Baseline Forecasting for Population Ageing and Greenhouse Gas Emissions in Taiwan: A Dynamic CGE Analysis

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[Draft. Please do not quote.]

April 15, 2013

Abstract

Rising life expectancy and dwindling fertility rates in Taiwan over the past few decades may lead to a negative population growth as well as accelerated aging trend. Together, they are leading to a large and enduring impact on carbon emissions trajectories following changes in the aggregate mix of goods and services consumed and produced. The main purpose of this study is to quantify the impact of population aging on carbon dioxide (CO_2) emissions baseline using GEMTEE (General Equilibrium Model for Taiwanese Economy and Environment), which is a dynamic, multi-sectoral CGE model with an endogenous population module. This study incorporates both direct and indirect effects of demographic transition on carbon emissions through the labor market dynamics and energy substitution mechanism to enhance the forecasting performances of GHGs emissions and macroeconomic variables. Our long-term projections for 2060 indicate that (a) a 36% of population decline by 2060 as compared to 2012 will lead to a steady-state annual growth of 0.24% in real GDP by 2060; (b) carbon emissions would fall by 74.4%, from 4.375 billion tons in 2012 to 1.119 billion tones by 2060; and (c) sectors such as residential, education services, and transportation sectors will decline more dramatically than the other sectors. Thus, failure to account for the demographic changes will distort the baseline projections of carbon emissions and in turn affect the institution of domestic regulation and international negotiations.

Keywords: Greenhouse gases emissions, demographic transition, ageing, dynamic computable general equilibrium model.

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1. Introduction

Building a low carbon society with new low-carbon energy supply which can replace the use of fossil fuels and reducing requirements for production of new material (Allwood 2013). Low-carbon electricity, transportation, tourism and consumer side are at the core of a sustainable energy system (IEA 2012, Horng et al. 2013, Wu et al. 2013, Waisman et al. 2013, Paloheimo and Salmi 2013), that can reduce greenhouse gases emission to meet target of 2°C Scenario (2DS) (Kainuma et al. 2013, UNFCCC 2010) and managing the risks of extreme events and disasters (IPCC 2012). Governments of countries in the world must play a decisive role in encouraging the shit to efficient and low-carbon technologies from now on (IEA 2012). The 2DS explores the technology options needed to realize a sustainable future based on greater energy efficiency and a more balanced energy system, featuring renewable energy sources and lower emissions (IEA 2012). Nordic countries which include Denmark, Finland, Iceland, Norway and Sweden, have announced ambitious goals named “carbon-neutral scenario” towards decarbonising their energy systems by 2050 (Nordic energy research 2013). The development of low-carbon energy is the key component of the post-petroleum era (Lund 2010, Panwar et al. 2011).

To achieve targets for low-carbon society, 2DS scenario of UNFCCC for Tokyo Protocal, regulations or constraints were be executed by cap-and-trade rules and voluntary carbon market. In Taiwan, government promote corporation carbon accounting and reporting system and ISO 14064 standard to achieve the principles and targets of voluntary carbon mitigation and Nationally Appropriate Mitigation Actions (NAMAs). The actions can reveal precise greenhouse gases inventory of Taiwan. According to World Resource Institute (2004), improving company’s GHG emissions by compiling a GHG inventory can manage GHG risks, identifying reduction opportunities, participating in GHG markets and recognition for early voluntary action. Advanced countries also promote GHGs accounting and report system to mitigate possible negative effects on GHGs (UK DEFRA 2009, 2011, US EPA 2007).

For tracking accurate GHGs emission trends and developing mitigation strategies, policy makers usually use the GHGs inventory as the first step to establish a baseline forecasting of future GHG emissions (Robinson 2011, US EPA), and to evaluate the success of our efforts and compare GHG emission levels overtime. Population growth and economic development have caused increasing demand of energy demand and greenhouse gases emissions (Pongthanaisawan and Sorapipatana 2013) in transportation sector (Zachariadis 2006), electricity (Özer 2013, Cohen 2010, Nag and Parikh 2005), regions (Majoumerd et al. 2012, Kløverpris and Mueller 2013) and countries such as Finland (Eneroth 2005), China and India (Blanford 2012), Pakistan (Ali and Nitivattananon 2012). Endogenous economic growth and GHGs emissions depend on technological advances, knowledge and capital accumulation, increased efficiency and population. As an energy-economic baseline forecasting model, which must be applied data that capture a possible economic and population future values, and the baseline results thus obtained will reveal the baseline potential of GHGs emissions for kinds of scenarios. Lack of population as a baseline inputs may mislead the GHGs emission.

Aging and dwindling fertility rates in Taiwan over the past few decades have made demographic policies top of the agenda. According to official statistics in Taiwan, the total fertility rate in Taiwan already declined to 1.065 in 2011, which is far below the suggested replacement rate of 2.1 for sustainable population. The situation may lead to negative population as well as a trend of fast aging population. Consequently, carbon emissions trajectories may vary accordingly following population driven changes in demand and production, and decoupling with economic growth and carbon emission still not be realized. Population, economic growth and carbon emission are influenced each other in normal situation.

Most of computable general equilibrium (CGE) models used for baseline forecasting with exogenous population prediction input as labor supply, which is so-called "soft link" between exogenous population module and CGE model. Population input may come from prediction by outer institution (Lisenkova et al. 2008, Bruan et al. 2009, Fouge`re and Harvey 2006, Fougère et al. 2009, Thurlow et al. 2009, Lueth 2003, Ferguson et al. 2007), or models such as overlapping generation (OLG) model (Seryoung and Hewings 2007, Fougère et al. 2007, Fehr et al. 2010, Fehr et al. 2008, Fehr 2009, Wendner 2001) or multi-sector infinitely lived agent (ILA) model (Melnikov et al. 2012, O'Neill et al. 2012, Dalton et al. 2008, O'neill et al. 2010, Jimeno et al. 2006). Population and economic status mutually influence each other, implies soft link between two models may mislead the results of baseline forecasting. Hellmuth et al. (2006) uses population, water and CGE model to evaluate HIV/AIDS effects on Botswana, but population model are specified for HIV/AIDS infection.

Tendency towards population aging and carbon dioxide (CO2) emissions baseline in this paper are based on forecasting results from GEMTEE (General

Equilibrium Model for Taiwanese Economy and Environment), which is a dynamic, multi-sectoral, computable general equilibrium (CGE) model of the Taiwan's economy, developed specifically to analyze population aging and climate change response issues (Lin et al. 2013, Pant 2002). The core economic module of GEMTEE is derived from the Australian ORANI model and the MONASH model. Noteworthy features of the GEMTEE model are the linked population module with endogenously determined rates of fertility and mortality.

The goal of this study is to compare the future CO2 emission baseline, with and without endogenous population module in GEETEE model. Contribution of this study is to modify original GEMTEE model to incorporate energy substitution mechanism that can reveal practical inter-energy substitution and coverage of GHGs emissions, and describe the differences results for above issues with and without endogenous population trend. This study consists of the followed sections, including introduction, population module of GEMTEE and its linkage with the economic core of GEMTEE, data processing, scenario design, carbon emissions baseline for Taiwan, and discussion sections.

2. The Model

2.1 The GEMTEE Model

The GEMTEE model is developed by Academia Sinica in Taiwan and the Australian Bureau of Agriculture and Resource Economics and Sciences (ABARES) (Lin et al. 2013), imitating the Australian GTEM model (Pant 2002) and its featured population dynamic model to establish computable general equilibrium model for economy of Taiwan. GEETEM is one of dynamic CGE model which incorporates the dynamic recursive mechanism of baseline forecasting and policy simulation with the endogenous investment and endogenous expected returns for industries (Dixon and Parmenter 1996). The major characteristic of GEMTEE model is it includes an endogenous population module that most of the literatures do not incorporate before. The population module describes changes in population scale and changes by age and gender groups over time periods. In GEMTEE model, the changes in population are one of the important factors that can affect economy, especially for the population change on baseline forecasting including real capita income, fertility per ages, and mortality per ages and genders. Hence, the changes in personal income influence fertility, mortality, migration, and population change. The structure of ages and gender is decided endogenously, and then turn out the scale of labor force, and finally, the scale of labor force decides the labor supply.

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. Humans are the terminal consumers of goods and services, while providing labor force and capital needed for producing. Consequently, the association of all producing and consuming in the economic system and population module actually helps to ascertain that the population changing works on the estimation of future macro economy and valuation of industry developing. Population and macroeconomy will be affected mutually in annually recursive simulation.

2.2 Endogenous population module

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. However, it is not certain whether the decline in fertility has a steady state at the replacement level or world population will start to slump. GEMTEE can simulate the scenario that the total fertility stabilizes at the replacement level of 2.1 or at any specific level.

The population module consist of five sub-modules to describe changes in population scale and changes by age and gender groups over time periods while macro economy is correlated with. First sub-module is Population cohorts, which is the core of the population model is the 100 years of age and two sexes cohort structure. Second sub-module is fertility rate, which is for later periods are perturbed with the change in per capita income. Total fertility at convergence is below replacement fertility (2.1 children per woman) in the base case, and fertility would fall even further as incomes rise. Third sub-module is life expectancy, which is postulated to evolve with rises in income per person using elasticity based on a similar weighting procedure to that applied to birth rates, and assume to continue to increase with economic growth. Note also that medical technology is assumed to primarily benefit the rich. The fifth sub-module is mortality rates, which is updated by assuming that all age-cohorts have the same proportional change in mortality rates. The final sub-module is net migration, which calculates the inflow of net migrants of each gender and age over time to 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.

In OECD economies, both birth rates and mortality rates have declined with rising per person incomes. The overall impact has been to reduce the rate of population growth (after allowing for immigration). A similar pattern has been evident in rapidly growing Asian economies. Changes in population, by gender, and by one-year age groups (one-year cohorts) from 0 to 100 years, are determined by the model for each region. Since the growth in population between time periods is the result of births, deaths and net migration, equations are needed to determine these variables on an age and gender basis. Equations are also needed to determine the transition between different age groups in each time period.

2.3 Energy substitution and interconnection between population module and nested structure for production

GEMTEE allows each industry to produce several commodities, using as inputs domestic and imported commodities, labor of several types, land, capital, energy of several types and “other costs”. In addition, commodities destined for export are distinguished from those for local use. The multi-input, multi-output production specification is kept manageable by a series of weak separability assumptions, illustrated by the nesting shown in **Fig. 1** where the production structure of the non-electricity sectors of GEMTEE model is shown.

The input demand of industry production is formulated by a five-level nested structure, and the production decision-making of each level is independent. Assuming cost minimization and technology constraint at each level of production, producers will make optimal input demand decisions. At the top level, commodity composites and a primary-factor composite are combined using a Leontief production function. Consequently, they are all demanded in direct proportion to the industry activity. At the second level, each commodity composite is a CES (constant elasticity of substitution) function of domestic goods and the imported equivalent (the armington assumption). Energy and primary-factor composites are a CES aggregation of energy composites and primary-factor composites. At the third level, the primary-factor composite is a CES aggregation of labor, land, and capital, and the energy substitution composite is a CES aggregation of coal products composites, oil products composites, natural gas products composites, and electricity.

There are two major features of modified GEMTEE model in this study at the fourth level. The most important feature is the energy substitution mechanism in third level which is developed by Hsu et al. (2000). To describe reasonable industrial structure in a modified GEMTEE model, this study incorporates four energy substitutions nested structure for GHGs forecasting includes coal product composition, crude oil product composition, natural gas product composition and electricity sector. Coal products composite is a CES aggregation of coal and coal products; the crude oil products composite is a CES aggregation of gasoline, diesel oil, fuel oil, and kerosene; the natural gas products composite is a CES aggregation of refinery gas, gas, and natural gas. At the bottom level the energy composite is a CES aggregation of domestic goods and imported goods. The energy substitution and population module will be the major conditions that this study wants to discuss. As a traditional ORANI-type model's behavior, price of energies will reallocate the energy usage between sectors. And also, GEMTEE is a Johansen-type linearization CGE model.

The second one is the labor inputs decided by equilibrium of labor market. Labor demand function comes up with traditional composite nest by occasions. Labor supply comes up with endogenous population module developed by this study. Population module is related to per person's real income and age-specific birth rates, and age and gender specific mortality rates. Therefore, changes in personal income affect fertility and mortality, and if given net migration rates, population changes are endogenously determined. The changes in age and gender composition of the population, in turn, determine changes in the working age population. As the size of the working age population determines the supply of labor, which contributes to the determination of economic outcomes, the interdependence between the economic core and the population module of GEMTEE is thus established. Finally, labor market follows the optimal behavior setting by the nest and decides the equilibrium, wages and quantities. As mentioned above, the population module for labor supply and economic performance will be feedback to each other to reach the recursive mutually interactiveness.

The output structure of GEMTEE allows the ORANI-type model that each industry to produce a mixture of all the commodities. Moreover, conversion of an undifferentiated commodity into goods destined for export and local use is governed by a CET (constant elasticity of transformation) transformation frontier. The formulas and equations for nested structure of GEMTEE model are similar to Dixon et al. (1986), Dixon and Rimmer (2002) and Pant (2002).

3. Data and scenario design

3.1 Data processing

This study builds GEMTEE database by 2006 benchmark input-output (IO) table in Taiwan and modified to fit the requirements of GEMTEE model. For clearer description and convenient comparison for energy sector and population-related sectors, original 166 sectors of benchmark IO table are merged into 50 sectors and 6 sectors (named agriculture, energy, industrial, residential, services and transportation) to show the details (**Table 1**). This study also needs the capital stock for recursive simulation, and provided by national statistics.

GEMTEE model modifies the elasticity of energy substitution and nested structure by local situation recently in Taiwan. CES elasticities for coal composition, oil composition, gas composition, electricity composition are setting by 0.25, 0.25, 0.5, 0.2 and 0.2. The CES elasticities set by 0.2 between four kinds of energy compositions. The elasticities between primary inputs are setting by 0.5, and 0.5 between energy composition and primary inputs composition.

This study primarily applies the population statistic by the official statistics and population projection of Taiwan from 2012 to 2060. This study collects and arranges the annual population statistic published by Ministry of the Interior. The data includes population per age and per gender, women fertility rate from age 15 to 49, life expectancy (75.98 for men and 82.65 for women for 2011), mortality, and net migration (by genders immigration and emigration). Any other kinds of parameters set in population module provided by Lin et al. (2013).

3.2 Scenario Design

Three types of simulations are made routinely with GEMTEE model. The first is historical simulation that uses for generating up-to-date data. Since models designed for forecasting contain dynamic equations that require initial conditions from the base year. Forecasts can be rather sensitive to these initial conditions. Moreover, through the historical simulations, we can calibrate detailed patterns of changes in technology and household tastes over the historical period (**Table 2**).

The second is forecasting simulation that is designed for us to incorporate into the forecasts as much specialist information as is available, allowing us to project prospects for likely developments in the structure of the economy. The third is baseline forecasting or policy simulations that are conducted by projecting deviations from an explicit control path, or showing the effects of policy changes or other shocks of interest (e.g., GHG mitigation policies).

Historical closures include in their exogenous set two types of variables: observables and assignables. Observables are those for which movements can be readily observed from statistical sources. Historical closures vary between applications depending on data availability. When forecasting the baseline, it needs the results of technology movements and taste movements that are solved by historical simulation. Thus, in the historical closure, the technology movements and taste movements are endogenous variables. In the forecasting closures, the exogenous variables are varied during the forecasting period and the closures must be modified to incorporate these new exogenous variables (**Table 3**).

For the CO_2 baseline forecasting, this study considers the period from year 2007 to year 2060. The benchmark database of GEMTEE model is the 2006 input-output tables. This study performs two scenarios to compare whether the endogenous population module should be considered into the baseline projection of CO2 emission from 2013 to 2060.

Scenario I: baseline projection of CO_2 emission from 2013 to 2060, without population projection module.

Scenario II: baseline projection of CO_2 emission from 2013 to 2060, with population projection module.

4. Results

4.1 Macroeconomic impacts and CO2 emission forecasting

Table 4 shows the results of scenario I (without population module) with macroeconomic variables, which is convergent, and till 2060 the real GDP attains a 2.47% of steady-state annual growth. It is a sign that the economy of Taiwan economy isgetting mature, with most of macroeconomic variables growing at a low rate annually. Apparently the economy development of Taiwan has slowed down due to the slowing in investment, consumption, technology advancement, rate of return, and increasing of prices of energy, inputs and commodities. In the scenario II (with population module and the low fertility rate), the total population of Taiwan will decrease from 23.19 million people in 2006 to 14.83 million people in 2060.

Therefore, the real GDP steadily falls to 0.24%, similar trend with other variables, and also much lower than scenario I. Population decline will affect economic growth slowdown, and also because of the mutual feedback effect (**Fig.2**).

Base on the official statistics for Taiwan, the total amount of CO2 emission is 286 million tons in forecasting year 2012. In scenario I, CO2 emission will be 1.965 billion tons in year 2060. When considering the possible population decline, it will be 1.119 billion tons in 2060 (**Table 4 and Fig.3**). The ratios that CO2 emission in year 2060 divided by year 2012 for two scenarios will be 6.87 and 3.91 times. It implies that population will play an important role in a long-term forecasting, especially the forecasting errors should be accumulated year by year. Results for two baselines show that if the future population decreased, the economic growth will slow down then decrease the CO2 emission and energy relevant index.

4.2 CO2 forecasting in sectoral level

For industrial, residential, energy, transportation, service and agricultural sectors, population decline effects will decrease the total amount of CO_2 emission by 585, 111, 105, 83, 39 and 6 million tons in year 2060 (**Table 5**). Turning to growth rate is quite different situation. CO2 emission decrease by population decline will be residential sector by -62.36%, followed by energy sector (-46.46%), industrial sector (-46.06%), transportation sector (-40.29%), agriculture sector (-35.29%) and services sector (-27.86%). If the total population decreases in the future, it means the demand of household consumption decreasing, then the amount of CO_2 emission are going to decrease as well. The table 6 brightens that in different scenarios, industrial sector will be the leading CO2 emission sectors, and others are all declining (**Fig. 4** and **Fig.5**).

5. Discussion

Scenario I shows real GDP will increase from USD 404.739 billion in year 2012 to USD 1.794 trillion in year 2060, and scenario II shows the real GDP will much lower in year 2060 by USD 1.234 trillion. The annual geometric growth rates of real GDP for with and without endogenous population are 3.15 % and 2.35%. Effects on other macro variables are similar. Results for two scenarios reveal that population will affect the macroeconomy of a country, especially for the long run effects. CO2 emission for scenario I will increase from 0.286 billion tons in year 2012 to 1.965 billion tons in year 2060, and scenario II is also much lower in year 2060 by 1.119 billion tons than scenario I. The annual geometric growth rates of CO2 emission for two scenarios are 4.07 % and 2.86%, imply that endogenous population will affect the CO_2 heavily, as well as other greenhouse gases emission.

Because of the mutual link mechanism between population and GDP, and mutual link between CO_2 emission and GDP in GEMTEE model, results reveal that the aspects affect each other mutually. The differences between with and without population module will be significantly larger for long-term forecasting. Results reveal that population factor should be seriously considered for policy evaluation to gather accurate forecast results. Most of the literature do not incorporate endogenous population mechanism will mislead the CO_2 emission forecasting, underestimate for countries with increasing population, and overestimate for countries with decreasing population.

For comparison of CO_2 emission intensity (CO_2 emission equivalent divided by real GDP) by national level in year 2060, scenario I and II will be 1.2933 and 1.2169 separately, it means that taking account of population in a dynamic CGE model for forecasting will show a lower CO_2 intensity for actual situation. Moreover, the real GDP created by CO_2 emission (real GDP divided by CO_2 emission equivalent) will be 0.7732 and 0.8217, imply that one unit CO_2 emission will create more real GDP when considering population status. Two kinds of indices are shown larger efficiency and lighter burden for global warming. Results remind that when calculating the energy or environmental related indices, making policy, even international negotiation for GHGs, proper simulation tools should be adopted for accurate and fair results.

Interestingly, the comparison of CO_2 emission intensity by six sectors level (CO_2 emission equivalent by six sectors divided by real GDP by six sectors) in year 2060, results of scenario II (with population module) are quite different from scenario I by sector level. Residential sector will be the most decreasing sector in CO_2 intensity for -13.61%, followed by service sector for -7.85%, transportation sector for -7.29%, energy sector for -3.97%, industrial sector for 3.80% and agricultural sector for -2.56%. The results are reasonable because of the different aging, population and labor supply structures provided by endogenous population module in GEMTEE model. The larger decreasing sectors such as residential sector, service sector and transportation sector are highly linked by aging, fertility, death, population, and labor supply. Results imply that policy maker should pay more attention to the sectoral impacts by future GHGs mitigation and climate-proof policies and regulations, and also provide accurate welfare for people in each countries in international climate change and global warming issues.

In two scenarios, results describe that growth rate of CO_2 will be higher than real GDP, which implies the energy efficiency could be treated as an important tool to improve and mitigate the effects on global warming in Taiwan. Considering the "decoupling problem" between CO_2 and GDP, the long-term baseline forecasting reveal the decoupling for CO_2 emission and GDP growth will not be realized without corrected mitigation policy, but population mechanism could make results more accurate. Annual geometric growth rate of CO_2 minus annual geometric growth rate of GDP scenario I and scenario II will be 0.92% (4.07% minus 3.15%) and 0.51% (2.86% minus 2.35%), imply that the differences between CO_2 and GDP will be smaller with population declining and aging, and may be caused by different resources reallocation of industry or consumption behavior. Decoupling problem will be slightly easier to solve by further policy execution.

It is also interesting for whether the energy substitution mechanism adopted in this study may make difference. For comparison of results by Lin et al. (2013) and this study, the real GDP for this study (USD 1.234 trillion) will be larger than Lin et al. (2013) (USD 1.216 trillion), and population for this study (14.835 million people) will be slightly smaller than it (14.838 million people). With adequate energy substitution mechanism in this study, resources will be reallocated between sectors by economic behavior, especially the population module of GEMTEE model will provide reasonable labor supply and labor market reallocation then past literature. Forecasting parameter includes energy prices increasing imply price mechanism of energy substitution will be affects the energy and resources reallocation. Results reveal that energy substitution mechanism does needed in a long-term forecasting econometric model and can make results fit the actual situation and more reasonable.

To sum up, policy makers should adopt better evaluation tools such as comprehensive econometric model with endogenous population module and energy substitution module to obtain reasonable, accurate and prevent over-estimate and under-estimate results for GHGs emissions and macroeconmic performance to improve the accuracy and efficiency for GHGs mitigation policies in national, regional and global level. Policy makers should focus on increasing population in the future such as Africa (1.046 billion people in year 2011, 3.574 billion people in year 2100) or Asia (4.207 billion people in year 2011, 4.596 billion people in year 2100) (UNPD 2011) to control GHGs emission, and the counties with decline population may have slight pressure on GHGs mitigation.

6. Conclusion

This study modifies the comprehensive and advanced GEMTEE model with complicatedly endogenous population by incorporating energy substitution mechanism to enhance the forecasting performances of GHGs emission and macroeconomic variables. Results reveal that GEMTEE model with mutually endogenous population module and even energy substitution mechanism will reflect reasonable and real situation for CO2 emission and macroeconomic variables. Most of the literatures did not incorporate the important features that may mislead the global GHGs policy makers. This study reveals that GHGs mitigation policy do need consider the future status of population.

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Figure Captions

Fig.1. The production structure of the non- electricity sectors of GEMTEE model

Fig.2. Real GDP growth of Taiwan for two scenarios

Fig.3. Taiwan's CO2 emissions for two scenarios

Fig.4. Estimated amount of CO2 emission by six sectors. Scenario I.

Fig.5. Estimated amount of CO2 emission by six sectors. Scenario II.

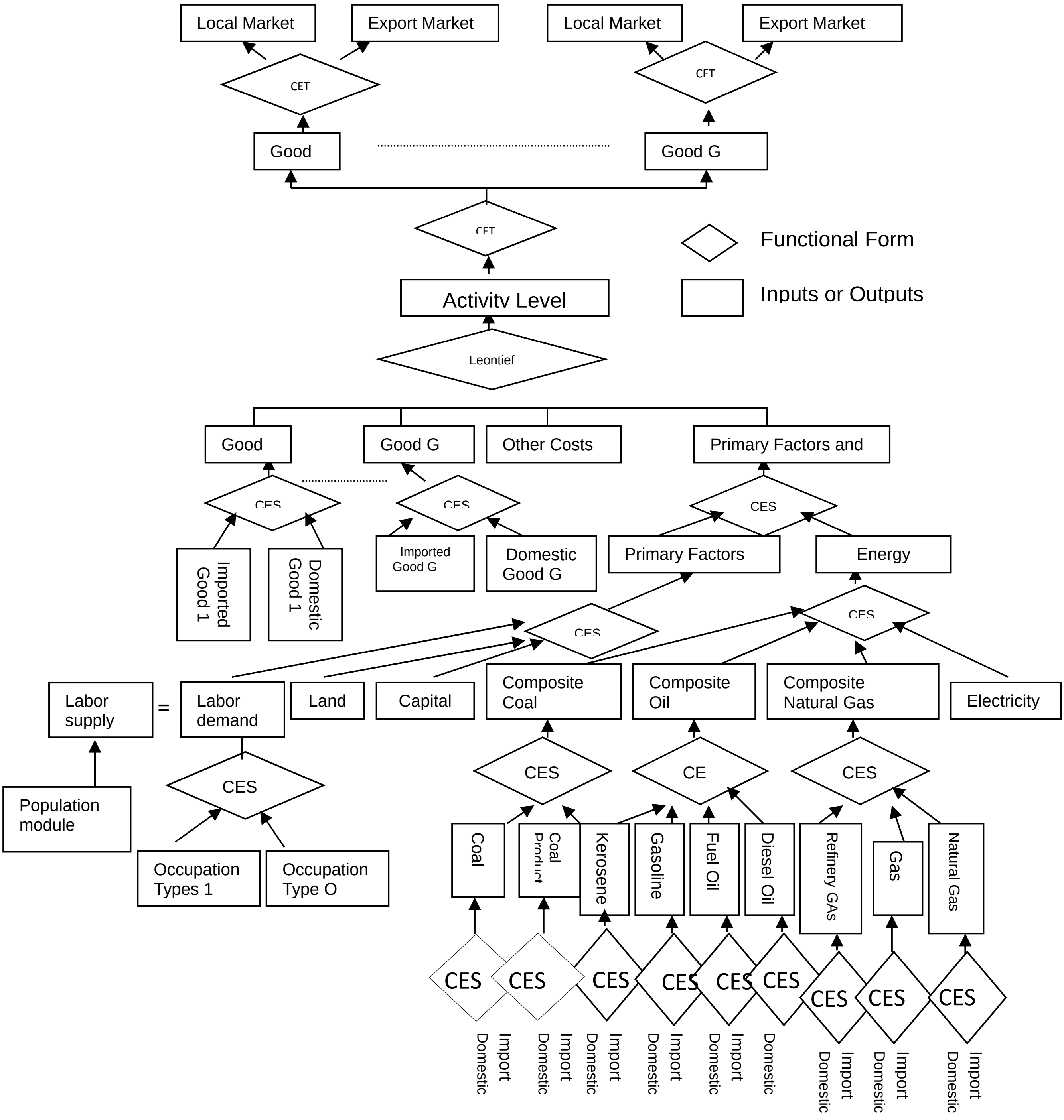
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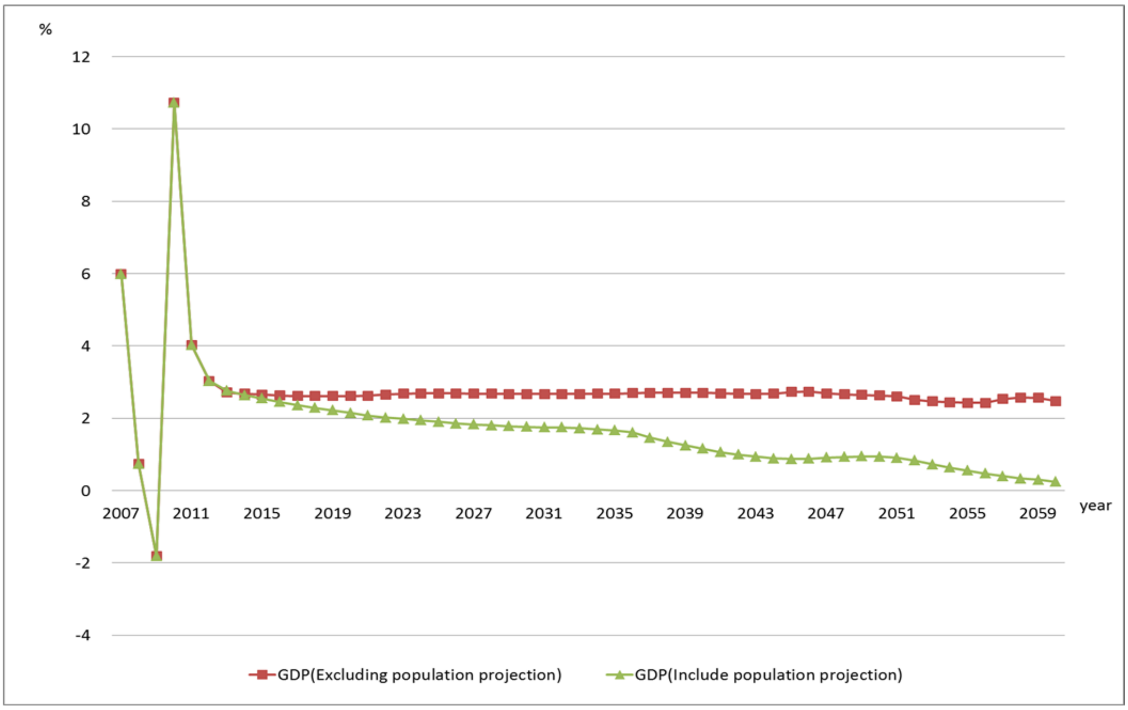
Fig. 1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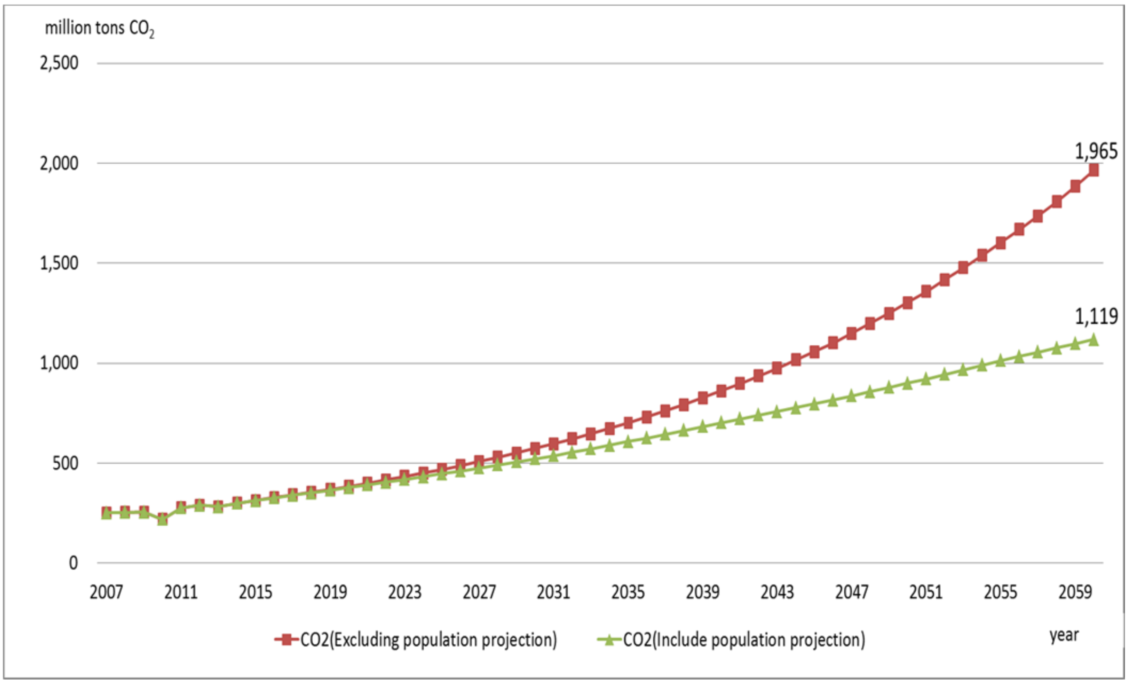
year
GDP(Excluding population projection)
GDP(Include population projection)

Fig.2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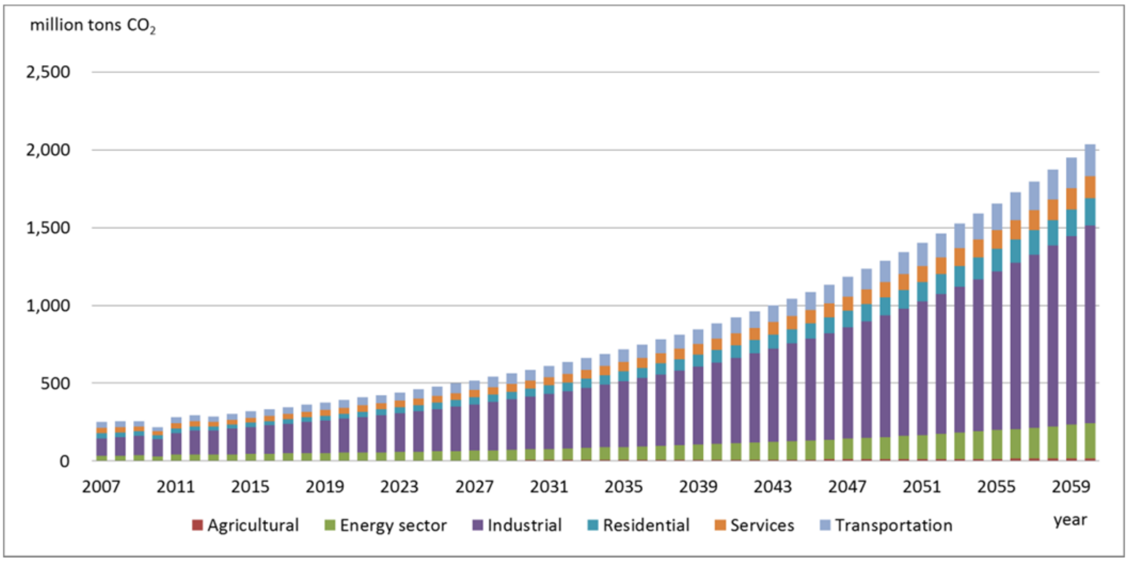
CO2(Excluding population projection)
CO2(Include population projection)

Fig.3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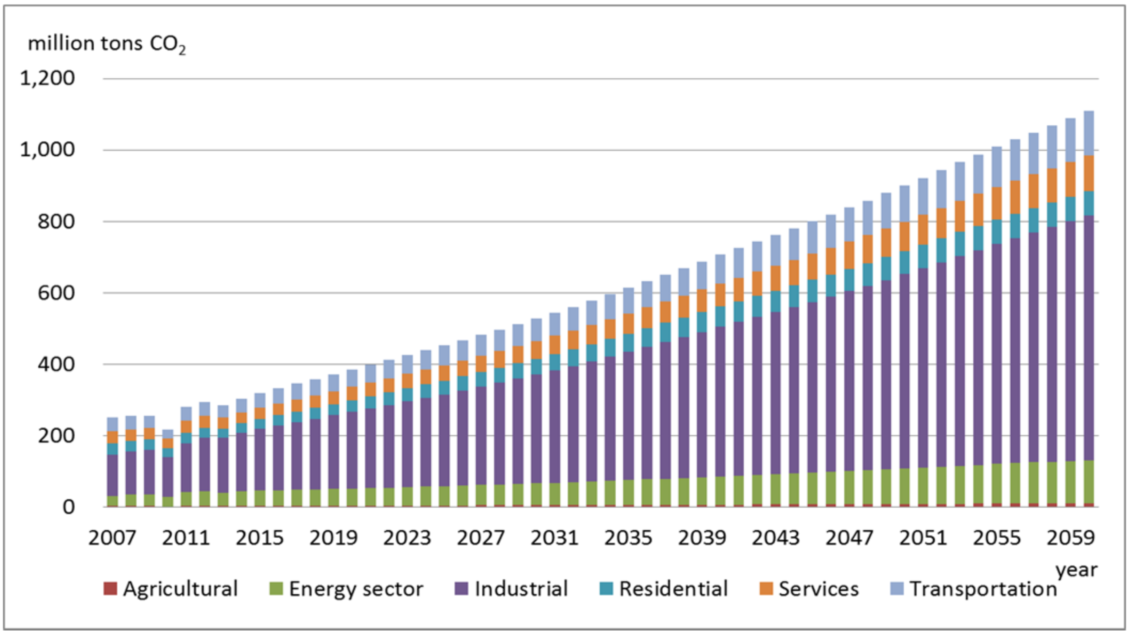
year
Agricultural
Energy sector
Industrial
Residential
Services
Transportation

Fig.4.


million tons CO_2
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800
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200
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2007
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2023
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2059
year
Agricultural
Energy sector
Industrial
Residential
Services
Transportation

Fig.5.

Table 1 List of the aggregated 50 sectors and 6 sectors (from 166 sectors)

Agricultural

- Agricultural products
- Fishery Products
- Forest Products
- Livestock

Energy sector

- Electricity and Steam
- Gas
- Minerals
- Petroleum and Coal Products

Industrial

- Beverages
- Chemical Materials
- City Water
- Construction
- Cosmetics
- Electrical Materials
- Electronic Components and Parts
- Fabrics
- Furniture
- Leather Products
- Machinery and Equipment
- Medicines
- Metal Products
- Motor Vehicles
- Non-Metallic Mineral Products
- Other Metals
- Other Transport Equipment
- Plastic Products
- Primary Iron
- Printing and Reproduction of Recorded Media
- Processed Foods
- Production of Computer, Electronic and Optical Products
- Pulp, Paper and Paper Products
- Remediation
- Repair and Installation
- Rubber Products
- Tobacco
- Wearing Apparel and Clothing
- Wood and Wood Products

Residential

- Real Estate Services

Services

- Accommodation and Food Services
- Arts, Entertainment and Recreation Services
- Educational Training Services
- Finance and Insurance
- Information Services
- Medical, Health and Residential Care Services
- Other Services
- Professional and Technologic Services Subsidies
- Public Administration Services
- Publishing Services
- Support Services
- Telecommunication Services Motor Vehicles
- Wholesale and retail

Transportation

- Transportation and Warehousing

Table 2 Historical Simulation for GEMTEE model

Unit: %

Year	GDP	Private Final Consumption Expenditure	Government Final Consumption Expenditure	Gross Capital Formation	Exports	Imports	Exchange rate
2007	5.98	2.08	2.09	-0.66	9.55	2.98	-0.94
2008	0.73	-0.93	0.83	-7.89	0.87	-3.71	4.12
2009	-1.81	0.76	4.01	-21.22	-8.68	-13.10	-4.60
2010	10.72	3.67	0.58	39.51	25.56	28.23	4.45
2011	4.03	2.97	1.86	-7.88	4.53	-0.68	7.40
2012	3.03	2.03	0.05	-1.70	3.13	0.18	-

Source: DGBAS (2013).

Table 3 Baseline forecasting for GEMTEE model

Items	GEMTEE baseline
1 GDP growth rate	GDP growth rates solved from the model
2 Number of households	Exogenous, shock 1.71%
3 Total factor productivity growth	Exogenous, shock 2.4%
4 CPI	Exogenous, shock 1.336%
5 Industrial structure	Endogenously determined
6 Land use efficiency	Exogenous, shock 1%
7 Inventories demands	Exogenous, shock -40%
8. International crude oil prices	Exogenous, shock 2.54% annually
9. Efficiency of energy use	Exogenous, shock 1.3%

Source: Source: DGBAS (2013).

Table 4 Baseline forecasting for macroeconomic variables and CO2 emissions

Unit: %, million tons CO_2

Year	2007	2013	2020	2030	2040	2050	2060
				Scenario I			
Real GDP	5.98	2.71	2.62	2.67	2.70	2.63	2.47
CO_2 Emissions	251	282	384	573	861	1,303	1,965
Consumption	2.08	1.83	2.16	2.04	2.03	1.91	1.80
Investment	0.19	-33.62	3.34	1.83	1.45	0.99	-0.93
Government	2.09	1.83	2.16	2.04	2.03	1.91	1.80
sExport	9.55	8.27	2.90	3.15	3.18	3.12	2.84
Import	3.06	-0.52	2.66	2.70	2.72	2.68	2.36
Production	0.92	-2.52	4.09	4.11	4.22	4.28	4.33
				Scenario II			
Real GDP	5.98	2.76	2.15	1.76	1.16	0.94	0.24
CO_2 Emissions	251	282	378	521	702	899	1,119
Consumption	2.08	1.87	1.79	1.39	1.03	0.84	0.26
Investment	0.19	-33.58	2.34	1.44	-0.17	0.63	-1.99
Government	2.09	1.87	1.79	1.39	1.03	0.84	0.26
Export	9.55	8.29	2.45	2.16	1.32	1.10	0.59
Import	3.06	-0.48	2.23	1.93	1.11	1.03	0.52
Production	0.92	-2.62	3.64	3.14	2.78	2.46	1.97

Table 5 CO2 emission baseline forecasting for six sectors

Unit: million tons CO_2

Year	2007	2013	2020	2030	2040	2050	2060
				Scenario I			
Agricultural	3	3	4	6	8	12	17
Energy sector	29	38	49	69	101	150	226
Industrial	115	153	218	338	524	819	1,270
Residential	32	26	33	52	79	120	178
Services	35	30	37	52	73	101	140
Transportation	37	36	50	70	99	142	206
				Scenario I			
Agricultural	3	3	4	6	7	9	11
Energy sector	29	38	48	61	79	100	121
Industrial	115	153	214	304	418	543	685
Residential	32	26	33	45	57	65	67
Services	35	30	37	49	65	81	101
Transportation	37	36	49	63	81	102	123

Table 6 CO2 emission shares forecasting for six sectors

Year	2007	2013	2020	2030	2040	2050	2060
				Scenario II			
Agricultural	1.20%	1.05%	1.02%	1.02%	0.90%	0.89%	0.83%
Energy sector	11.55%	13.29%	12.53%	11.75%	11.43%	11.16%	11.09%
Industrial	45.82%	53.50%	55.75%	57.58%	59.28%	60.94%	62.35%
Residential	12.75%	9.09%	8.44%	8.86%	8.94%	8.93%	8.74%
Services	13.94%	10.49%	9.46%	8.86%	8.26%	7.51%	6.87%
Transportation	14.74%	12.59%	12.79%	11.93%	11.20%	10.57%	10.11%
				Scenario II			
Agricultural	1.20%	1.05%	1.04%	1.14%	0.99%	1.00%	0.99%
Energy sector	11.55%	13.29%	12.47%	11.55%	11.17%	11.11%	10.92%
Industrial	45.82%	53.50%	55.58%	57.58%	59.12%	60.33%	61.82%
Residential	12.75%	9.09%	8.57%	8.52%	8.06%	7.22%	6.05%
Services	13.94%	10.49%	9.61%	9.28%	9.19%	9.00%	9.12%
Transportation	14.74%	12.59%	12.73%	11.93%	11.46%	11.33%	11.10%