IR-1.1.1 Basic Economic Model Development for Identifying Integrated Target in Environment and Economic Growth

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Total Budget for FY1995-FY1997 29,832,000 Yen (FY1997; 9,888 Yen)

Key Words Sustainable development, Computable general equilibrium model, Dynamic optimization model, Bottom-up model, Global environment

Abstract: This project is to develop several economic models for the analysis of the specific targets to integrate environmental conservation with economic growth. Three types of economic models, those are, computable general equilibrium model, dynamic optimization model and bottom-up model, were developed and improved by linking to environmental simulation modules. These economic models were, then, applied to various policy assessment on timing of policy implementation, integration between energy and land use policies, integration of global environmental policies with domestic policies, international collaboration in global environmental conservation, cost reduction for environmental conservation, and macro-economic effects of environmental industries and environmental investments.

1. Introduction

Global environmental problems such as global warming, depletion of the ozone layer, tropical rainforest destruction and desertification are caused mainly by economic growth, and many kinds of trade-offs have been recognized between global environmental conservation and world economic growth. On the other hands, environmental conservation requires considerable amount of investments which are financed from economic production processes. And active industries which produce technologies and service for environmental conservation, contribute to increase in GDP. The relationship between environment and economy is much more complex than the theoretical description that is explained based on current paradigm of economics.

In order to find a target to integrate global environmental conservation and economic growth, it is inevitable to improve previous economic model to simulate the complex relationship between environment and economy. The purpose of this study is to develop new economic models which can analyze and identify the interactions between environment and economy for finding the integrated target for sustainable development.

2. Review of Economic Models

There are enormous numbers of economic models to respond to various research needs from decision makers in governmental and industrial fields. Most popular model is Neo-Keynsian type of macro-economic model that has been applied to short-term economic performance. However, most of these models have their limits to be applied to global environmental field, because of their short time horizons, difficulty in extending them to world scale model, their poor structure to assess dynamic growth path of economy, and neglect of endogenous change in technology and lifestyle.

The applicable economic models to the global environmental research were reviewed

in previous papers and research reports, and three types of economic models were identified to be applicable to it. These are computable general equilibrium model, dynamic optimization model, and bottom-up type models.

The general equilibrium model, such as SGM model, GREEN model, GTAP model, and BLS model, can reproduce the interactions among various economic sectors in a consistent manner based on the market theory. The dynamic optimization model, such as DICE model, MERGE model, MARIA model and GDMEEM model can estimate optimal path to maximize long-term economic welfare including environmental services. The bottom-up model, such as MERKAL model, MEDEE model, AIM/enduse model, and NE21 model, can simulate endogenous change in technology and lifestyle based on bottom-up estimations.

These three types of economic models are selected to be improved and applied for this project's purpose, and the following models were actually examined as case study of this project.

(1) Dynamic optimization models: MERGE model (Stanford University), DICE model (Yale University), MARIA model (Science University of Tokyo), Integrated M-E model (Osaka University), and GDMEEM (Tokyo University)

(2) Computable general equilibrium models: GTAP model (Pardue University) and SGM (Pacific Northwest National Laboratory)

(3) Bottom-up type model: NE21(Yokohama National University)

1. Improvement and Application of Dynamic Optimization Models

3-1 MERGE Model

The MERGE model is a popular integrated model of energy and mocro-economy, developed by Professor Manne and his colleague. This model was improved in this project and applied to the following three studies:

First, Japanese country model of MERGE was developed, and a sulfur emission model was integrated into MERGE in order to analyze Japan's historical relationship between air pollution and economic growth. The improved MERGE could amazingly reproduce the historical path of Japan's annual investment into desulfurizations. The simulation results based on this model shows that Japan would have had significant loss in economy if Japan would have delayed the timing to introduce desulfulization policies.

Second, a forest sink module was linked to MERGE model, and several simulations were conducted to assess the effects of plantation which have been expected for "Joint Implementation" project between China and Japan. The simulation results show that Chinese plantation policies supported by Japan could decrease enormous cost for CO2 reduction bothe in China and Japan.

Third, a specific module that can reproduce the relationship between technological change and R&D investment, was introduced into the MERGE model in order to endogenize the parameter of technological efficiency improvement. This revision of model structure significantly changed the original MERGE simulation results, and concluded that CO2 reduction policies should be introduced at much earlier timing than that estimated by the original MERGE model.

3-2 MARIA Model

The MARIA model was developed by Prof. Mori based on the DICE model. This model integrates wider field of global system than that of MERGE. Especially, this model has a land use module linked to energy model through biomass energy supply. This land use module was improved in this project for the purpose of analyzing competitive situation between

biomass production land and crop production land. New simulation based on the revised MARIA shows that biomass firm would be controlled by rapid increase in crop land after 2030 year in the case of high population growth.

3-3 Integrated Material-Economy (M-E) Model

The Integrated M-E model was developed to reproduce recycle processes of waste materials in relation to various industrial sectors and macro-economy. Although the origin of such approaches can be found in "Material Balance Approach" in Environmental Economics field since 1970's, Dr. Masui developed a systematic M-E model with well quantified parameters. This Integrated M-E model was extended in this project by adding a special industrial sector (called "environmental industry sector) which produce the goods and services for environmental conservation, then, this model was applied to assess the effects of environmental industry on Japanese macro-economy. A company which produces advanced recycle technologies was selected for the case study, and value added produced by the company, by cost reduction in recycle processes, and also by reduction in environmental pollutions. The simulation results show that the company will increase GDP by 0.5 to 1 trillion Japanese yen in 2010 year.

3-4 GDMEEM Model

The GDMEEM model was also improved and applied for sustainable development studies as one of dynamic optimization models. This model was developed originally for the assessment of Japanese energy system, and revised to link to a module of CO2 emissions. In this project, the GDMEEM model was extended to China, and Chinese version of GDMEEM was developed. This new version was then linked to the previous Japanese version to estimate the effects of "Joint Implementation" of CO2 reduction between China and Japan. The simulation results show that collaboration of two countries could save 20-30 trillion Japanese yen (current value of the 50 years' amount) which is equivalent to 1 % of Chinese GDP.

4. Improvement and Application of General Equilibrium Model

Two computable general equilibrium models were improved and applied in this project, those are, the GTAP model and the SGM model.

The GTAP model is very popular general equilibrium model which aggregates world economic system into 24 regions and 37 industrial sectors. This model was improved in this project to be applied to the assessment of CO2 reduction impacts on international trade. Several simulation results show that CO2 reduction policies will have significant impacts on developed countries through international market by changing price of energy intensity goods. It is also concluded that developing countries would take some significant impacts through international market by changing international oil price. These results suggest that it is necessary for CO2 reduction policies to introduce international collaborative system in order to avoid the impacts caused by international trade. Other simulation results using the revised GTAP model shows that Japanese economic welfare loss caused by CO2 reduction without international collaboration, would be 40 % higher than that assuming international collaboration.

Other research results using the SGM model are introduced in the next project report of IR-1.1.2.

5. Improvement and Application of Bottom-up Model

For the purpose to assess the technological contributions on energy system, a bottom-up model, NE21 was improved and applied. The NE21 model, developed by Professor Fujii of Yokohama National University, has systematic energy supply module which is related to

detailed technology data. This model aggregates world into 10 regions and each regions' model of energy system has linkage to the regional module of macro-economy. In this project, the NE21 model was improved by introducing new linked module to estimate impacts caused by climate change.

The revised NE21 model was applied to assess the effects of "emission banking" which enable CO2 emitters to borrow their future emission rights. The simulation results show that introduction of emission banking could decrease CO2 reduction costs because long-term strategy can assume more technological innovation and flexible capital management. This model was also applied to estimate the optimal path of CO2 emissions in consideration with climatic impacts. Several simulations suggested that dynamic path of CO2 emission should be shifted bellow in order to reduce the damaged caused by climate change even if the reduction cost would increase.

6. Concluded Remarks

In this project, three types of economic models, those are, computable general equilibrium model, dynamic optimization model and bottom-up model, were developed and improved by linking to environmental simulation modules. These economic models were, then, applied to various policy assessment on timing of policy implementation, integration between energy and land use policies, integration of global environmental policies with domestic policies, international collaboration in global environmental conservation, cost reduction for environmental conservation, and macro-economic effects of environmental industries and environmental investments.

Based on these studies, it is clarified that the developed models in this project can contribute to the following research need:

(1) To clarify the impact of difference in timing to introduce global environmental policies on sustainable development
(2) To estimate environmental impact of interactions between energy systems and land use systems
(3) To assess the effects of integrated policies between global environmental conservation and domestic various policies
(4) To clarify the effects of international collaboration in the global environmental fields
(5) To design integrated policies to reduce cost for global environmental conservation
(6) To estimate macro-economic effects of environmental industries

The developed model in this project is planned to be applied to Asian sustainable development studies, and to be improved for Asian assessment models.

International collaborations

The members of this project has been participating in the following international collaboration programs: New emission scenario project of Intergovernmental Panel of Climate Change, International Model Comparison Project of Stanford Energy Modeling Forum, Joint program to develop MERGE model of Professor Allan Manne, and SGM Project at Pacific Northwest National Laboratory

Publications

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