The Potential Crisis of Population Ageing and Low Fertility: GEMTEE Dynamic Computable General Equilibrium used in Population Forecasts and Analysis

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Abstract

Based on the Cohort-Component Method, the Department of Manpower Planning, Council for Economic Planning and Development (CEPD) (2012) made population projections through the assumptions of fertility, mortality, and migration to calculate future population by age and gender groups, and took economic factors as exogenous variables. However, after Becker's work (1960), it is generally accepted that fertility is impacted by income and other economic factors, and that fertility is an endogenous variable. In other words, a population projection should consider economic factors before deciding fertility endogenously.

This article applies the population module on the General Equilibrium Model for Taiwanese Economy and Environment (GEMTEE), wherein fertility and mortality are decided endogenously. Moreover, this study projects the baseline population of Taiwan from 2012 to 2060, and valuates the impacts of low fertility and aging problem to Taiwan economy.

Key words: low fertility, population ageing, potential economic crisis, dynamic computable general equilibrium, and population prospects.

I. Introduction

In recent years, trends like late marriage, no marriage, late pregnancy, having few children, or even no children are growing; and longer life expectancy, low fertility, and the ageing population have become the inevitable topics. According to statistics, the total fertility of Taiwan had decreased to 1.065 in 2011. This figure is much lower than the replacement level and almost the lowest one in the world, which means that the total population may have negative growth, and population ageing happens faster in Taiwan than in other developed countries. Based on the definition from World Health Organization (WHO), Taiwan had reached the threshold of an aging society since 1993, when the percentage of elders over 65 years old was 7%. CEPD (2012) estimates that Taiwan will become an aged society in 2017, when the percentage of elders over 65 years old approaches 14%, which means that it takes only 24 years from an aging society to an aged society. Moreover, the percentage of elders over 65 years old will be over 20% in 2025, the super aged society. Chu Ching-Yi (2012), Minister Cyrus of the National Science council, and Hsueh Cheng-Tai (2012a), from the agency of Executive Yuan, both publicly warned the people that population ageing would become a serious issue in Taiwan. In other words, changes in people structure will affect the macroeconomic interior, especially the government fiscal. The government should consider this issue in long term instead of pushing policies only effective in short term which damage to long-term economy.

The correct policy depends on accurate projects of population and people structure. For now, the government relies on the population prospects from the Department of Manpower Planning, and the Council for Economic Planning and Development (CEPD). Based on the Cohort-Component population projections made by CEPD (2012), future population by fertility, mortality, and migration are calculated by age and gender groups. The method CEPD (2012) used took economic factors as exogenous variables. However, after Becker's work (1960), it is generally accepted that fertility is impacted by income and other economic factors, and that fertility is an endogenous variable. In other words, a population projection should consider economic factors before deciding fertility endogenously.

This article applies the population module on the General Equilibrium Model for Taiwanese Economy and Environment (GEMTEE) to project the baseline population of Taiwan from 2012 to 2060 and compares the results to the CEPD (2012) population projections. Then we analyze the impacts and bumps of low fertility and population ageing on the economy and industries of Taiwan. Academia Sinica and the Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES) follow the GTEM model (Pant, 2002) from Australia and cooperate to establish a dynamic population module for Taiwan; GEMTEE, is a computable general equilibrium (CGE). It is rare in the world that a CGE model of a single country has endogenous population variables, which also has the interaction between population and macroeconomics. This module can be used to analyze and simulate the impacts of population changing on macroeconomic development more comprehensively, then draw up policies consistent with population changing and prevent economic crisis.

The remainder of this paper is organized into five sections as follows. Apart from the abstract and introduction, section 2 describes the literature about population changing effects on the economy. Section 3 introduces the GEMTEE model and data. Section 4 is forecasting and analysis, including the comparison to results from CEPD (2012) and the impacts and dumps on Taiwan economy. Section 5 is conclusion and suggestion.

II. Literature Review

The relationship between population growth and economic growth has three aspects; first, the population pessimist such as Coale and Hoover (1958) and Ehrlich (2009), they follow the concepts of Malthusian argument which believes that the rapidly growth in world population are upon the economic benefit from accumulated capital and technology evolution, then human being are sink into the poverty traps. Second, the population optimists such as Kuznets (1968), Simon (1980), and Boserup (1981), they believe that population growth are thrilling creations to adopt the new consumption demands and it provides the benefit on economies of scale. However, Kelly (1981) has the revisionist view. She worked on huge scale of international demonstrated analysis and found population growth has no significant relation neither positive nor negative to per capita income.

To respond the studies about this issue, Chen and Liu (2007) assume that social and economic growth is a latent trigger to population change, and if the economic growth keeps rising, then low fertility can reverse to the replacement level. In the past 50 years, Taiwan has changed a lot on social and economic aspects. This paper uses simultaneous equations to discuss the impacts of economic and social factors on fertility by age groups, then prospects the total population from 2004 to 2033. The high-estimation assumes that the government has the appropriate policy to raise the economic growth and reach the objectives; the low-estimation assumes that the government cannot approach the prospects as usual. The results of low-estimation and medium-estimation are similar to the results of medium-estimation and high-estimation from council for economic planning and development in the same period, and have close results for high-estimation. Therefore, if the economy and social condition of Taiwan develop quickly, total fertility may rebound to the replacement level in 2033; if the development grows neutrally, total fertility may rebound to 1.6; and if the development rises slowly, fertility may stay extremely low.

Besides, the changes in age structure and population ageing have direct impacts on labor market, retirement planning, the medical care system, and the social economy. It even induces depression, government bankruptcy, and other economic crises (National Research Council, 2012). There are many researches on this topic such as Rogers et al.(2000), Hondroyiannis and Papapetrou (2001), Hondroyiannis and Papapetrou (2002), Bettendorfa and Heijdra (2006), and Mahlberg et al. (2012). America established a special cross-cutting council to discuss about the impacts on long-term economy and drew up relevant policies (National Research Council, 2012).

Chen Kuan-Cheng (2009) believes that the negative growth of population, not only in amount but also in structure, and the transition from youth stage to elder stage will cause serious problems on producing, consuming, and elder care. Besides, even the increasing labor force can sort of release the problems caused by population aging, but cannot entirely offset them, also cannot solve problems such as the social participation of elders, medical care, and labor force requirement. Chen Kuan-Cheng (2009) used the relationship between population aging and medical fee to analyze the impacts of population aging on medical fee. It decomposes medical fee in to daily fee, days in hospital, appointment frequency, and population structure. Population aging can steadily push the average medical expenses to rise, especially since the increasing number of days in the hospital has the most significant effects on medical expenses. In addition, the constant fall in mortality implies that disease spread really causes increases in medical demands, and that the medical system can meet the demands leading to the risen medical expenditure.

Tsai Fang (2012) believes that the impacts of population aging on social economy include scale down in labor forces, total producing and consumption, contort on fundamental tax, changes in the demands of goods and service, changes in saving and flow of international capital, and reducing of population dividend. Chu Ching-Yi (2010) points out that Taiwan should focus on intelligent industry, seeking to get the maximum products with minimum labors. Labor force in the future should be of high quality rather quantity. Therefore, the policy of thrilling fertility to sustain the population should be reconsidered. Chen Yu-Hua and Tsai Ching-Lung (2011) state that if Taiwan and other Southeast Asian countries want to rebound the fertility, they should appropriately respond to unsecured labor benefits, unbalanced family responsibilities, and the career of childbearing women. To respond to the demands of social security in an aged society, we need to constantly increase the youth human capital and examine the quality and productivity of labor forces, whether they can stably support the life of elders.

Recently many foreign scholars used CGE model or dynamic CGE model to discuss the problem about population aging and low fertility. Giesecke and Picton (2005) applied the MONASH dynamic CGE model to analyze the impacts of population aging on health care industry and macro economy. The results showed that population aging makes explosions of the health care industry and the expenditure on health care both for the government and individually. Seryoung and Hewings (2007) used the American and Chicago CGE model, including Chicago city and other provinces in the U.S. It also integrates an overlapping generations analysis structure to probe for the aging and retiree immigration problem in Chicago city. Volz (2008) established a CGE model for Germany, using household data to analyze the change in labor supply and consumption demand while population aging happens in Germany. It turns out that population aging results in a huge change on medical treatment, education, and social benefit industries. Honkatukia et al. (2009) applied MONASH dynamic CGE model to analyze the effects of population aging on regional economy in Finland. It used regional population amount and age group data from 1975 to 2006 to forecast 2007 to 2015, and showed that population growth is an important factor for government fiscal expenditure. Peng and Mai (2008) used MC-HUGE dynamic CGE model to analyze the effects of the decreasing labor supply on Chinese economy from 2008 to 2020. Fehr (2011) used dynamic CGE to simulate and analyze the trends of global aging, dependency rate growing rapidly, and the fertility decline from 1950 to 2050, especially in Japan, Italy, and Germany. China and India have low fertility and long life expectancy due to the population control policies.

As previous, there are many literature discussed about population problem. The age and other structure may affect on economic growth in many ways. The relationship can be seen from literatures such as connection with external data, external projects model, specialized correlated connection, generalized correlated connection to demonstrate the real connection between social economics and population.

The literature of the relationship between population and economic growth usually use external connection, which means that uses the population projection from other institutions or use general population forecast module and adopts the population, fertility, mortality, migration rate, inheritance and bequest, labor participate rate, trades and current capital into CGE model as exogenous variables to get the resolution endogenously. It so called soft link between population modules. Lisenkova et al. (2008) used POPGROUP population module with Cohort-Component Method to forecast the composite of population and labor forces. After the got the impact on labor market and indirectly adopted A Macro-Micro Model of Scotland (AMOS) CGE to simulate the effects on Scotland economy and macroeconomic. Bruan et al. (2009) used Markov process to forecast the saving rate and total factor productivity (TFP) after the changes in population structure of Japan. It assumes that the population distributed Markov translate matrix is fixed exogenous, which means that the endogenous assumptions are fixed exogenous. Fouge're and Harvey (2006) adopted the population projects from Canadian government into VGE model. Fouge're and Harvey (2009) adopted exogenous population projects from South African government to estimate the impacts of HIV/ AIDS to South African economy. The similar documents such as Lueth (2003): Inheritances Alleviate the Fiscal Burden of An Aging Population, Ferguson et al. (2007) and others.

The literature about external projects model usually uses overlapping generation model (OLG) and multi-sector infinitely lived agent model (ILA) to obtain the results of forecasting on population age and structure. OLG model goes with saving or life-cycle theory to forecast the population overlapping generation when life is limited, and combines with CGE model. As Seryoung and Hewings (2007), Foue're et al. (2007) used it to projects the impacts on the macroeconomic and industry after changes in labor supply with CGE model. Fehr et al. (2010) evaluated five economic growth like China and India from 91 generations. Fehr et al. (2008) evaluated the population structure of America, Japan, and Euro zone. Fehr (2009) and Wendner (2001) also e similar ways.

Besides, in literature it normally used ILA to do population age and structure forecasting and combines with CGE. Melnikov et al. (2012) used population-environment-technology (PET) CGE model combine with ILA forecasts on population structure. The different age adopts to different household department, and then use CGE model to simulates the changes in labor supply indirectly affect on India economy. Dalton et al. (2008) combined ILA and PET to forecast the impacts of population structure of America on carbon release. O'neill et al. (2010) also combined ILA and PET to forecast the impacts of population structure on carbon release in America, China, India and other 6 regions. Jimeno et al. (2006) adopts ILA which forecasts the fertility and life expectancy by the exogenous projects from Spanish Statistic Office and the CGE model with retirement policy. The others, O'Nwill et al. (2012) uses ILA forecast the population structures, urbanization, and energy usage.

The document mentioned above are mainly a module that forecasts a population structure by age and calculates the labor forces, which have effects on human capital market. The connection, indirect resolution from CGE, has only one way impact, it has no reacts of the macroeconomics to population changes. It is more suitable to the hard link of the endogenous relationship between modern population age and structure and economic growth. In GEETEM module, CGE and population module have bi-directional links, and have two-way dynamic feedback to economic growth, fertility, mortality, migration, and life expectancy. The two modules together can endogenously solve the complete representation of the population age composition and combination with other structural and economic performance. Compared to the other only soft link or other specialized disease literature, it is more in line with most of the actual mechanism of the general economic and social.

III. The Structure of Model and Data

Population is one of the constituent elements of a country. However, the number of the population and changes in the age structure are the key to determine national development. In order to understand the future demographic trends, every two years, CEPD fixes the future population projections according to the latest population, birth, death, migration and other relevant statistical data. We mainly use Cohort-Component Method for population estimate. The number of male and female single age population in 2011 are applied as the base period, increasing each age year by year, and add on births, deaths, social increases and other assumptions to calculate the future male and female single-age population number.

The population module in this paper is mainly connected with the economic core of GEMTEE. Population module contains the real income per person, birth rate of the specific age, and mortality rates by ages and genders. Therefore, the change of per capita income endogenously affects fertility, mortality, and net migration. The age and gender constitute the population changes, and thus determine the changes in the labor force. The size of labor force decides the labor supply and it helps determine economic outcomes. The economic core and the population module of GEMTEE are interdependent. The main difference with the estimation method of CEPD is in consideration of changes in birth and death rates by per capita income change in the future, and thus to estimate future population changes. In this article, consideration to economic factors, the population estimate assumptions of GEMTEE is found to be quite similar to the CEPD's low estimate. The following is the comparison between CEPD's low estimate and GEMTEE.

3.1 GEMTEE, the Methodology of Computable General Equilibrium model used in population forecasts and analysis

GEMTEE is developed by Sustainable Development Center, Academia Sinica and the Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES), imitating the Australian GTEM model (Pant, 2002) population dynamic model to establish Taiwanese computable general equilibrium model. GEMTEE includes a complete population module and dynamic invest function of the Taiwan region. The population module describes changes in population scale and changes by age and gender groups over time periods. The dynamic invest function pushes the current net capital and additional investments to the next period, and it becomes the available capital in the next period. Additional investments are decided by current information such as the marginal productivity and price of factors to calculate the expected return for the next period.

3.1.1 Two Features of GEMTEE model:

（a）Dynamic Mechanism

According to Dixon and Parmenter (1996), the dynamic CGE model has four kinds: (1) recursive module with the exogenous investing; (2) recursive module with the endogenous investing; (3) non-recursive inter-temporal module; and (4) non-recursive perfect investing model. The first and second modules are the most widespread, yet the first module assumes investing is exogenous; the second module assumes investing is endogenous, which means the investment at t+1 and accumulated capital are decided by the expected return at t+2, and the expected return are decided by the real capital return and cost at t+1.

In the GEETEM model, the dynamic mechanism of baseline forecasting is processed by the second module, the recursive module with the endogenous investing. Since the setting of dynamic mechanism of producing behavior involves the assumption of investment, changes in capital, investment returns, GEMTEE processes the dynamic mechanism through investing on the behavior of product industries to do the baseline forecasting. GEMTEE simulated the beginning value at first year through the base year data from the input-output table and calculates the effect of changes in exogenous variable to endogenous variable, then used the results at first year to simulate the beginning value of second year, the same for the following years. It indicates that the GEETEM model uses annual recursive to show the path of endogenous variable responding to the changes in the exogenous variable.

(b) Endogenous Population Growth：

GEMTEE contains a comprehensive demographic model which explains population growth, and age and gender composition changes over time. This model contains a decorative description of population dynamics, which reflects the basic conclusion of demographic transition theory, as a country moving along the path of economic improvement and increasing personal incomes, both fertility and mortality decline. The decline in mortality precedes the decline in fertility.

(1)Population cohorts

The core of the population model is the age/sex cohort structure. We distinguish two sexes, male and female. The size C of an age/sex cohort in sex s and age a at time t follows from:

$$\mathrm{C}_{\mathrm{s,a,t}} = \mathrm{C}_{\mathrm{s,a-1,t-1}} \times \left(1 - \mathrm{M}_{\mathrm{s,a-1,t-1}}\right)\ \forall\, \mathrm{s,t,a} = 1,2,3,\ldots..100 \tag{1}$$

where M is the mortality rate, specified below. That is, in each period, people either die or promote to a higher age cohort. People do not change sex. The size of the oldest cohort follows from:

$$\mathrm{C}_{\mathrm{s,100,t}} = \mathrm{C}_{\mathrm{s,99,t-1}} \times \left(1 - \mathrm{M}_{\mathrm{s,99,t-1}}\right) + \ \mathrm{C}_{\mathrm{s,100,t-1}} \times \left(1 - \mathrm{M}_{\mathrm{s,100,t-1}}\right)\ \forall\, \mathrm{s,t} \tag{2}$$

That is, people above 100 years of age either die or remain in their age cohort. The total population P at time t follows from:

$$P_{r,t} = \ \sum_{s=f,m}\ \sum_{a=0}^{100} C_{r,s,a,t} \tag{3}$$

(2)Fertility

Fertility rates for the base year (2011) are as observed. Fertility rates for later periods are perturbed with the change in per capita income. Fertility follows

$$F_{f,a,t} = F_{f,a,t-1} \times [\,1 + \sum_{g} W_{g,t-1} \times \delta_{g,a} \times \frac{y_t - y_{t-1}}{y_{t-1}} + \alpha_g \times I_{g=3} \times (\frac{F_{conv,a}}{F_{a,t-1}} - 1) \tag{4}$$

where y is per capita income, g denotes income group (\$340/person/year < y < \$3,845/person/year, \$3,845/person/year < y <\$20,930/person/year, y >\$20,930/person / year), and δ is the income elasticity at the median income. $\mathrm{I_C}$ is the indicator function, nought if C is false, unity otherwise; α_g is a rate of convergence parameter that equals 0.05; multiplied with the indicator function, this implies convergence for high income regions and no convergence for other regions. $\mathrm{F_{conv,a}}$ is the age-specific equilibrium fertility; it is specified to add up to 1.6 (the convergent total fertility rate) while the age-profile equals the average age-profile of the countries in the highest income group. W is a weight specified as

$$W_{g,t} = \frac{1}{W_t^*} \times e^{-\beta\left(\ln(y_t \times \acute{y}_{g,t})\right)^2} \qquad (5)$$

where ý denotes the median per capita income per group, $\beta = 2.314$ is a smoothing parameter and W_t^* is defined such that $\sum_g W_{g,t} = 1 \forall t$. Equation 4 was estimated separately for each income group using panel data analysis. Equation 5 represents a kernel smoothing process to make continuous the transition of one income group to the next. The interpretation of Equation 6 is that the income elasticity of fertility is a weighted average of the income elasticity of three reference groups. The income elasticity for high income regions is zero; their fertilities evolve only through convergence to an exogenously specified profile. Total fertility at convergence is below replacement fertility (2.1 children per woman) in the base case; that is, population asymptotically goes to zero. According to Equation 4, fertility would fall even further as incomes rise.

(3) Life Expectancy

Given initial conditions, life expectancies are postulated to evolve with rises in income per person using elasticity based on a similar weighting procedure to that applied to birth rates.

The growth rate of life expectancy g^{LE} follows

$$LE_{s,t} = LE_{s,t-1} \times \left[1 + \sum_g W_{g,t-1\varepsilon_{g,a}} \times \frac{y_t - y_{t-1}}{y_{t-1}} + \tau I_{g=3}\right] \qquad (6)$$

where W is the same kernel smoothing weight as defined in Equation 5, y is per capita income, g income group, " is the income elasticity at the median income, τ is the rate of technological progress, and I_C is the indicator function, nought if C is false, unity otherwise. Note that life expectancy is projected to continue to increase with economic growth. Note also that medical technology is assumed to primarily benefit the rich.

(4) Mortality Rates

Mortality is updated by assuming that all age-cohorts have the same proportional change in mortality rates, and hence by numerically solving

$$LE_{s,t+1} = \sum_{a\in A}\prod_{b<a}\left(1 - M_{s,b,t+1}\right) = \sum_{a\in A}\prod_{b<a}\left(1 - \left(1 + g^{M}_{s,t}\right) \times M_{s,b,t}\right)$$
$$= \left(1 + g^{LE}_{s,t}\right) \times LE_{s,t} \qquad (7)$$

where LE is life expectancy, M is mortality, and g^{LE} is the sex and time-specific growth rate of life expectancy, and g^{M} is the growth rate of mortality; g^{LE} is implied by Equation 6; g^{M} is obtained by solving Equation 7 numerically 2. The first part of Equation 7 gives the definition of life expectancy, which is the ratio of the total number of people in a population over the number of people aged zero, under the assumptions that mortality rates and the absolute number of newborns are constant.

(5)Net Migration

GEMTEE calculates the inflow of net migrants of each gender and age over time to a region (Taiwan) based on a given national net migration rate of each region for the base year. To keep the flow in balance, it is a requirement that the sum of net migrants, by gender and age, across all regions be zero.

The age and gender composition of net migration to each region is determined by the initial period net migration rate for region, the population of each gender and age in a region at one time, and a positive global adjustment factor determined so that the constraint. While the sum of net migration is zero, which satisfied for each gender g of age a at time t, it measures the flow of net migrants of each gender and age to a region at one time. As this flow may not be globally balanced, it needs an adjustment. But this has come at a price. A fixed net migration rate implies that if a region has been a net recipient of immigrants in the base year, then it remains so for all future years irrespective of its economic performance and vice versa.

3.2 Database and Population module

This study primarily applies the "2006 Taiwan industry Input-Output Table" made by the Directorate-General of Budget, Accounting and Statistics

(DBAS), Executive Yuan, also refer to the industry, commerce and service census, national Income Account by DBAS, population statistic by the Department of Household Registration, M.O.I. (DHR), and 'population projection of Taiwan from 2012 to 2060' by the Council for Economic Planning and Development. The data are constructed by two parts; 2006 Industry Input-Output table (includes capital stock) and 2011 population of Taiwan by ages.

(a) Structure of 2006 Input-Output table

The Input-Output Table made by the DBAS, Executive Yuan demonstrates the industries structure and the co-exist relationship of departments, it also shows the flows of currency and human capital in domestic economy system. The rows are the distribution of goods and the columns are the structure of industry departments or terminal demands.

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Other	Change in Inventories
	Size	I	I	1	1	1	1
Basic Flows	C x S	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Taxes	C x S	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	V6TAX
Capital	1	V1CAP					
Labour	O	V1LAB					
Land	1	V1LND					
Other Cost	1	V1OCT					

I＝Number of Industries,
C＝Number of Commodities,
O＝Number of Occupation Types,
S＝1.Domestic 2.Imported.

	Joint Production Matrix
Size	I
C	MAKE

	Import Duty
Size	1
C	V0TAR

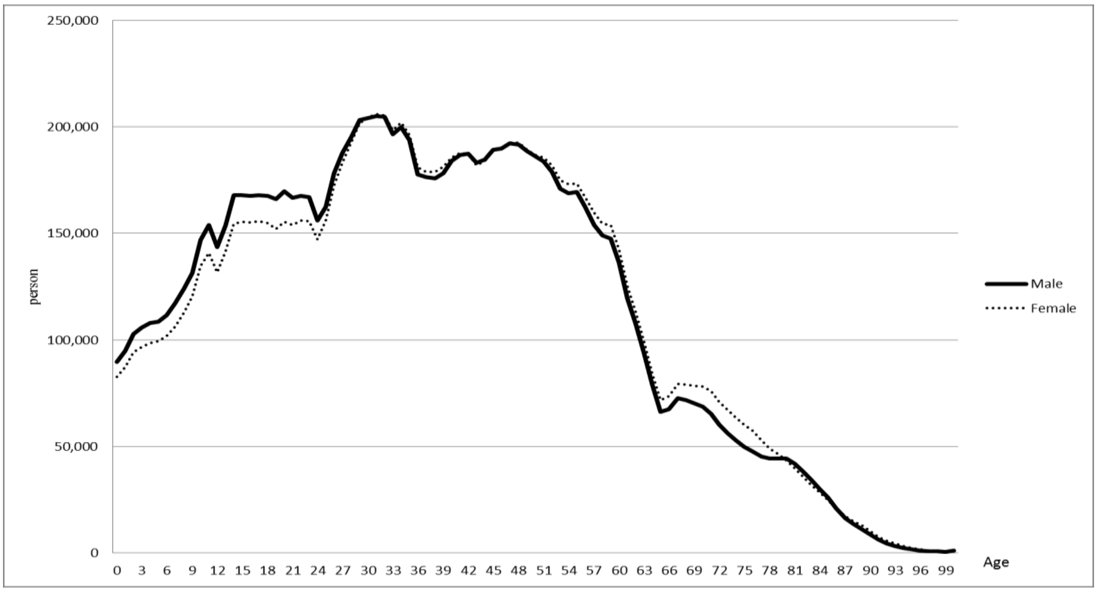
Figure 3-1 Structure of Input-Output Table

This paper builds GEMTEE model database includes three sectors: absorption matrix or called used matrix maintains all demand departments, make matrix maintains all supply departments, and Import duty vector matrix.

Moreover, in this model the classification of departments follows the 2006 Taiwan Industry Input-Output Table made by the DBAS, Executive Yuan, and combines 116 departments into 50 departments. We use the 2006 total capital stock NTW $31.27 trillion dollars from ‘2006 National Statistic’ by the DBAS and real used capital and related department from ‘2006 industry, commerce and service census’ to estimate the detail capital stock for 166 or 50 industry departments.

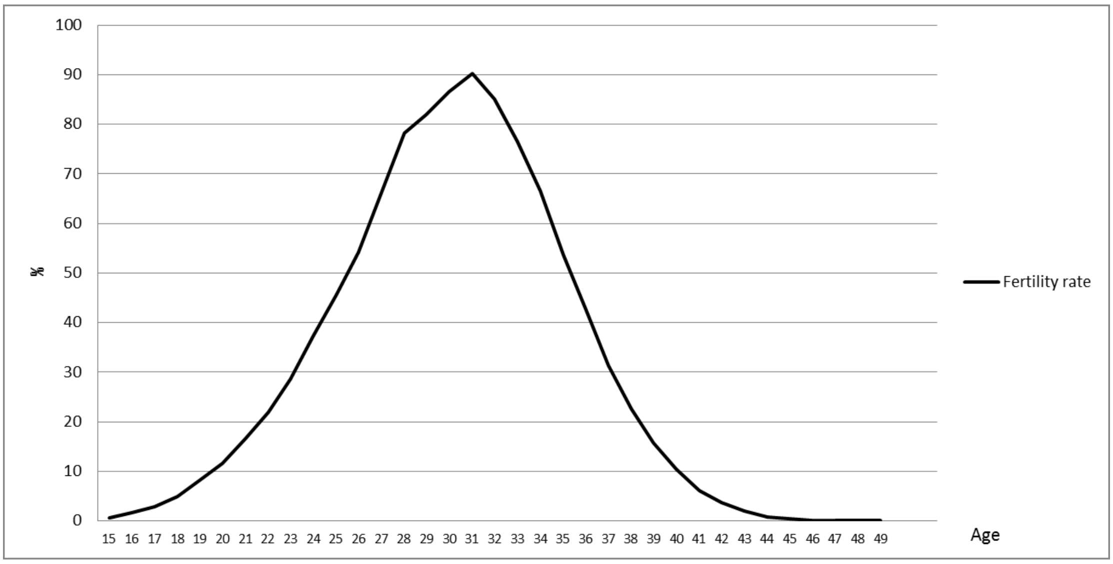
(b) 2011 population of Taiwan by ages

This study collects and arranges the annual population statistic published by Ministry of the Interior. The data includes population per age and per gender (Figure 3-1), women fertility rate from age 15 to 49 (Figure 3-2), life expectancy (75.98 for men and 82.65 for women for 2011), mortality (Figure 3-3), and net migration (by genders immigration and emigration (table 3-2)).



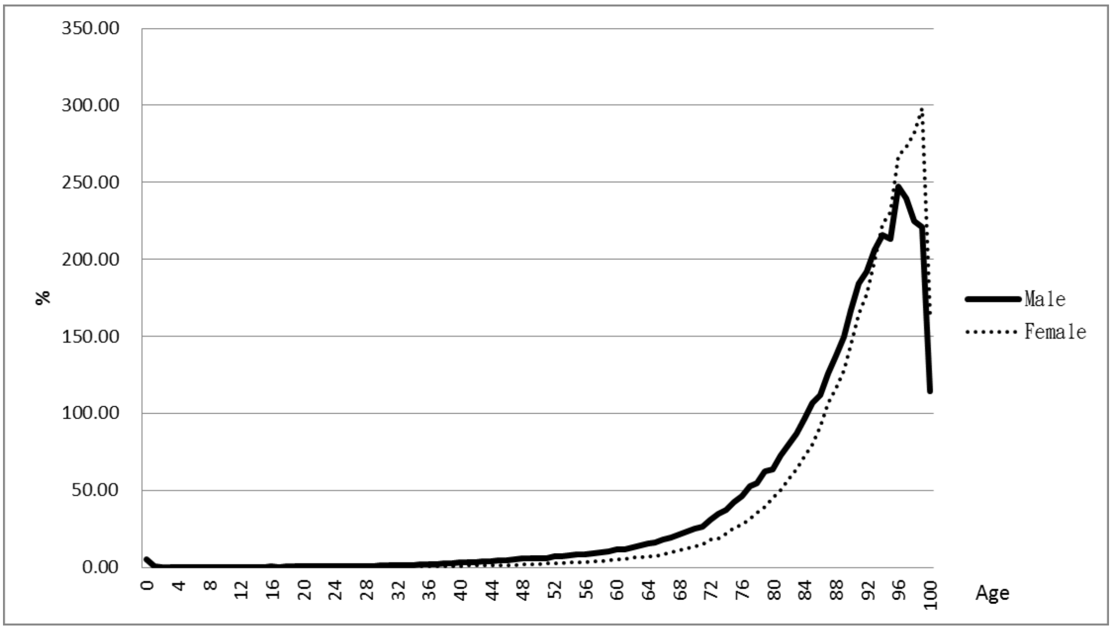
Sources：Department of Statistic, Ministry of the Interior (2012)， Civil Affairs from Statistical Yearbook of Interior

Figure 3-1 Gender structure of population 2011 (by single age)



Sources：Department of Statistic, Ministry of the Interior (2012)， Civil Affairs from Statistical Yearbook of Interior

Figure 3-2 Fertility rate of 15-49 years old women 2011 (by single age)



Sources：Department of Statistic, Ministry of the Interior (2012)， Civil Affairs from Statistical Yearbook of Interior

Figure 3-3 Mortality rate for male and female 2011 (by single age)

Tabel 3-2　Migration 2011

unit：person

Migration	Emigration	Immigration
Total	51,523	71,198
Male	23,795	26,361
Female	27,728	44,837

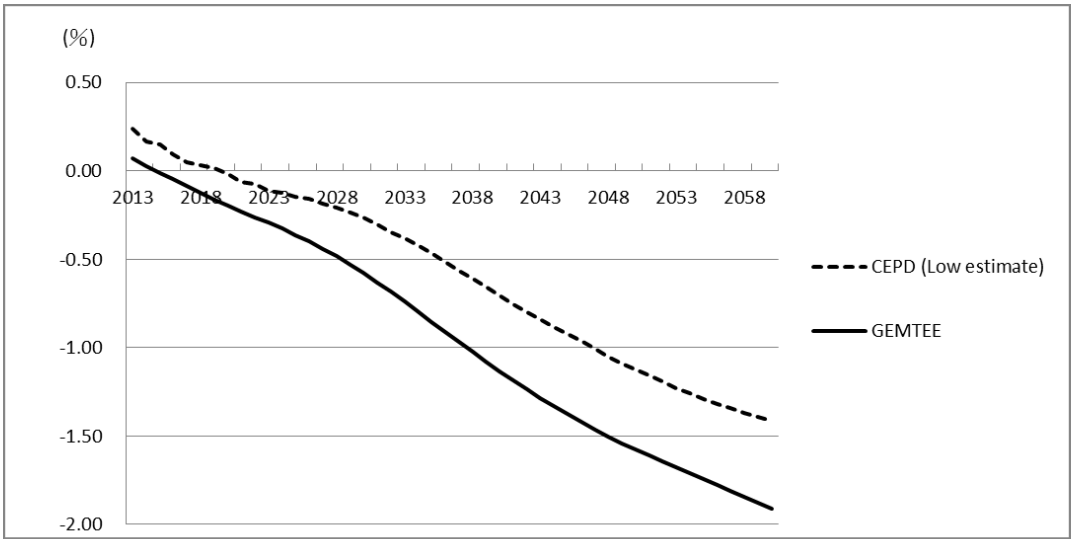
Sources：Department of Statistic, Ministry of the Interior (2012)， Civil Affairs from Statistical Yearbook of Interior

IV. Analysis of Population Projects and Economic Impacts

This study uses computable general equilibrium model, GEMTEE, which including dynamic population module to forecast the baseline of Taiwan population in the future，and compared with the Cohort-Component Method adopted by the Council for Economic Planning which forecasts the baseline projections of the population in 2060. It mainly includes: the comparison of population estimation method, the estimates of total population trend, three-stage age population, aging level, and labor forces. Furthermore for facing the declining birth rates and the aging trend in the future, this study simulates and analyzes its impact and influence on Taiwan's economy.

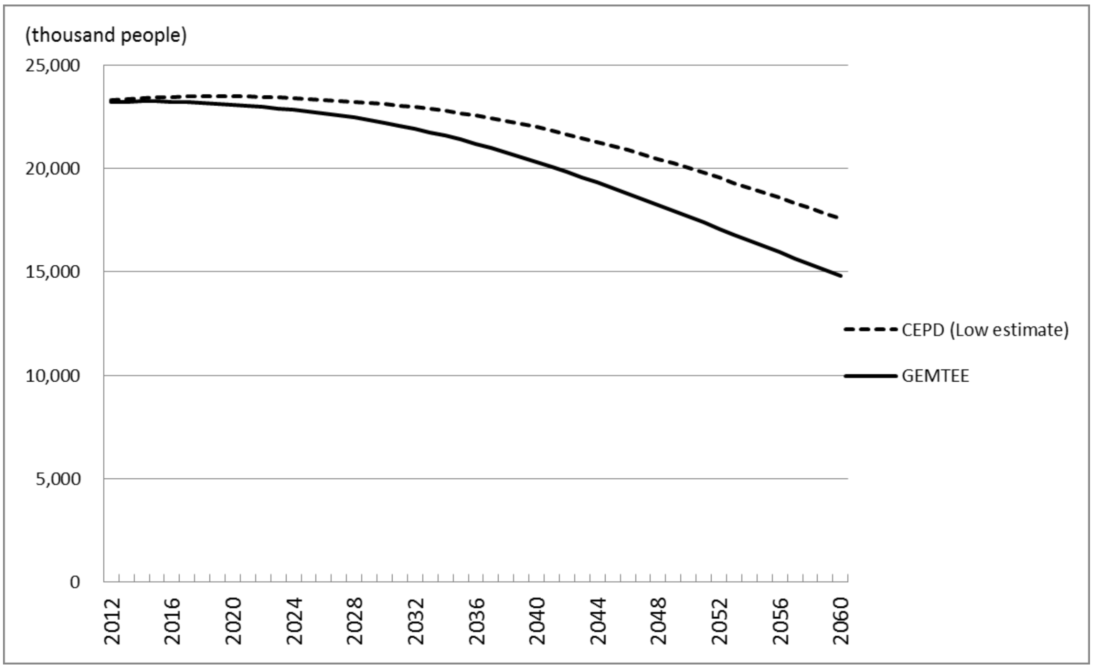
4.1 The comparison of estimate of total population trend

According to CEPD due to the fertility rate has fallen in the past 50 years, it is inevitable that the total population growth is going to become negative in the future. The total population will increase year by year from 2,331.3 million in 2012, and starts decreasing in 2019 which will reach the peak of 2,348.8 million, and decrease to 1,757.9 million in 2060. Compared with the year 2012, the highest peak in the total population number will increase to 17.5 million, and decrease 573.4 million in year 2060. The population growth rate will be 0.38% in 2012, and drop to -1.42% in 2060 (Figure 4-1). However, the future total population trend estimated by GEMTEE is more negative than the one by GEPD (2012). It estimates that total population in 2060 will be 1,478.8 million, which reduces 814.2 million; the population growth rate is -1.91%. Considering the different income impact of high, medium and low groups, the prediction of total population by GEMTEE is less about 279 million than CEPD's. (Figure 4-2)



Source: CEPD (2012) and our research

Figure 4-1 The comparison of changes in population growth from 2013 to 2060, GEMTEE and CEPD



Source: CEPD (2012) and our research

Figure 4-2 The comparison of population baseline from 2013 to 2060, GEMTEE and CEPD

4.2 Comparison of different age population

CEPD predicts that young population (0-14 years old) will be continued to decrease from 340.7 million in 2012 to 136.3 million in 2060. The population of young adults (15-64) will continue to increase from 2012 to 2015, reach a peak and begin to reduce to 875.4 million in 2060, and the percent of the total population ratio will decrease to 49.8%. Older population (65 years and older) will be a substantial increase of 746.1 million, and the percent of the total population ratio will rise to 42.4% in 2060. The GEMTEE simulation results in Figure 4-3. We can find that the three-stage age population in GEMTEE's prediction, especially in the elderly population over the age of 65, is less than CEPD's about 197 million people which is because of the difference of average life assumption. It doesn't not take any measures in the face of the future elderly social welfare or medical subsidy, so the expected average life will not rise, the elderly population will face a greater shock (dying earlier). The major three-stage population differences are shown in Figure 4-4 (The population prediction of GEMTEE deducted CEPD's).

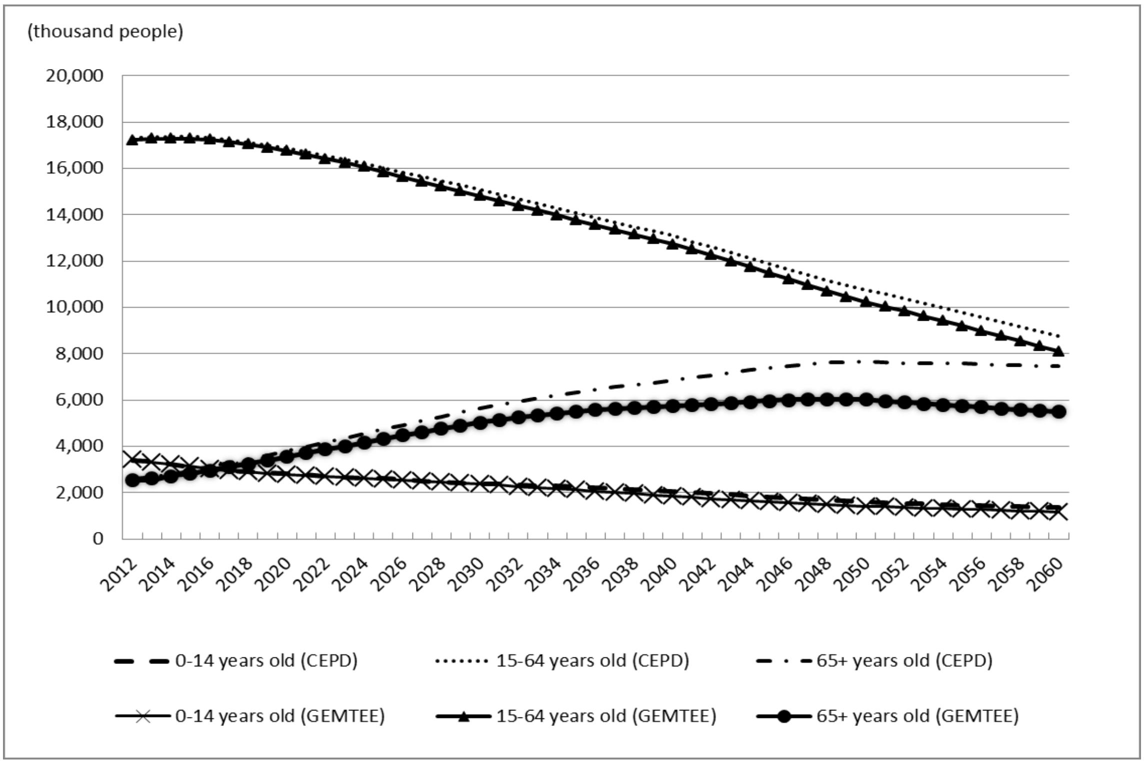


Figure 4-3 The comparison of three ages structure, GEMTEE and CEPD

Source: CEPD (2012) and our research

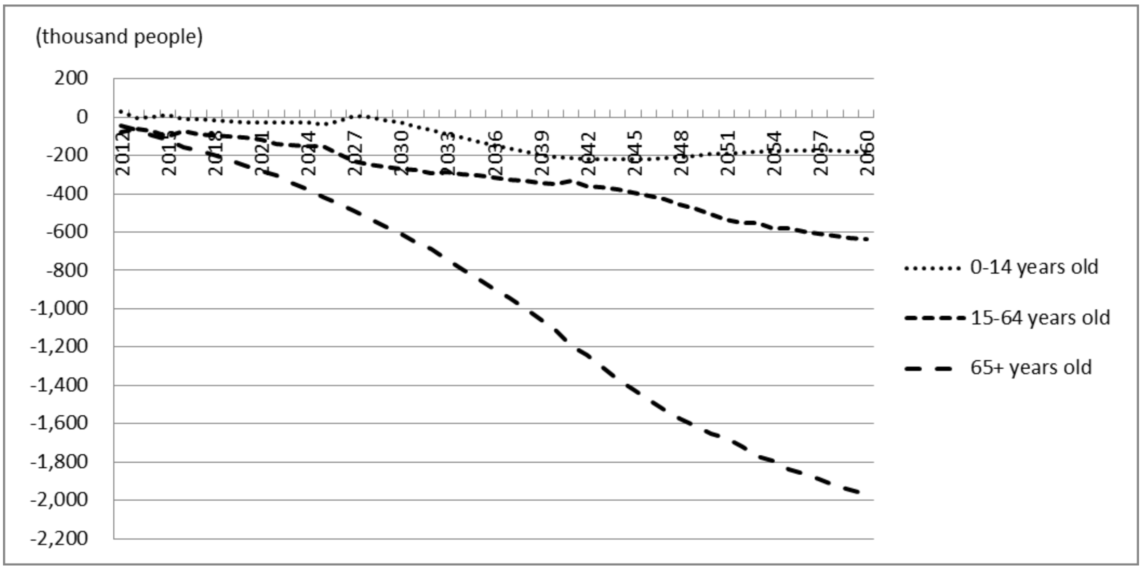
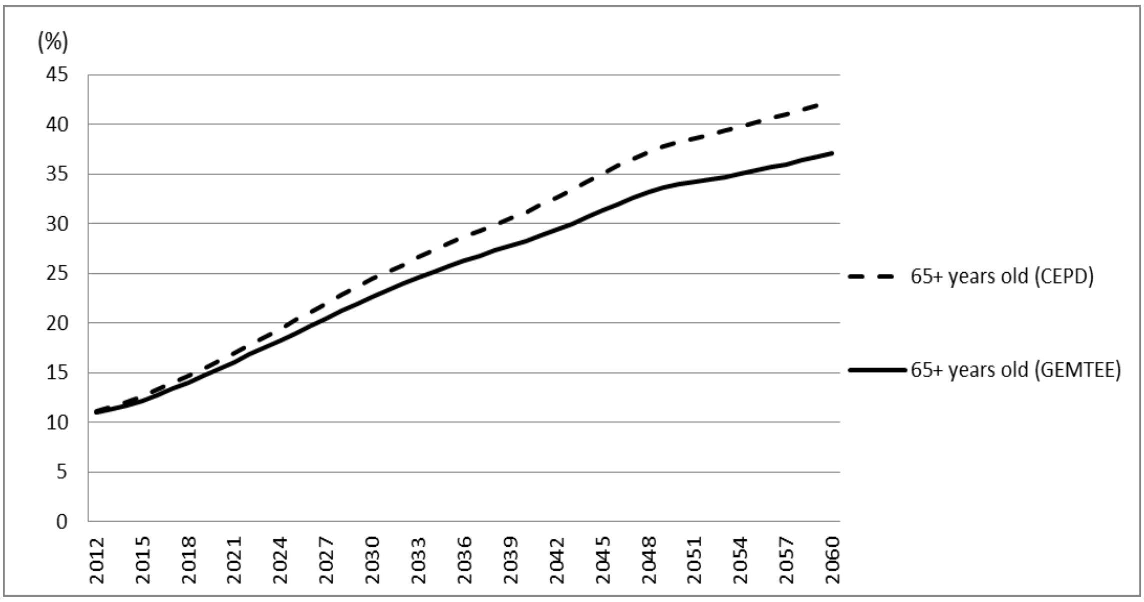


Figure 4-4 The comparison of the difference of three ages structure, GEMTEE and CEPD

Source: CEPD (2012) and our research

4.3 Aging Level

Based on the conclusion statistics and estimated by CEPD (2012), the elderly population in the total population is more than 7% in 1993, which made Taiwan become an aging society; infer that the ratio will be over 14% in 2018, and Taiwan will become aged society; by 2025, this ratio will be further than 20%, and Taiwan will enter into the member of super-aged society. The results from GEMTEE show that while economic growth rises slowly and without elder welfare or medical benefit in the future, life expectancy will not goes up. That is the reason why the percentage of population above 65 years old is lower than the prediction by CEPD (2012). (Figure 4-5)



Source: CEPD (2012) and our research

Figure 4-5 The percentage of 65 years old in total population, GEMTEE and CEPD

Additionally every one hundred of working age (15-64 years) population burdens with 35 people of dependent population (young population and elderly population) in 2012. And because of the rapid increase in the elderly population, the amount will rise to 100 people in 2060. While predicted in GEMTEE model, dependency ratio is 35 people in 2012, and will grow to 82 in 2060. In addition, the aging index is the population aged over 65 divided by the population under the age of 14, and then multiplied by 100, which is an important indicator used to measure the degree of aging of the population in the area. According to the prediction of GEMTEE model, aging index is about 74.4 in 2012 (76.4 in CEPD's low estimation), approximately 167.3 in 2025 (180.5 in CEPD's), and will grow to 464.3 in the future 2060 (547.5 in CEPD's). In the figure 4-6, aging population in the future estimated by GEMTEE is less than CEPD, so the dependency ratio and the elder dependency ratio estimated by GEMTEE will be lower than that estimated by CEPD. But, no matter the forecast by CEPD or GEMTEE, structure changes of the future population will build more serious issues about young and old care.

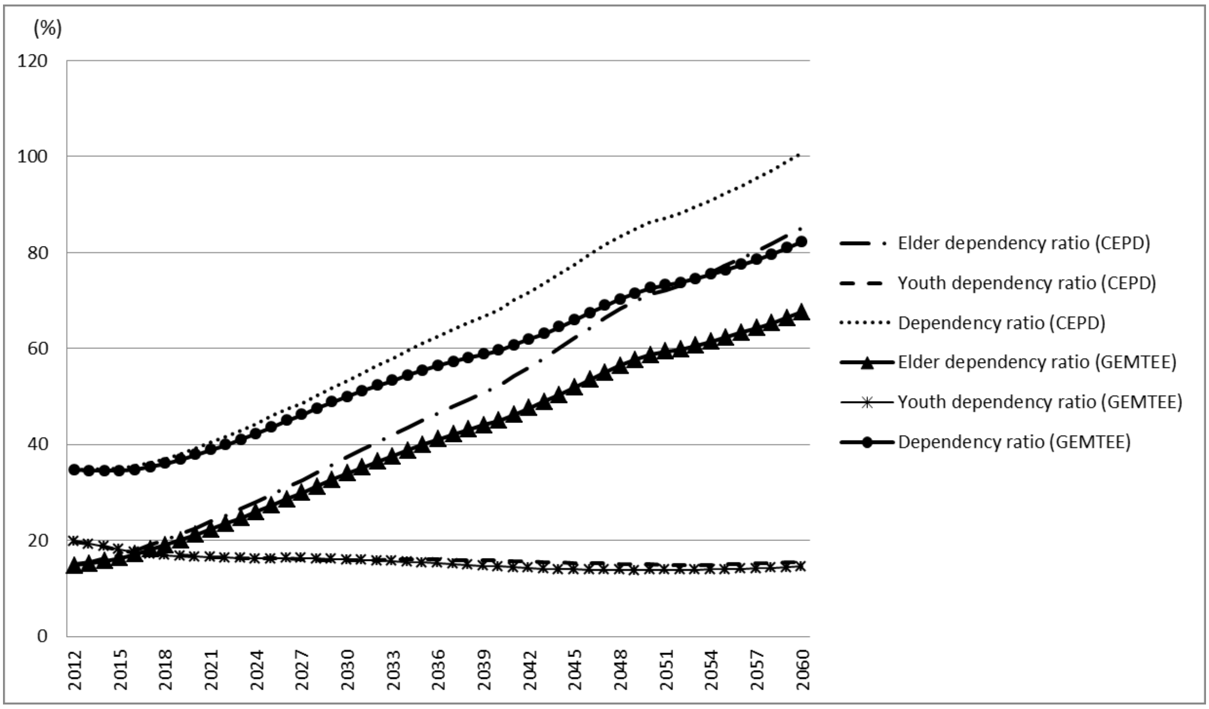
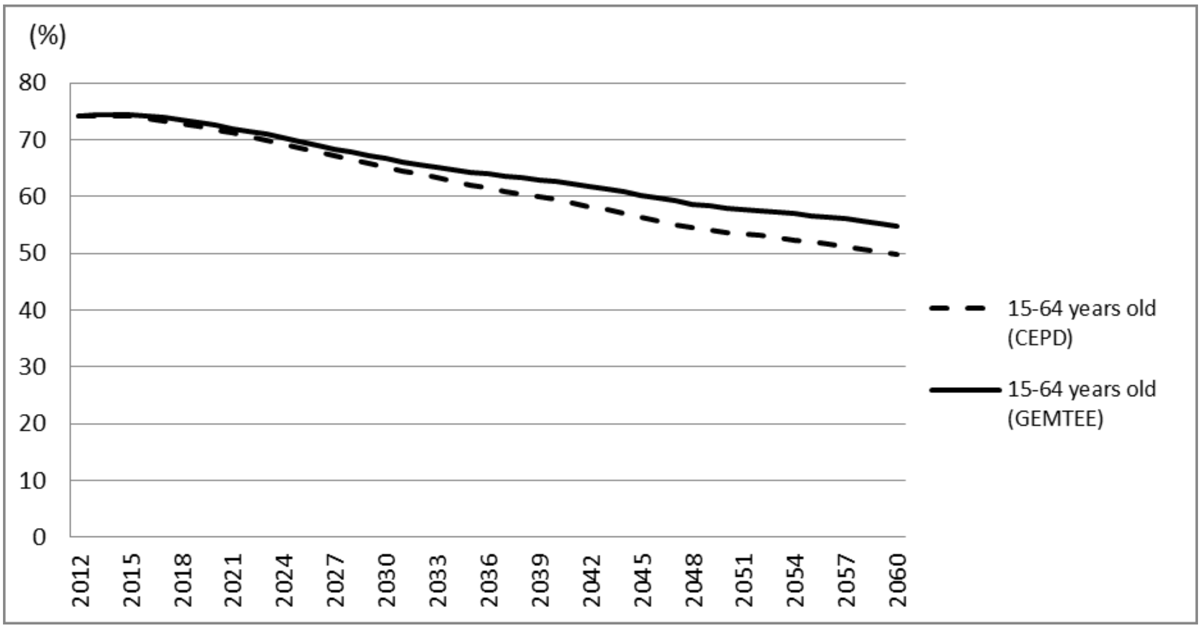


Figure 4-6 Dependency ratio, young dependency ratio, and elder dependency ratio, GEMTEE and CEPD

Source: CEPD (2012) and our research

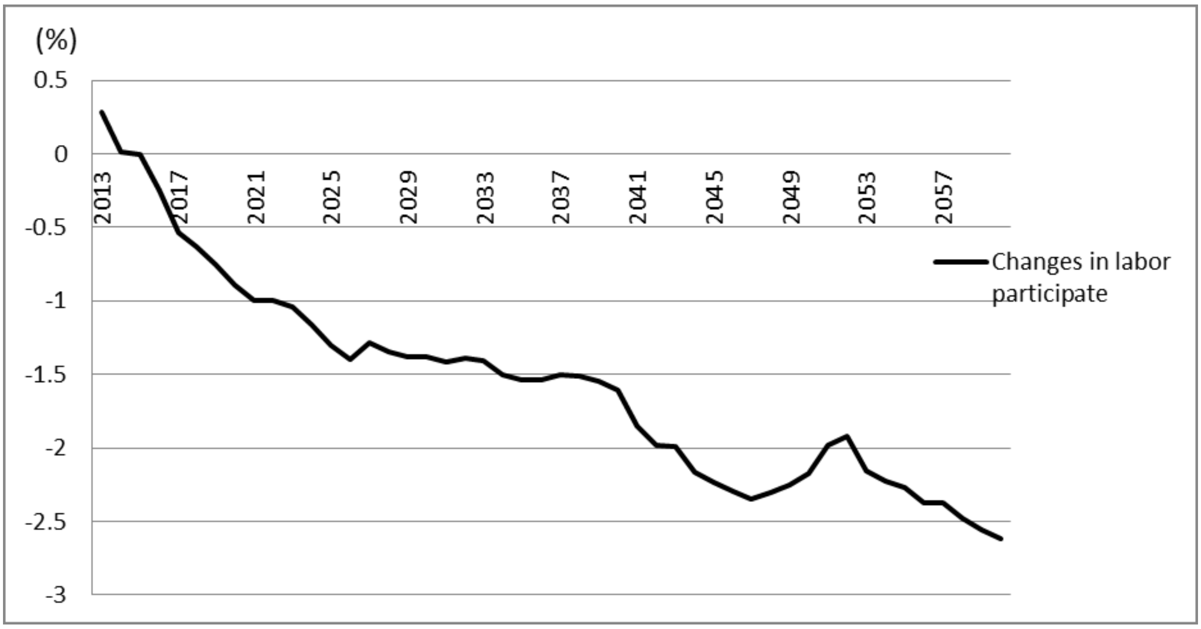
4.5 Labor Forces

Estimated that the future born population decline leads to atrophy of entering into the job market after 15 years gradually (Figure 4-7). About 70% of the labor force will decrease to about 50% in 2060. Moreover, the labor force decline in Taiwan is much larger than in other countries. It can be found by the estimate of GEMTEE; labor supply in Taiwan to 2060 will decrease average 1.55% annually (Figure 4-8). Therefore, the industries needing labor face the labor shortage first. Over the last decade, Taiwan introduces a large number of workers from abroad, partly reflecting the shortage of labor.



Source: CEPD (2012) and our research

Figure 4-7 The percentage of 15-64 years old in total population, GEMTEE and CEPD



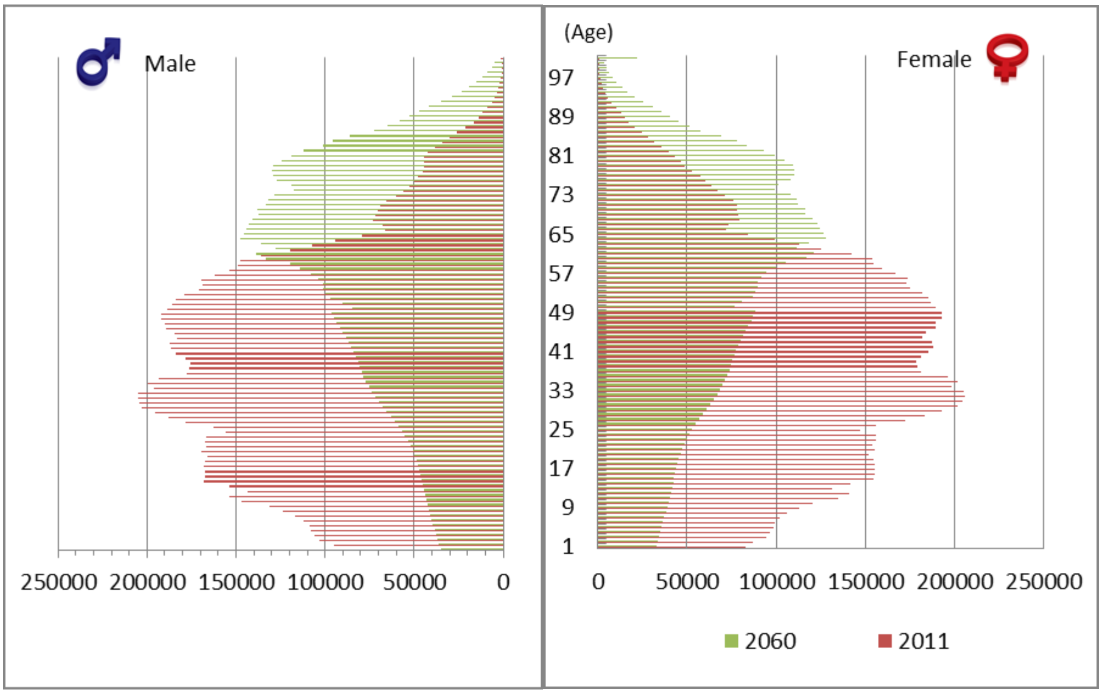
Source: Our research

Figure 4-8 The projection of labor supply from 2013 to 2060 by GEMTEE

The average age of the labor force is gradually rising, and then the workforce is aging (Figure 4-9). In the labor force in 2012, the highest peak in the population age distributes in the 30-35 year-old, moves to right of 51-55 years old in 2035, and moves to 60-65 years in 2060, which makes a very serious problem of the aging workforce. Willingness and ability to absorb new knowledge in the higher age of employees is probably to decline, in this era of technology innovation, the aging of the workforce will be adverse effect. (Skirbekk, 2003).

Figure 4-9 The projection population in 2012, 2035 and 2060 from GEMTEE
Source: Our research

To analyze the gender structure through population pyramids, the population pyramid is a inverted and it means that labor supply is abundant. But the GEMTEE simulation results (Figure 4-10) that the shape of population pyramid will transform into a poured gourd-type in 2060, the social burden will be heavier relatively, and recession in the female labor force in the future will be greater than the male.

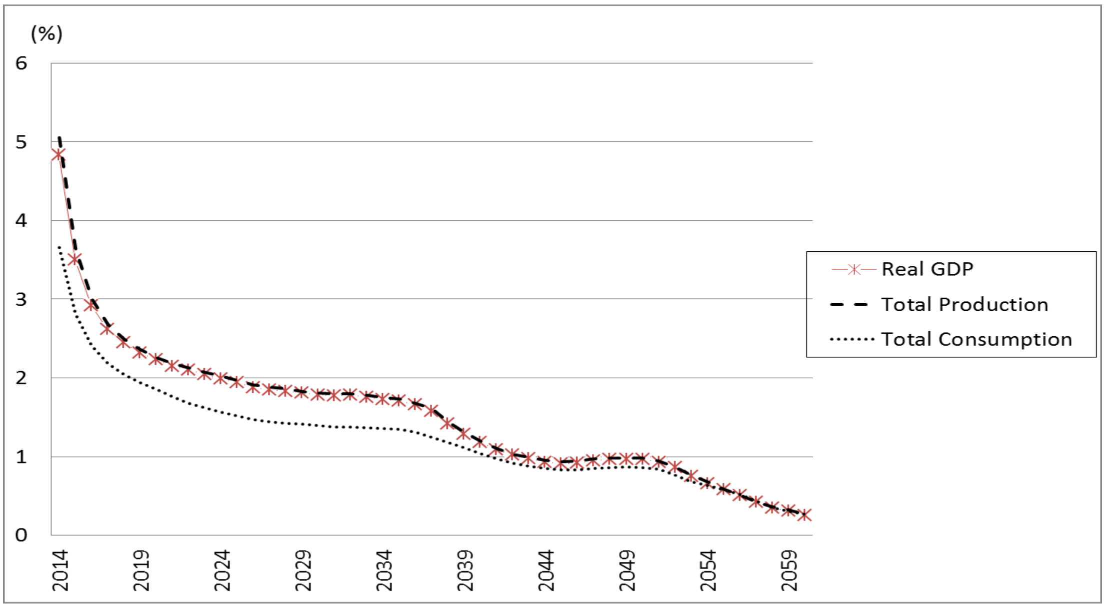


Source: Our research

Figure 4-10 The comparison of population pyramid in 2011, GEMTEE

4.6 Impact for Taiwanese economy

In the case of the current policy does not change, if the fertility rate continues to decline, the population structure will have a tendency to low birth rates and aging, and the labor force will decline; With the population decline and the changing population structure linked to reduced labor supply, regardless of GDP, the total output or total consumption will decrease by 2.4% per year from 2051 to 2060. It can be seen that population issues will inevitably cause shocks for the overall economic development of Taiwan in the future (Figure 4-11).



Source: Our research

Figure 4-11 The changes in real GDP, total production, and total consumption from 2013 to 2060 by GEMTEE

I. Conclusions and Suggestions

Recently, according to the extension of the life expectancy and the continuously increasing percentages of late marriage, non-marriage, late births, fewer births, and even non-births, the problem of aging society and fewer children becomes an unavoidable issue in public concern. However, the proper policy depends on the proper estimation of population size and structure. So far, the future population trend determined by government is mainly based on the CEPD population projection; however, it is widely believed that the fertility rate will be affected by economic issue such as personal revenue, and is one of the endogenous variables of the economic growth model. In other words, the population projection should take the endogenous fertility rate of those economic issues such as personal revenue into concern. Therefore, this article builds GEMTEE dynamic computable general equilibrium to see the interactive feedback affected between population module and macroeconomic module. It endogenously decides fertility and mortality rate, and predicts the baseline of Taiwan population from 2012 to 2060. The results are used to compare with population projections by CEPD (2012), and analyze the impacts of low fertility and aging on Taiwan economy.

According to the past 50 years, the fertility rate in our country is in a long term decreasing trend; thus, the negative overall population growth will be an unavoidable trend in the future. Furthermore, GEMTEE estimates that the decreasing rate of the future overall population will be more severe than CEPD's prediction; the country will has a population of only 14.79 million in 2060, which is 8.1 million less than now, and the population growth rate is -1.91%. GEMTEE has taken the effect of revenues from different classes into concern, so the estimation of the future overall population shows a 2.79 million less than CEPD's.

GEMTEE population projection also shows fewer amounts in all 3 stages of age; majority in the population over 65 years old, it's about 1.6 million. The main reason might be the different assumptions in average lifetime. Facing the truth that the social welfare or medical allowances won't have any changes for elders in the future, GEMTEE estimate the average lifetime won't increase, so the elder population will be decreased in long term concern. For the level of aging, our country has become an aging society in 1993, and the population over 65 years old grew to 12% of the overall population in 2010 based on the report of CEPD. Compared with the other nearby countries in Asia, the ratio of the aging population wasn't specifically severe. But under the estimation of GEMTEE, the proportion of the aging population will increase to 40% in 2060, a more rapid and severe aging of population than other countries; the dependency ratio and elder dependency ratio are less than the estimation of CEPD, but the problem of aging is growing rapidly and worse compared with other countries. Therefore, making the population structure changes rapidly and facing a more severe problem of caring the elders and children.

GEMTEE estimate the average labor supply will decrease 1.56% annually to 2060, and the primary age of labor supply will be 60-65 years old, compared with 30-35 years old in 2012. The problem of the aging labor population not only forces us to import the laborers from other countries to solve the impact of the continuous labor supply shortage, but also reduce the desire and ability to absorb new knowledge, making our country's labor population less competitive in this creative era.

Under the assumption that the related policies won't be altered, the continuously decreasing fertility rate (overall fertility rate = 1.065) will make the population structure tend to aging society with fewer children and the labor supply decreasing (average -1.56%). In the sight of the overall economic development of Taiwan, the impacts are that the annually growth is -0.82% for GPD, -0.8% for overall productivity, and -0.72% for domestic consumption. In brief, Taiwan will suffer from a lasting economic recession. On the other hand, the GDP per capita will still shows an increase because the decrease of the population is greater than GDP. After the increase of the personal revenue, the fertility rate will still be low if we don't hold any policy to encourage the birth, and thus will make the problem of aging society with fewer children still.

In conclusion, taking the effect of economic issues into concern, the changes of population structure is expected to make the low fertility rate more severe. And for the problem of aging society, the more elders will die earlier if no related policies are provided. Besides the problem of aging society with fewer children, the shortage and aging of the labor supply in Taiwan may cause the crisis of economic recession in the future. Our government should make related policies as soon as possible to deal with the underlying economic crisis.

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