures that encourage labor participation can mitigate output decline resulting from population aging. Labor market policies aiming at improving labor market efficiency and increasing job opportunities of the silver-aged should be advocated.

A final policy implication of this study is that, given current trend of aging transition, policy measures that increase the size of working-age population by means of encouraging continuous immigration or encouraging the increase in total fertility, can yield the most significant effect in combating the adverse effect of population aging on output growth. However, this measure is the most complicated one because it may trigger social and political tensions between interest groups. The implementation of such measure needs through and delicate planning. The limitation of current study is that the conclusions were drawn from the theoretical setting of the Solow (1956) growth accounting. In this theoretical setting, aggregate saving and capital deepening are taken as exogenously given; changes in saving and capital stock are not related to the dynamic shares of age cohorts in the demographic transition. Furthermore, the presence of pension may also affect saving and consumption behavior of the age cohorts yet this social security system is missing from current study. These limitations are rectifiable by the introduction of general equilibrium framework in future studies.

Reference

Foot, David K. (2007). "Population Aging," in J. Leonard, C. Ragan and F. St-Hilaire (eds.), *A Canadian Priorities Agenda: Policy Choices to Improve Economic and Social Well-Being* (Montreal: Institute for Research on Public Policy, 2007), 181-213. (http://www.footwork.com/irpp_pop_aging.pdf)

Bloom, David E., David Canning and Günther Fink (2010). "Implications of population ageing for economic growth," *Oxford Review of Economic Policy*, Oxford University Press, vol. 26(4), pages 583-612, Winter 2010.

Gruescu, Sandra (2007). *Population Ageing and Economic Growth: Education Policy and Family Policyin a Model of Endogenous Growth*, Berlin, Germany: Physica-Verlag Heidelberg, 2007.

Futagami, Koichi and Tetsuya Nakajima (2001). "Population aging and economic growth." *Journal of Macroeconomics*, Volume 23, Issue 1, Winter 2001, Pages 31-44.

Solow, Robert M. (1956). "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics*, *70* (1), 65-94.

Leibfritz, Willi and Werner Roeger (2008). "The effect of aging on labor market and economic growth," Chapter 3 in *Demographic Change in Germany The Economic and Fiscal Consequences*, Hamm et al. (eds.), Springer, pp. 35-64