

## **IR-1.1 Research on Economic Model for Asian Application and Economic Evaluation of International Public Goods**

**Contact person** Tsuneyuki Morita  
Director, Social and Environmental Systems Division  
National Institute for Environmental Studies  
16-2 Onogawa, Tsukuba, Ibaraki 305 Japan  
Phone +81-298-50-2541 Fax +81-298-50-2572  
E-mail t-morita@nies.go.jp

**Total Budget for FY1998-FY2000** 105,349,000Yen (FY2000 34,245,000Yen)

**Key Words** Sustainable development, Economic model, International Public goods, CDM, Input-output tables, Chinese environment

**Abstract:** This is a set of studies to develop new economic models and evaluation methodologies for Asian application. First, eight kinds of economic models were revised and improved to analyze the relationships between Asian economic development and environmental issues, and they were applied to climate change, air pollution, and other environmental issues. Next, for CVM improvement, a questionnaire on reduction of CO<sub>2</sub> emissions was tested to assess validity of methodology. Finally, present state and future prospects of population, economic growth, environmental degradation, energy and urbanization in India and Indonesia were analyzed to provide a basis for developing analytical tools for the integration of environment and economy.

### **1. Introduction**

As it is recognized as fundamental goal of global environmental policies to integrate environmental conservation with economic development, urgent tasks have been required to clarify the goal and the way to reach it. Especially, these tasks are very important for the Asian region including Japan, because this region is expected as high growth region in economy in the 21<sup>st</sup> century.

The purpose of this study is to develop methodologies to analyze sustainable development goals and the way to reach them. For this purpose, several economic models developed in the 1995-1997 project of this fund were improved in order to apply them to Asian policy analyses in the field of global warming, acid rain, local air pollution, and other environmental issues. In addition to this, fundamental studies to improve CVM methodology for economic value estimation as well as case studies in the Asian region were conducted.

### **2. Model development and application for the Environmental Kuznets Curve analysis (by T. Morita, National Institute for Environmental Studies)**

This study aims to clarify the ways for developing countries how to develop with less pollution problems. These way can be analyze by means of a specific economic model which simulates the relationship between long-term economic growth and pollutant emission level. As the first step to develop such a model, historical time series data for the last one century was analyzed, and a specific inverse-U curves of SO<sub>2</sub> emissions according to increasing per capita income were found in the seventeen developed countries. This curve is called as "Environmental Kuznets Curve (written as "EKC" after this)", the peak emission level of which can be a good indicator how economic development is polluted in each country. This historical data analyses also suggested several factors to change the peak emission levels.

Next, a dynamic optimization model, MERGE, was improved to apply to the EKC

prediction in China. MERGE was developed reproducing the relationship between economic growth and energy consumption. MERGE was modified for our research purpose by incorporating a pollution investment module and pollution damage function module. Using this model, the peak emission levels of EKC were simulated under the several assumptions of environmental policies. Figure 1 shows part of simulation result of Chinese EKC prediction, which clarifies that transfer of energy efficient technology to China could play a very important roll to decrease the peak emission level of SO<sub>2</sub>. Besides of technology transfer, it was clarified that education program to increase Chinese environmental premium has significant effects to lead less polluted development pattern in China, and on the contrary that subsidy policy for energy supply sector is less effective to reduce the peak level of SO<sub>2</sub> emissions.

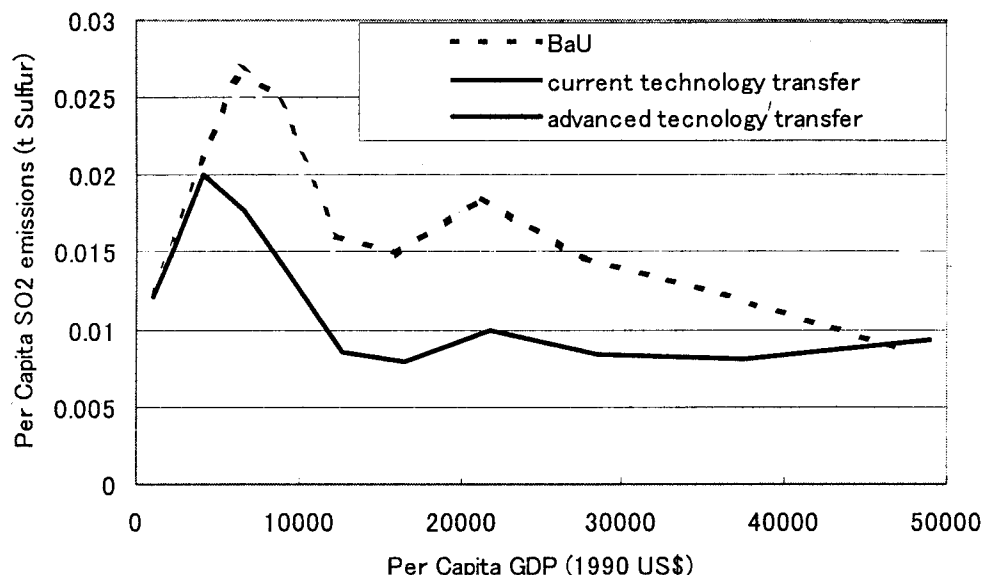


Fig 1 Possible economic growth with low SO<sub>2</sub> emissions for China

### 3. Cost analysis to reach Kyoto target based on GDMEEM and other Models (N. Goto, Tokyo University)

In a series of research in the past three academic years (1998-2000) we have attempted to develop analytical models, evaluating various mitigation scenarios and socio-economic policy measures related to the issue of a global warming. Particular attention has been paid to modeling the effective substitution between energy and the other factors in production as well as that among energy resources toward less carbon-intensive ones in the framework of an economic general equilibrium model, incorporating the technical efficiency improvements in energy utilization in the model, and integrating methodologies to assess the effectiveness of some policy measures into the simulation analyses.

By extensive empirical examination of the structural changes in the Japanese economy in 1960 through 1995, or more concretely the estimation of trans-log type production and cost functions, we could find the following ( $\sigma$ : the estimated Allen elasticity of substitution):

- (1) capital is complementary to energy in production overall ( $\sigma_{KE} = -0.33$ ),
- (2) labor is substitutive to energy in production overall ( $\sigma_{LE} = 0.72$ ),
- (3) materials are also substitutive to energy in production overall ( $\sigma_{ME} = 0.60$ ).

Though we are hesitant to present the numerical results here since we have not yet attained at the sufficient level of confidence, we have constructed the prototype of a rather complicated dynamic multi-sector general equilibrium model that incorporated energy details and mutual interactions among industrial sectors in a way of advanced Leontief input-output model. This research is still on the way.

Finally, we attempted to evaluate the socio-economic implications of employing a

domestic system of trading CO<sub>2</sub> emissions rights among manufacturing sectors by using a modified version (e.g., the incorporation of more available technological options to improve energy efficiency in industrial sectors) of the GDMEEM (Goto's Dynamic Macroeconomic-Energy Equilibrium Model). According to our simulation results, it was estimated that, compared to the case of imposing carbon taxes in achieving the Kyoto scenario, the economic burden incurred by the manufacturing sectors could be waived more than 75% in 2010 and almost in same size thereafter (see the Figure 2. below), though it would strongly depend on whether or not the initial allocation of emissions rights among members (or, the redistribution of revenues in case of sales by some internally established authority) could be successfully designed to realize the scenario.

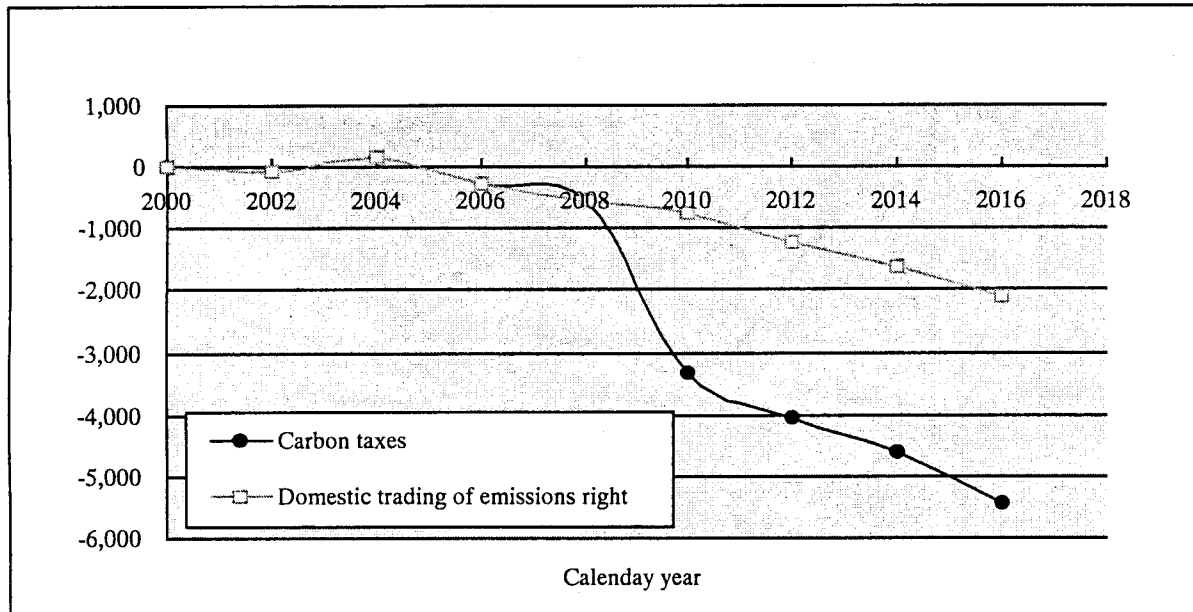


Fig. 2 Economic costs of manufacturing sectors in the Kyoto scenario

#### 4. Energy system and eco-system analyses based on MARIA Model

(S. Mori, Science University of Tokyo)

I extended an integrated assessment model called MARIA (Multiregional Approach for Resource and Industry Allocation) developed firstly in 1994 to evaluate the global warming mitigation policy and technology options. Since 1997 IPCC started a research activity named "IPCC-SRES" to develop an alternative emission scenarios to IS92 series. MARIA has been extended to participate in this activity.

The model has been developed to assess the potential contribution of fossil, biomass, nuclear and other energy technologies and land-use change to future GHG emissions. It also incorporates a simple carbon cycle and climate change model. I describe here how the model was used in developing GHG emissions scenarios based on narrative storylines and assesses mitigation strategies that would lead to the stabilization of atmospheric GHG concentrations. The results indicate that zero-carbon technologies such as the fast breeder reactors and carbon sequestration technologies can make a significant contribution toward emissions mitigation especially when drastic reductions are envisaged. One simulation result on primary energy supply profile corresponding to B2-Marker is exhibited in Figure 3.

MARIA model is then applied to evaluate a new hydrogen production process which produces hydrogen through steam-methane reforming at a significantly lower temperature (300-500C) than that of conventional steam-methane reforming processes (800-1100C). The simulation results suggest that hydrogen with FBR could supply 5-8 GTOE of hydrogen in the second half of the 21-st century when the climate policy which stabilizes the atmospheric

carbon concentration is introduced.

Besides the above extension of MARIA, I also developed two models: the one is to see the influence of global warming on world food supply using GIS and Chikugo-photosynthesis model. Another one is a model focusing on Asian region to evaluate the regional heterogeneity on fossil fuel quality and endowment. These two suggest the future directions of this research field.

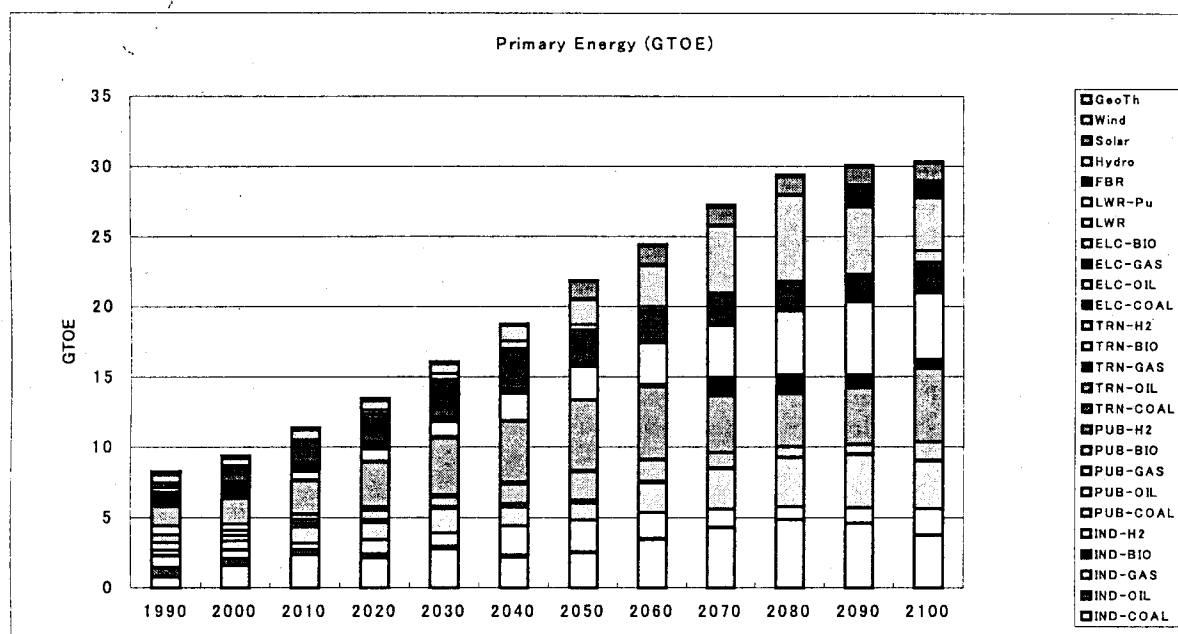


Fig. 3 World primary energy flows in B2-Marker with reference hydrogen production and end-use cost

## 5. Environmental tax system analyses based on SGM Model

### (A. Hibiki, National Institute for Environmental Studies)

The purpose of this study was first to analyze economic impact of carbon tax for stabilizing Japanese CO<sub>2</sub> emission at 97% of 1990 level, and second, to clarify the way how to use the tax revenue for minimizing GDP loss. For this purpose, a 17-sector computable general equilibrium model was developed, and the model was applied to analyses of the policy effects of carbon tax and the return of its revenue as well as of reform of energy-related tax system in Japan. The results of these analyses can be summarized as follows:

- (1) In the case to return carbon tax revenue to expanding governmental expense, carbon tax rate would be 25,000 –36,000 yen per carbon ton, and GDP loss in real term would be 0.05 – 0.2 %. In the case of return to income tax reduction, the tax rate would be 26,000 –38,000 yen per carbon ton, and GDP would decrease by 0.2 – 0.4 %. And in the case of return to debt reduction in government account, the tax rate would be 27,000 –38,000 yen per carbon ton, and GDP would increase by 0.15 – 0.3 %.
- (2) The reason why GDP loss is largest in the case of return to income tax reduction, is that the reduction of capital stock would be largest in this case. This means, the larger reduction in capital stock decrease caused by tax revenue return, the larger GDP loss in real term.
- (3) The impact of carbon tax would be considerable large in petrochemical sector as well as coal manufacture sector, where the loss would be three to four times of energy conversion sector. On the other hand, the impact would be small in the other manufacture sector and the other service sector.

In addition to the above analyses, specific macroeconomic impacts were studied in

the case to reform energy-related tax system combined with carbon tax introduction. Current energy-related tax system is not designed to reduce carbon-dioxide emissions because the tax is relatively lower in coal combustion and relatively higher in gas combustion. Our analyses clarified that the adjustment of current tax system could reduce GDP loss by half caused by carbon tax introduction.

**6. Global environmental policy analyses based on NE21 Model**  
**(K. Yamaji and Y.Fujii, University of Tokyo)**

This study examines the potentials of the Kyoto Mechanisms for CO<sub>2</sub> emissions through the use of a newly developed multi-region global energy. The new global model has 54 world regions, and was formulated as a linear programming model that has about a half million variables. The model can calculate the optimal energy systems up to the year 2012 at two-year time step. Our analysis focuses on the potentials of the Kyoto Mechanisms on the respective world regions. The results of the model exercises can be summarized as follows.

First, if a CO<sub>2</sub> emissions reduction countermeasure isn't done, the amount of CO<sub>2</sub> emissions in 2012 reaches about 9 billion tons of carbon in the whole world. A developed country has a big burden forced because of the CO<sub>2</sub> emissions reduction only with the domestic countermeasure. The Former Soviet Union/East European countries will not reach their emission targets during the first commitment period, and large quantities of the Hot Airs occur in these countries. As seen in Figure 5, the introduction of the emissions trading reduces CO<sub>2</sub> abatement costs in the developed country drastically. However, a large quantity of Hot Air flows out into the market, and the whole amount of CO<sub>2</sub> emissions itself of the world increases from the case that there are no emissions trading. Figure 6 indicate that Russian amount of sale may grow very huge, and that Russia may have a great influence on emission trading market.

Then, the introduction of CDM reduces the abatement cost of Annex I drastically, and mitigate the increase of CO<sub>2</sub> emissions in non-Annex I. The major areas to reduce CO<sub>2</sub> emissions in non-Annex I seem to be Asian countries, such as China, India, Southeast Asia. The introduction of CDM banking may further reduce the abatement costs.

From now on, it is preferable to conduct detailed analyses on Kyoto mechanism in the consideration of present international politics about Kyoto protocol. The collection and revision of the variety data are necessary for the improvement of the energy model analysis.

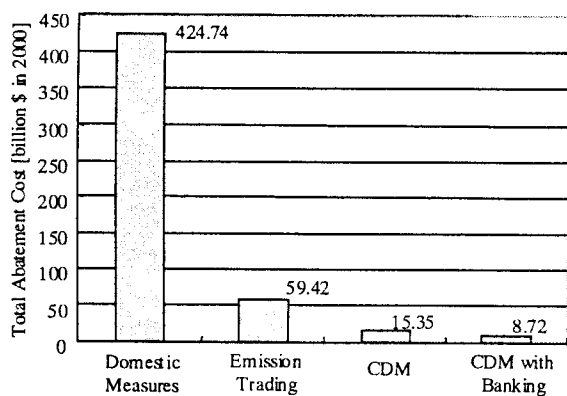


Fig.5 Total Abatement Costs

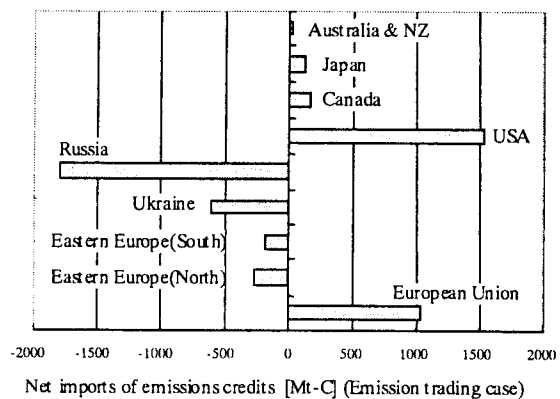


Fig.6 Emissions Trading among Annex I

**7. CVM methodological improvement for the evaluation of global environment**  
**(N. Hidano and T. Kato, Tokyo Institute of Technology)**

This study focused on how respondents of contingent valuation reacted to benefit and cost of a survey. Spending time on a survey would be cost for a respondent, because the

person has to give up some other activities in order to join the survey. On the other hand, respondents may benefit from new information on goods in question during the course of a survey. We clarified what kind of benefit and cost our respondents had and then tested whether satisfied respondents answered more plausible answers. We used questionnaires that described the positive effects of Kyoto Protocol and asked respondents' willingness to pay (WTP) to achieve Japan's target of reducing CO<sub>2</sub> emissions.

In 1999, we conducted a survey using computerized version of our questionnaire, which was written in HTML. Twenty-one students of Tokyo Institute of Technology joined the survey. We employed a verbal protocol method to record the process of answering questions. In order to avoid subjectivity in analyzing the verbal protocols, two researchers independently categorized them. Most of the categories were consistent to each other, the verbal protocols, thus, were clear to understand. We found that our survey respondents benefited from joining the survey and most of them appreciated the benefit of obtaining new information on global warming. But, we could not determine whether satisfied respondents stated more plausible WTP.

We conducted a panel survey with two waves in 2000. We extracted at random four groups of households from the registration of addresses in Suginami Ward, Tokyo. We use the symbols of A, B, AA, and BB to denote these groups. The AA and BB groups involved 670 households for each and took only the second wave of the survey in order to check changes in social environment. The A and B groups included 840 households for each and took the two waves of the survey. Respondent in the A and AA groups received a booklet explaining global warming other than a questionnaire, which is common to all groups. We contacted respondents by mail and respondents send us their answers by mail. WTP was asked with a payment card format.

We considered two indexes of plausibility. The first index was whether to join the second wave. The second index was consistency of WTP across the two waves. We found that respondents who were satisfied with the first wave of the survey in the A group tended to join the second wave more than those dissatisfied. Those satisfied in the survey in the A group showed more consistency of WTP across the two waves. On the other hand, the B group showed few signs of relating benefit of the survey to plausible WTP. The B group differs from the A group in their absence of a booklet, meaning the A group had to process more information than the B respondents. We, thus, concluded that satisfaction to surveys helped respondents to state more plausible WTP when they faced much information to process.

## **8. Case Study for the Asian Region**

### **(Institute of Advanced Studies, United Nations University)**

Several case studies were conducted to analyze policies for sustainable development in China, India and Indonesia where high economic growths are predicted. Key variables were investigated to identify major trends and issues. These variables are population increase, economic growth, consumption of natural resources, degradation of environmental qualities, energy consumption and CO<sub>2</sub> emissions, environmental impact caused by urbanization, and other trends closely related to sustainable development.

Next, a research was conducted to establish new indicator to analyze the relationship between economic activities and environmental cost. Figure 7 shows an estimated green GDP which is identified as GDP minus environmental conservation cost. Chinese cost for environmental conservation was estimated about 9 percent of total GDP, which invested mainly into land conservation and water conservation.

The survey of international organizations was also conducted in order to establish a network to promote sustainable development studies in the Asia-Pacific region.

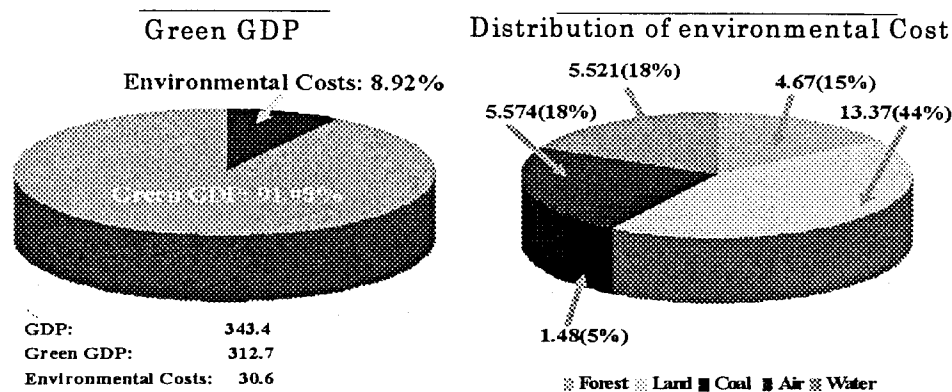


Fig. 7 Green GDP estimates for China

## 9. Concluded Remarks

Three years project developed several new economic models to analyze the relationship between environmental conservation and economic growth, and it was confirmed that these modes are useful to assess the effects of sustainable development policies in the Asian region. The CVM methodology was also improved for estimating the economic value of global environment. Furthermore, case studies in the Asian region clarified the direction to assess sustainable development policies. These results can be applied generally to Asian studies in the field of global warming, acid rain, and local air pollution. However, several tasks are remained to develop economic models in the field of water pollution, waste management, and natural ecosystem conservation. These tasks are expected to be promoted in the individual research project of this fund.

## 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, SGM Project at Pacific Northwest National Laboratory, and the Eco-restructuring Project at United Nations University.

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