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GLOBAL WARMING AND ECONOMIC GROWTH

- Modeling Experience in Japan -

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PREFACE

During past one year after the foundation of Center for Global Environmental Research, so rapid changes and large progresses have been seen in the international issues on global environment. A series of worldwide energetic efforts have been made towards global consensus at the "Earth Summit" in Rio de Janeiro. Intergovernmental Negotiating Committee for a Framework Convention on Climate Change was established based on the scientific warning made by IPCC in 1990, and discussions for preserving tropical forest and biodiversity are on the table to be agreed as Conventions signed at UNCED. These progresses mean that the human being is entering into the action stage from the recognition stages of the crisis, after a twenty year probing from Stockholm.

But still there remain large discrepancies in the recognition of necessity of responding strategies among countries, between North and South, and among industrialized countries, depending on the historical, geographical and economic bases they stand on. One reason of disagreement comes from scientific uncertainty this issue has, and another from contradictions between responding strategy to protect global environment and other political goals such as to keep economic stability.

The ultimate goal of global environmental issue is not only to preserve precious ecosystem and to protect ozone layer physically, but also is to search the way we, human being, can maintain bases of our survival on this planet Earth, by controlling human activities autonomously , which tend to expand by themselves. Already a lot of researches have been carried out in many countries and in international organizations to discuss whether the responding strategies to global warming hinders economic growth or not. But the results they suggest differs among researchers, mainly because of the range of factors they covered, model structures they used and input data they applied.

This Conference, "Global Environment - Tsukuba 1991" focuses on the econometric models as a powerful scientific vehicle to evaluate effectiveness of strategies for solving our common global problem. By comparing almost all working models proposed by eminent econometric researchers in Japan, we expect to attain common understandings on the differences of concepts and structure of models.

Economic countermeasures such as carbon tax to mitigate environmental problem have been already introduced in some European countries, and discussion on its implications will continue as one of the major international issues even after UNCED. The discussions in this conference can be one of the substantial scientific contributions dispatched from Japanese academic society.

Finally, we express our sincere thanks to Professor Akihiro Amano for his favor of taking chairmanship at the Conference and editorial works of this report, and to Dr. Tsuneyuki Morita for his planning and coordinating all of the Conference.

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INTRODUCTION

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This volume is an outgrowth of a symposium held at the Center for Global Environmental Research in Tsukuba on December 16-17, 1991. The theme of the symposium was "Global Environmental Protection and Economic Growth: Evidence from Quantitative Studies in Japan" and its principal purpose was to review the existing studies in Japan on macroeconomic impacts of controlling greenhouse gas emissions. In view of a great interest of the audience, we decided to publish the proceedings in two different forms, and the present volume is its English version.

Major questions concerning the global warming issue that occupied the minds of participants are:

* What are the likely courses of CO2 emissions in Japan and in the world?
* Will there be some policy measures that are able to limit or stabilize the carbon dioxide emissions without imposing too much burden on the economy?

Among the policy measures, interests in the environmental taxes, or carbon taxes in particular, have been considerable. The opening paper by Uzawa, therefore, discusses theoretical foundations of environmental taxes and forestation subsidies (along with their applications to the Pacific Rim countries). He proposes a formula to evaluate per capita burden of carbon dioxide emissions for each country on the basis of an imputed price of CO2 emissions in a steady state equilibrium of a dynamic optimization problem. An important feature of Uzawa's formula is that it takes into account not only efficiency aspects but also inter-country equity aspects as well.

Another opening paper by Morita, on the other hand, indicates that there remain several important aspects of the carbon taxes that must be subject to closer review before such taxes are actually implemented. Some of the questions, such as the macroeconomic effects of carbon taxes and differences in their effects depending on the way how tax revenue is used, are addressed in the papers that follow. Many other problems, however, are seldom touched upon in the modeling exercises, so that some comments will be made in the final chapter.

In the next two parts of this volume, each modeler then attempts to evaluate the two problems mentioned above by means of a medium-term or long-term model of the Japanese economy or of the world economy. Five studies in Part II are based on Japanese models and four studies in Part III on global models. Table 1 summarizes their main features, and, as can be seen from this table, they are full of variety. At the present stage of our knowledge, however, this is an advantage as we can identify many problems from different angles.

There are not significant differences, however, as to the views concerning the first question. That is, carbon dioxide emissions are expected to grow considerably in the business as usual scenarios both in Japan and in the world in coming decades. The expected, average annual rate of growth of real GNP in Japan during the period 1990-2000 ranges from 3.4 to 3.9 with that of CO2 ranging from 1.2 to 2.7 (see Table 2).

Table 1 Outline of Economy/CO2 Interaction Models*

Author/ Reference	Outline of the Model	Simulation Period
	Japan Models	
Noriyuki Goto (1991)	A dynamic optimization model with a detailed energy sector. Five primary fuels and nine secondary fuels. Nine industries and one residential sector.	1990-2040
Kenji Yamaji (1990)	A large-scale medium-term econometric forecasting system developed by the Central Research Institute of Electric Power Industry, composed of four sub-systems: World Energy Model, Domestic Multi-Sector Model, Interfuel Competition Model, and Domestic Regional Model.	1988-2005
Kokichi Ito (1990)	A macroeconometric model with a simple energy sector. Modeling the impacts of energy price changes and of energy saving investments.	1988-2010
Kanemi Ban (1991)	A macroeconometric model based on intertemporal optimization behavior of the private sector energy demand in such sectors as iron and steel, electric utilities, automobiles and gasoline. Nuclear power generation and new energy sources are exogenous.	1991-2000
Shunsuke Mori (1990)	An econometric energy-sector model combined with a simple aggregate-demand block. Six primary energy sources and eight secondary energy sources. Three final demand sectors use thermal/electric energy.	1988-2020
	Global Models	
Akira Onishi (1991)	Detailed global econometric model with 180 countries/regions based on an AI oriented expert system. The model has been used for various other simulation studies of the world economy.	1991-2000
Shuntaro Shishido (1991)	A global econometric model with 36 countries/ regions, emphasizing sectoral details of production and trade in industrial countries. CO2 emissions are explained by production and prices.	1990-2000
Nihon Keizai Shimbun/GEF-KANSAI (1991)	A global econometric model with nine countries/ regions, each having macroeconomic and energy blocks.	1991-2010
Yuzuru Matsuoka (1991)	Edmonds-Reilly Model, the version that takes 1985 as the starting point (and the base year). Five greenhouse gasses (CO2, CH4, N2O, CO, and NOx) are covered.	1985-2100

* There is a slight change in the list of models as between the symposium and this volume.

Table 2 Average Annual Growth Rates: Business as Usual Scenario

Japan 1990-2000	Goto	Ito	Mori	Ban	Yamaji*	Onishi	Nikkei
GNP	3.4	3.8	3.8	3.6	3.9	3.9	3.6
CO2	2.7	1.8	1.6	2.2	2.2	1.6	1.2

Japan 2000-2010	Goto	Ito	Mori**	Yamaji#	Nikkei
GNP	3.2	2.8	3.3	3.1	3.3
CO2	1.5	1.4	0.5	0.9	0.9

World 1990-2000	Onishi	Shishido	Nikkei	World 2000-2010 Nikkei
GNP	2.9	3.1	2.9	2.7
CO2	2.3	2.1	2.0	1.8

* 1988-2000 ** 2000-2020 # 2000-2005. Nikkei=Nihon Keizai Shimbun.

Much larger variations arise when authors consider the impacts of emission control policies. It is not easy to summarize the results of emissions reduction scenarios by various authors in a neat table, because they have not been derived from simulations performed on a common, comparable basis. However, Table 3 attempts to present their major conclusions to facilitate comparison.

Table 3 Impacts of CO2 Reduction Scenarios

N. Goto

Annual CO2 emissions stabilized at 320 MtC (around the 1990 level) after 2000.

	Shadow price of CO2		GNP losses (in current values)
2000	¥26,710/tC ($205/tC)	2000	¥1.3 tril. (0.22%)
2010	¥32,500/tC ($250/tC)	2010	¥6.1 tril. (0.76%)
2030	¥18,000/tC ($138/tC)	2040	¥14.2 tril. (0.99%)

K. Yamaji

Carbon Tax of ¥4,000/tC (about $31/tC) introduced in 1990, raised by the same amount every year until 2005 to reach ¥64,000/tC (about $492/tC). The CO2 emission level in 2005 to be reduced to the level of 1988.

Annual real GNP growth rates are reduced by 0.4 per cent when tax revenue is not recycled, and by 0.3 per cent when it is recycled via income tax cut.

K. Ito

Fossil fuel taxes. Case 1: 50% on coal, 40% on oil, and 30% on LNG. Case 2: 100% on coal, 80% on oil, and 60% on LNG. Case 3: the same as in Case 1 with additional energy saving policies and foreign aid programs.

	Carbon tax rates		Reductions in growth rates	
	2000	2010	1990-2000	2000-2010
Case 1	around $100/tC	$140/tC	0.2%	0.1%
Case 2	around $200/tC	$280/tC	0.4%	0.1%
Case 3	around $100/tC	$140/tC	0.2%	0.1%

S. Mori

Carbon taxes introduced after 1993 to stabilize annual CO2 emissions at around the 1990 level. Required carbon tax rates: ¥17,500/tC ($135/tC) for the average of the 1993-2020 period. Maximum rate of GNP reduction during the period is 3.6% relative to the baseline (tax revenue being not recycled).

Table 3 Impacts of CO2 Reduction Scenarios (continued)

K. Ban

Case 1 : Carbon taxes to stabilize CO2 emissions at the 1990 level; 24% on oil, 16% on LNG, and 30% on coke and coal (about $66/tC in 2000) with tax revenue recycled via indirect-tax cut. Case 2: Direct regulation; uniform cut in production and consumption (roughly 5%) to reduce emissions as in Case 1.

	Cumulative reduction in real GNP (1985 prices) in 2000	Equivalent reduction in constant average growth rates (% p.a.)
Scenario 1	¥28 tril.	0.10
Scenario 2	¥41 tril.	0.15

A. Onishi

CO2 emissions stabilization at the 1990 level by 2000. Scenario A: all countries introduce carbon taxes of 10% on oil, 12% on coal, and 8% on natural gas; furthermore, all countries cut back non-housing investments to attain their emission targets. Scenario B: developed countries increase R&D expenditures by 0.5% of GDP to reduce CO2 emissions; these countries also increase ODA by 20% compared to the baseline case to help reduce CO2 emissions in developing countries. Scenario C: most countries introduce at lease 5% carbon tax on fossil fuels; developed countries increase R&D expenditures by 0.25% of GDP to reduce CO2 emissions; these countries also increase ODA by 10% compared to the base-line case to help reduce CO2 emissions in developing countries.

	Changes in Growth Rates: 1991-2000 av.					
	GDP			CO2		
Scenario	A	B	C	A	B	C
World	-2.0	0.1	-0.4	-1.5	-2.2	-2.3
Developed Market Economies	-2.1	0.1	-0.4	-1.4	-2.2	-2.0
Developing Market Economies	-1.6	0.0	-0.3	-1.7	-5.0	-2.1
Planned Economies	-2.0	0.1	-0.7	-1.4	-2.2	-2.5
Japan	-3.2	0.4	-0.6	-1.3	-1.9	-2.1

S. Shishido

Fossil fuel taxes introduced in G7 countries, starting from 10% in 1990, raised to 20% in 1995, and sustained thereafter.

	Changes in Growth Rates: 1990-2000 av.	
	GDP	CO2
World	-0.1	-0.1
Developed Market Economies	-0.1	-0.3
Developing Market Economies	0.0	0.0
Planned Economies	-0.1	0.0

Y. Matsuoka

Type 1: uniform and time-invariant carbon taxes throughout the world. Tax of $100/tC will keep the level of CO2 emissions in 2010 around the current level, but it will be insufficient to stop increasing emissions afterwards. If all GHGs are considered, even $200/tC tax will be insufficient.

Type 2: controlling world emissions. In order to reduce CO2 emissions from fossil fuel combustions by 1% p.a., the level of carbon tax will start from $40/tC and will exceed $1000/tC in 2070. In this case, the atmospheric concentration of CO2 will be stabilized at 550 ppmv around 2070. World GNP will be reduced, however, by about 15 per cent.

Perhaps, the most optimistic results are those of Goto, who works with a model in which resources are allocated most efficiently in a dynamic context. This position is followed by Ban. Although his results are based on an annual econometric model, which usually involves rather low estimates of price and substitution elasticities, Ban has paid

careful attention to estimate the long-run responses to price changes. On the other hand, Onishi has given us a rather alarming picture. His model does not seem to yield sufficiently large price effects, so that massive R&D and ODA expenditures will be needed to prevent economic slow down arising from CO2 abatement policies. (Incidentally, Matsuoka also arrived at rather cautious conclusions. We should note, however, that his targets are the stabilization of atmospheric concentration rather than that of flow emissions, and that he considers not only CO2 alone but also other GHGs as well.)

Although other models give somewhat intermediate results, it appears that models currently used for medium-term forecasting purposes generally give fairly large GNP reductions emanating from CO2 taxes. It seems quite natural that models paying more explicit attention to price elasticities have given more credits to carbon taxes.

In the works presented in Parts II and III, not only taxes and charges but also a variety of other policy measures are discussed. I should like to take up some of the issues in the final chapter which will be addressed to some concluding remarks.

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