IR-1.1.2 Studies on the Development of Economic Model for Pan Pacific Region (Final Report)

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Abstract

A lot of economic models have been developed to assess the economical impacts of the global warming policy. They are classified into 2 types, that is, the bottom-up model and the top-down model. The bottom-up model has the advantage in showing the change of the technology choice in detail resulting from the input price change but the disadvantage in describing and analyzing the change of the economic structure. Contrary, the top-down model has the advantage in describing and analyzing the economic structure in detail but the difficulty in describing the concrete image of the technology change. Therefore the linkage of these models makes the more detailed analysis of the policy effects possible because of compensating one model for the disadvantage of another.

The purpose of this study is to examine the methodology of the linkage of the bottom-up model and the top-down model with collaboration with Battelle-PNL and to make a preliminary study of modeling of the linkage. In our study, we explain the theoretical framework for the preliminary model with the linkage. Then, we describe about the model extension of SGM Japan for the preparation of the complete linkage for the future study and show some simulation results by it.

1. Introduction and Research Objective

A lot of economic models have been developed to assess the economical impacts of the global warming policy. They are classified into 2 types, that is, the bottom-up model and the top-down model. The bottom-up model can describe the technology choice among many kinds of technology, which have been collected under the assumption of the cost minimization. The top-down model can describe the behavior of the household, the industry(or the firm), the government, etc by equations and project the economy using the concept of the market equilibrium. The bottom-up model has the advantage in showing the change of the technology choice in detail resulting from the input price change but the disadvantage in describing and analyzing the change of the economic structure. Contrary, the top-down model has the advantage in describing and analyzing the economic structure in detail but the difficulty in describing the concrete image of the technology change. Therefore the linkage of these models makes the more detailed analysis of the policy effects possible because of compensating one model for the disadvantage of another.

Currently, to analyze the effects of the global warming policy in more detailed with the concrete investigation the effects of the introduction and the development of the energy-saving technology, the studies of the linkage of the bottom-up model and the top-down model are demanded.

For the past years, our institute, National Institute for Environmental Studies(NIES) has not only been developing the bottom-up model called AIM but the top-down model called SGM Japan by joining the SGM project organized by Battelle Pacific Northwest Laboratories(Battelle-PNL). The purpose of this study is to examine the methodology of the linkage of the bottom-up model and the top-down model with collaboration with Battelle-PNL and to make a preliminary study of modeling of the linkage. In the following section, we explain the theoretical framework for the preliminary model with the linkage. In the third section, we describe about the model extension of SGM Japan for the preparation of the complete linkage for the future study and show some simulation results by it.

2. Linkage of the bottom-up model and the top-down model

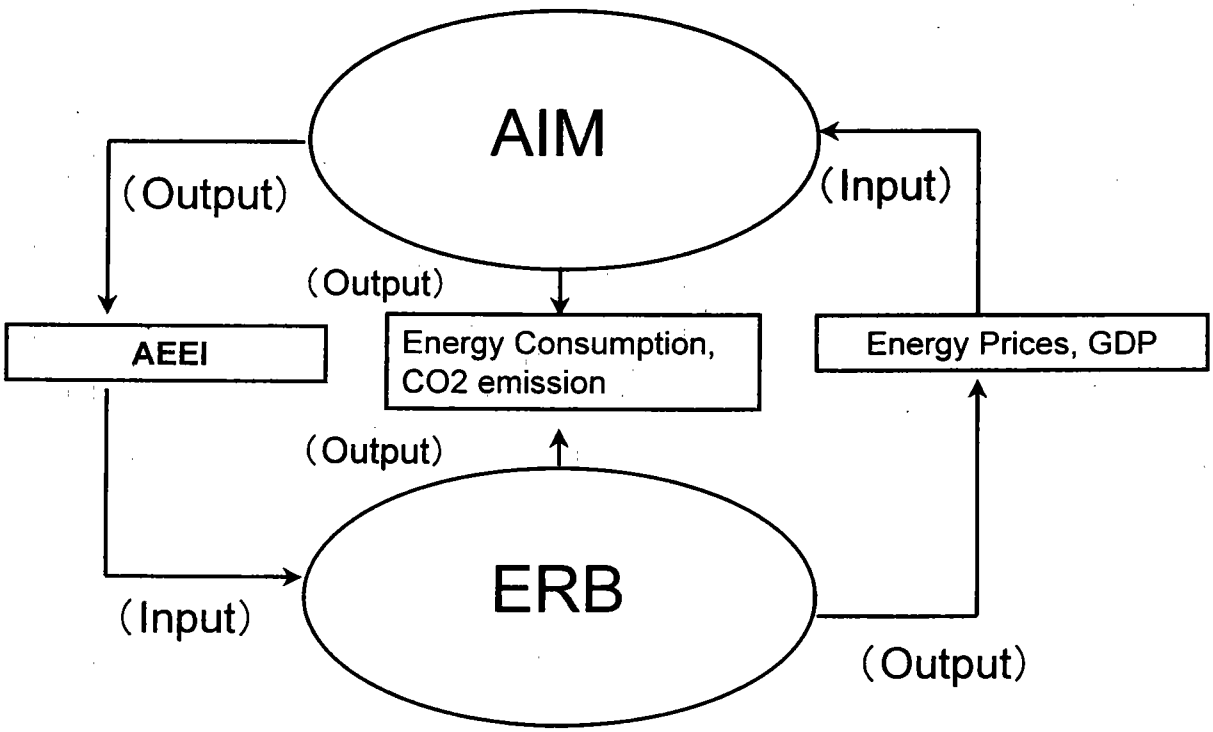
We would like to describe the theoretical framework of the linkage briefly and the example of the simulation. The bottom-up model used for the linkage in our study is AIM and the top-down model is ERB(Edmonds-Reily-Barns model). AIM is a simulation model to determine the technology choice by the cost minimization under the given energy prices and to calculate the AEEI(autonomous energy efficiency). Therefore, AIM has the mechanism that the rise of the energy prices improves autonomous energy efficiency through

the choice of the more energy-saving technology. In the other hand, ERB is a kind of a partial equilibrium world economic model to describe energy sectors and a model to determine GDP, energy prices, energy consumption and CO2 emission under the given AEEI of the sector. The theoretical framework of the linkage between AIM and ERB is shown in Figure 2-1.

We link AIM with ERB in AEEI, energy prices and GDP since AEEI is output from AIM and input for ERB, while energy prices and GDP are outputs from ERB and inputs for AIM as is shown in the figure.

An example of the simulation by the linked model is shown in Figure 2.2. This figure shows the paths of the energy-GDP ratio throughout 1990 and 2100 in the world under the 3 scenarios, which are the high growth rate scenario, sustainable development scenario and the low growth rate scenario. The reason why the energy-GDP ration in high growth rate scenario is smaller than the others is that higher demand for energy due to higher GDP growth raises the energy price and promotes the choice of the more energy-saving technology which is determined in AIM module.

Figure 2-1 Theoretical Framework of the Linkage between AIM and ERB

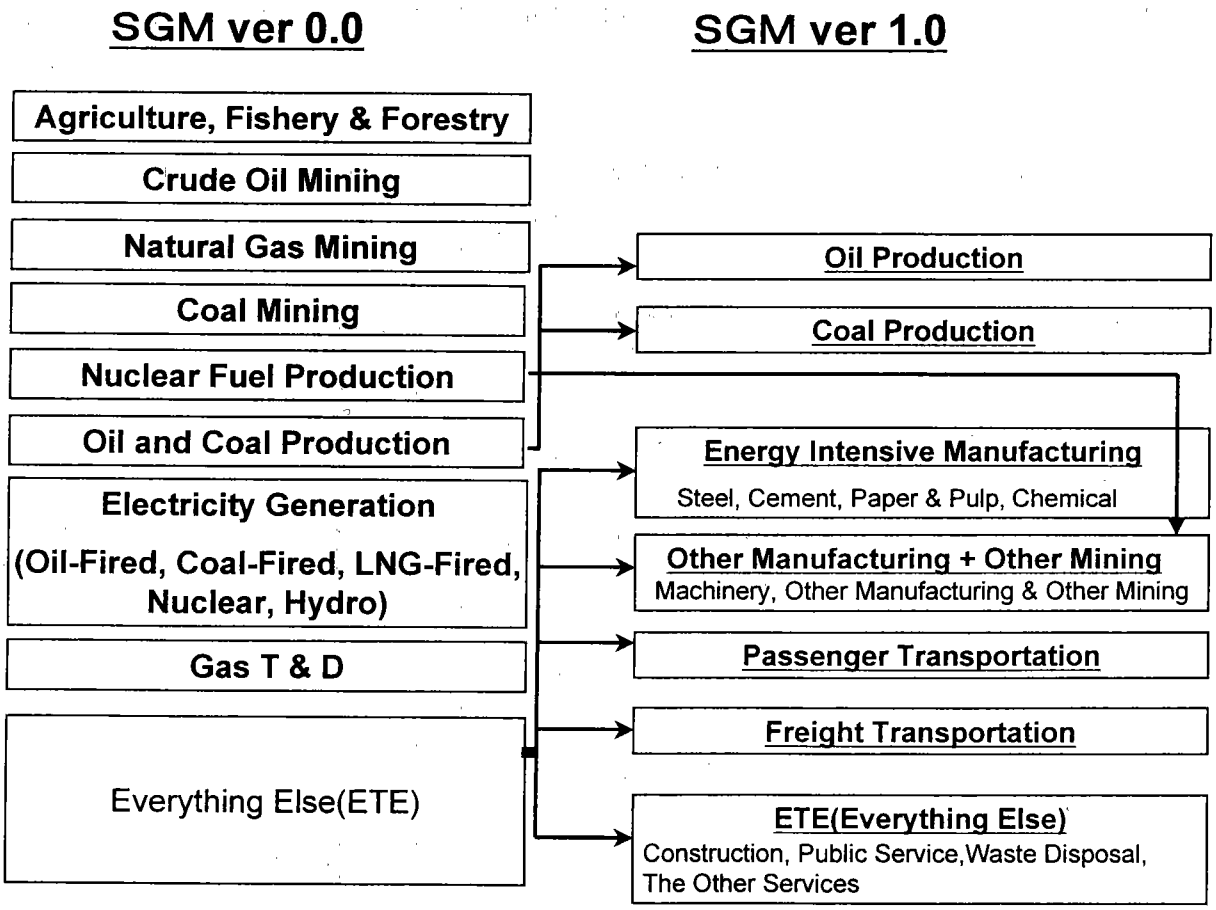


3. Extension of the top-down model(SGM Japan) and the analysis the impacts on the Japanese economy by the carbon tax

SGM Japan (ver. 0.0), which we have developed to analyze impacts on the economy by

the carbon taxation, is a computable general equilibrium economic model with 13 sectors and subsectors, as is shown in Table 3-1. However this break down is not good enough to analyze the impacts of the carbon tax on the structure of the industry. Because the shares of the sectors and subsectors except ETE(everything else) sector in terms of the value added in Japan are very small, while that of ETE sector is more than 90%. Also in order to link the top-down model with the bottom-up model, the model needs to be shared out in detail. For those reasons, in this study, we extend the model so that it (SGM ver.1.0) has more sectors and subsectors, as is shown in Table 3.1 and analyze the impacts on the Japanese by the carbon tax. At first, we would like to show the reference case of SGM ver.1.0 and make a brief analysis of the economical impacts on the Japanese economy by carbon tax introduced in 2010 for stabilizing CO2 emission at the 6% reduction level to the 1990.

Table 3-1 Sectors and Subsectors in SGM Japan



(1) Reference Case by SGM ver. 1.0

The summary of the reference case, which are shown in Fig. 3-2 and 3-3, is as follows. It should be noted that the simulation time step of SGM is 5 years and that the simulated

period is throughout 1990-2030.

① The real GDP growth rate is about 2% in average.

② The fluctuation of the path of the real GDP growth rate is due to the growth rate of 15-65 age population which is assumption in the model.

③ The path of growth rate of the primary energy consumption, CO2 emission is due to that of the real GDP growth rate and their rates are 1.2% and 1.3 respectively.

Figure 3-2 Real GDP Growth, Primary Energy Consumption Growth, CO2 growth and 15-65 age Population Growth (Reference Case)

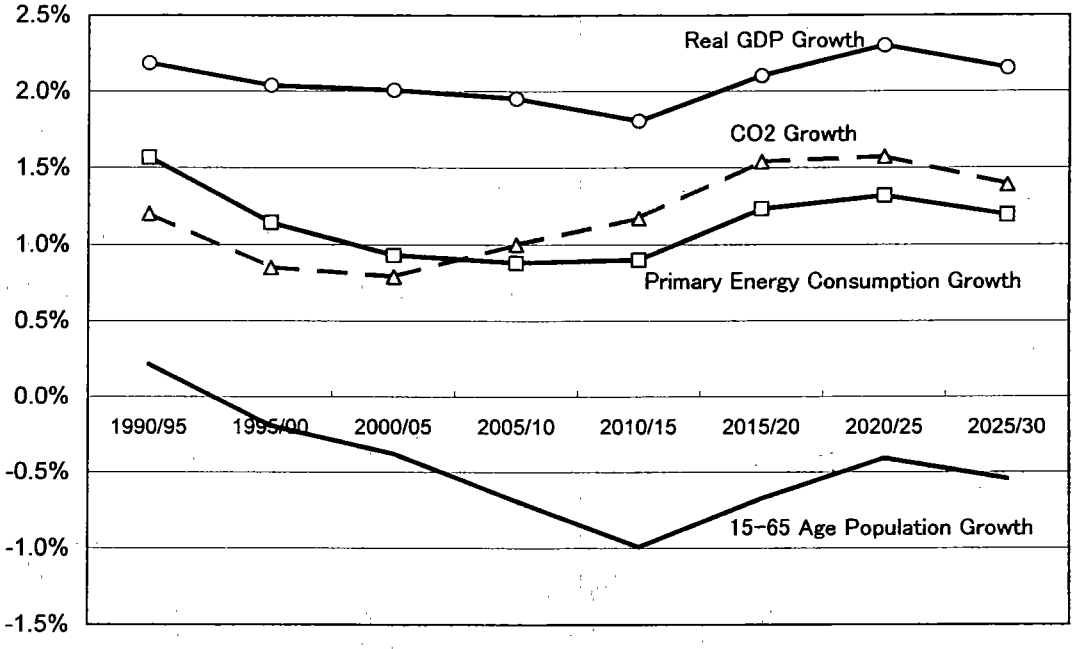
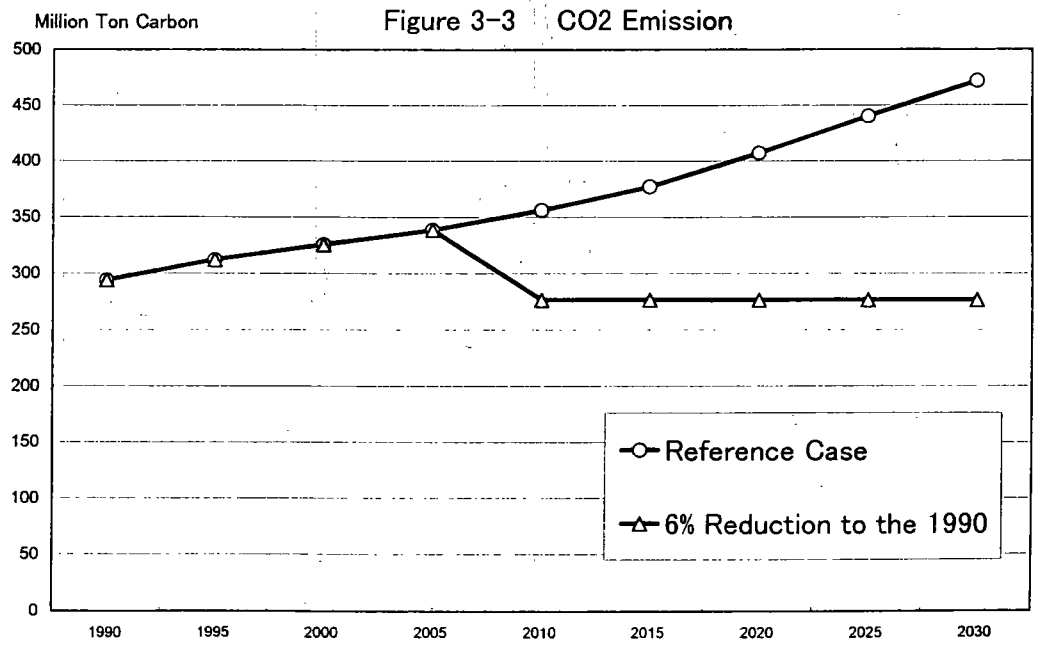


Figure 3-3 CO2 Emission



(2) Simulation of Economical Impact by Carbon Tax

Here, we would like to explain the results of the simulation for the economical impacts on the Japanese economy by carbon tax introduced in 2010 for stabilizing CO2 emission at the 6% reduction level to the 1990. It should be noted that we assume that the carbon tax revenue is spent for the government expenditure.

The summary of the results, which are shown in Fig. 4-4 and 4-5, is as follows.

①The CO2 reduction rate to the reference case will grow over time due to the economic growth. 22% in 2010 and 55% in 2030 will be required for the stabilization to the 6% reduction level to the 1990.

②The carbon tax rate will also grow over time due to the increase in the CO2 reduction. The rates will be 34,000yen/TC in 2010 and 229,000yen/TC.

③The real GDP loss to the reference case will increase over time due to the increase in CO2 reduction. It will be 0.5% in 2010 and 2.7 in 2030.

④The energy-output ratio in each sectors will decrease by the carbon tax. Especially, the decrease in the ration of the energy intensive sector is largest, while that of oil production is the smallest.

Figure 3-4 Real GDP Loss and Reduction in Primary Energy Consumption & CO2 by Carbon Tax and Carbon Tax Rate

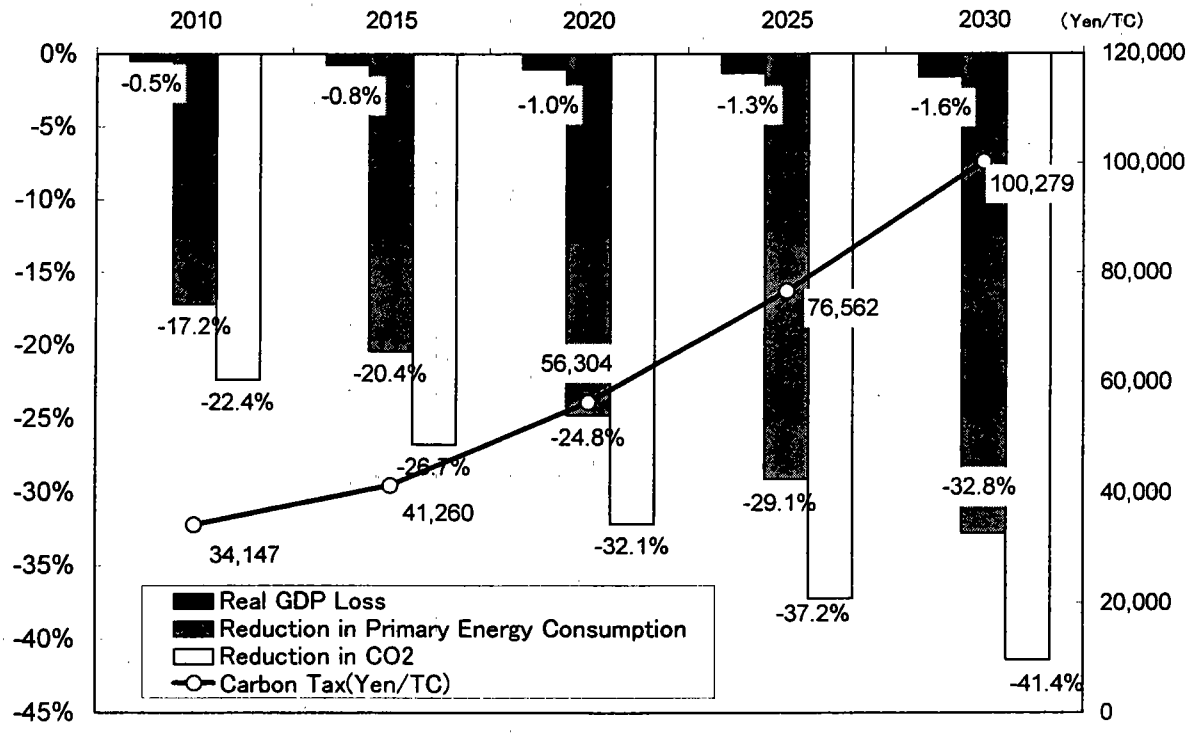
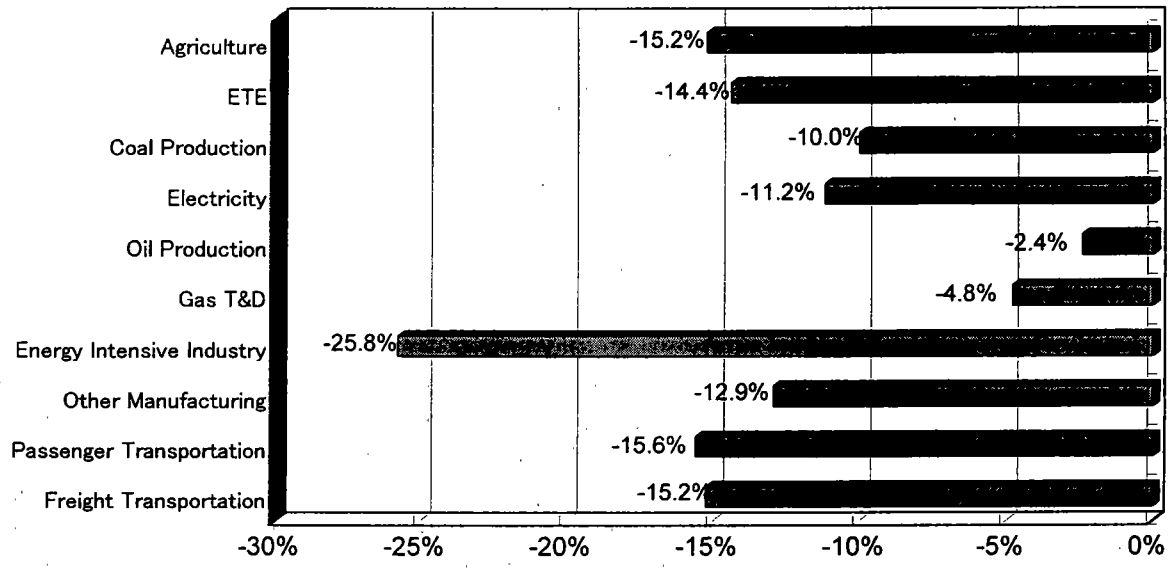


Figure 3-5 Possibility of the Decline in Energy-Output Ratio in Each Sectors by Carbon Tax (to Reference Case; in 2010)



4. Final Remarks

We examined about the theoretical framework and the methodology of the linkage of the bottom-up model and the top-down model in this study. Then we tried the linkage using AIM for the bottom-up model and ERB for the top-down model but the partial equilibrium model.

Moreover, we extended SGM ver. 0.0 to have more sectors and subsectors which meet the breakdown of the sectors in AIM. And also I made some simulation to assess the economical impact on the Japanese economy by carbon tax. This extension will be used for the linkage of AIM and SGM. Because we should use the general equilibrium model but not the partial equilibrium model like ERB, which we used for the first trial, to complete the linkage to take the indirect effects among sectors into account. This linkage will be remained for the future work.