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Global Emission Trading Scheme

-New International Framework beyond the Kyoto Protocol-

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Executive Summary

In February 2007, the United Nations' Intergovernmental Panel on Climate Change (IPCC) observed that the average global temperature has climbed 0.74 degrees Celsius in the ten years from 1996 and 2005, and basically concludes that global warming is escalating due to human activity. In May 2007, looking ahead to the G8 summit to be held in Germany in June, Prime Minister Abe and the Japanese government proposed the strategy of "Cool Earth 50". Regarding the post-Kyoto framework, Prime Minister Abe proposed that all of the major emitting countries including the US, China and India aim to create a framework that will accomplish a 50% global reduction by 2050. The specifics of this plan, however, have not been produced, and what comes after the promised term of the Kyoto Protocol—in other words, the specific institutional design of the global framework after 2013—remains unclear. In this paper, we begin by assessing the Kyoto-type framework, which sets emission targets for developed countries and no targets for developing countries from economic and environmental perspectives by using a dynamic computable general equilibrium model. We then consider global emission trading scheme (GETS) as an alternative to the Kyoto Protocol and assess GETS from economic and environmental perspectives.

Key words: Climate Change, Emission Trading

CONTENTS

1. Introduction

In February 2007, the United Nations' Intergovernmental Panel on Climate Change (IPCC) observed that the average global temperature has climbed 0.74 degrees Celsius in the ten years from 1996 and 2005, and basically concludes that global warming is escalating due to human activity. If countermeasures are not taken, the panel warns that the temperature could climb a maximum of 6.4 degrees Celsius by the end of this century compared to the end of the 20th century. With this in mind, discussion regarding the post-Kyoto Protocol, an international framework concerning the reduction of greenhouse gases after 2013, has become animated. In January 2007, the EU independently declared that it would reduce greenhouse gases by at least 20% by 2020 (compared to the level in 1990). In May 2007, looking ahead to the G8 summit to be held in Germany in June, Prime Minister Abe and the Japanese government proposed the strategy of "Cool Earth 50". Regarding the post-Kyoto framework, Prime Minister Abe proposed that all of the major emitting countries including the US, China and India aim to create a framework that will accomplish a 50% global reduction by 2050. The specifics of this plan, however, have not been produced, and what comes after the promised term of the Kyoto Protocol—in other words, the specific institutional design of the global framework after 2013—remains unclear.
In this paper, we begin by assessing the Kyoto-type framework, which sets emission targets for developed countries and no targets for developing countries from economic and environmental perspectives by using a dynamic computable general equilibrium model. We then consider global emission trading scheme (GETS) as an alternative to the Kyoto Protocol and assess GETS from economic and environmental perspectives.

2. Methodology

In this study, we use the GTAP-E model (Burniaux and Truong 2002) which is the standard GTAP model (Hertel 1997) but with energy substitution incorporated into the basic production structure (see Figure 5.1). GTAP stands for "Global Trade Analysis Project", and the GTAP model is a global computable general equilibrium (CGE) model developed at the Center for Global Trade Analysis, Purdue University, USA, for use in global trade analysis. With energy-substitution incorporated, the modified GTAP-E model is often used for trade-environment analysis. In this paper, we further modify the GTAP-E model to allow for the disaggregation of the electricity generation sector into various 'technologies' such as 'coal-fired', 'gas-fired', 'oil-fired', 'hydro', 'nuclear', and 'other'. Each technology is assumed to produce a particular type of product (coal-electricity (ELYCoal), gas-electricity (ELYGas), etc.) using relatively fixed input proportions, and then combine the different electricity outputs using a constant-ratio-of-elasticity-of-substitution-homothetic (CRESH) production structure. This approach of disaggregating the production structure of an aggregate commodity such as electricity has been referred to as the "technology bundle" approach (see Figure 2)(Saijo and Hamasaki 2009).

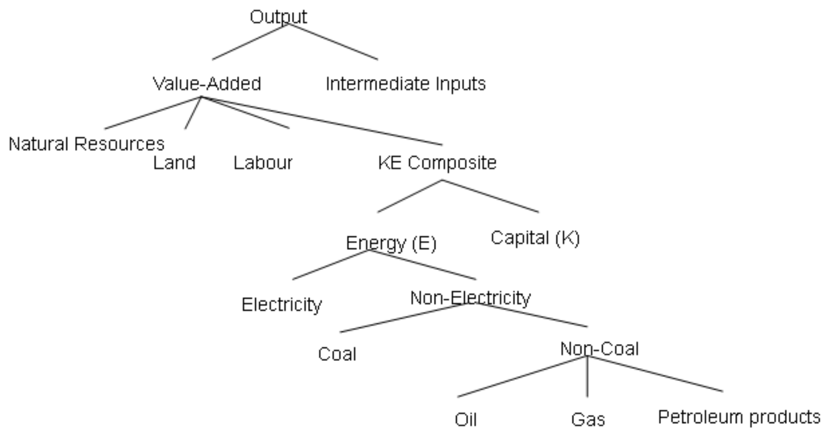


Figure 1 Standard GTAP-E Production Structure

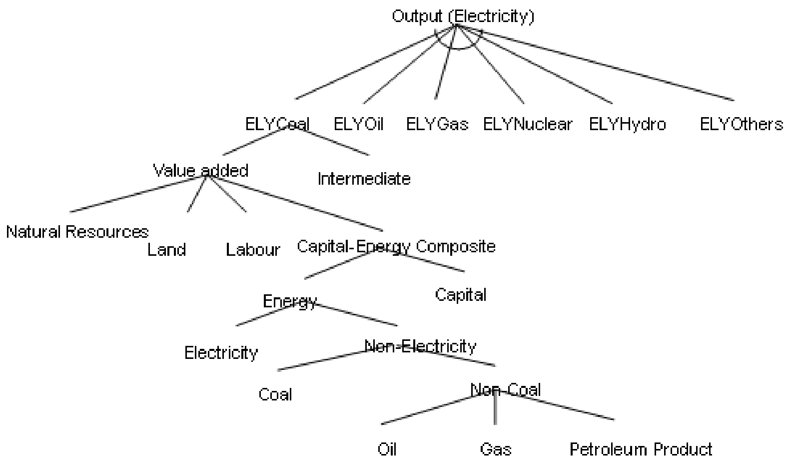


Figure 2 Production Structure for Electricity Sector

This kind of a production tree is a convenient way of representing separable, constant return-to-scale technologies. Each group of equations refers to one of the branches in the production trees. For each branch, substitution amongst inputs within the nest follows directly from the CES (Constant Elasticity of Substitution) form of the production function for that branch.

For example, value added nest in Figure 1 is describes as follows:

$$qfe(i,j,r) = qva(j,r) - \sigma_{VA} * \left[pfe(i,j,r) - pva(j,r)\right]$$

$qfe(i,j,r)$: percentage change in quantity of endowment commodity i demanded by firms in sector j of region r

$qva(j,r)$: percentage change in quantity index of value-added in firms of sector j in region r

σ_{VA}: substitution elasticities in value-added branch

$pfe(i,j,r)$: percentage change in demand price of endowment commodity i supplied to firms in sector j of region r

$pva(i,j,r)$: percentage change in price of value-added in sector j of region r

In this study, we use 9 regions and 14 sectors aggregation based on the GTAP version 6 database. Details of the aggregation are presented in Table 1.

Table 1 Categorisations of Regions and Sectors

Regions	**Sectors**
China	Agriculture
India	Coal
Japan	Oil
USA	Gas
Canada	Petroleum Products
EU15	Electricity
Russia	Iron and Steel
Rest of Annex I	Non-Ferrous Metal
Rest of the World	Mineral Products
	Paper, Pulp and Publishing
	Chemical, Rubber and Plastic
	Other Manufacturing
	Transport
	Service

3. Limits of the Kyoto Protocol

The most glaring weakness in the Kyoto Protocol is that China and India do not have quantitative emission targets and Russia's commitment is quite generous. In addition, the largest greenhouse gases contributor, the United States, has not ratified the Kyoto Protocol. The Kyoto Protocol imposes costs on sources in countries with commitment, but no costs on sources outside these industrialised countries. The difference in costs across countries can also cause emission leakage. The leakage can further reduce the efficiency and environmental benefits of the Kyoto Protocol (Aldy and Stavins 2007a). Leakage of emissions could come about by relocation of carbon-intensive industries from countries with emission commitments to nonparticipating countries, or by increased consumption of fossil fuels by nonparticipating countries in response to declines in global oil and coal prices. An authoritative survey concludes that "Leakage rates in the range 5 to 20 percent are common" (IPCC 2001). Article 3 of the UNFCCC defines the principle of common but differentiated responsibilities (CBDR). However, a generally agreed upon definition does not exist. Under the existing Kyoto Protocol, the principle of CBDR has been translated in practice into a set of specific, quantitative emission mitigation obligations for industrialised countries and no emission mitigation obligations for developing countries (Aldy and Stavins 2007b). In this analysis, we evaluate the Kyoto-type framework, which set GHG emission reduction target for developed countries and no target for developing countries. Under the simulation, we assume that the Kyoto-type framework will be kept after 2012, the last year of the Kyoto Protocol, and Annex I countries will reduce their emissions by 40% below the 1990 level in 2020, the toughest IPCC (2007) target for Annex I countries to stablise carbon concentration at 450 ppm. Figure 3 shows deviation of global carbon emissions from the baseline and climate change stabilization scenarios 450ppm, 550ppm and 650ppm. Global emissions will decrease by 18.8% below BAU scenario in 2020 if developed countries reduce their emissions by 40% below 1990 by 2020. However, the reductions are not enough to meet even the 650ppm scenario.

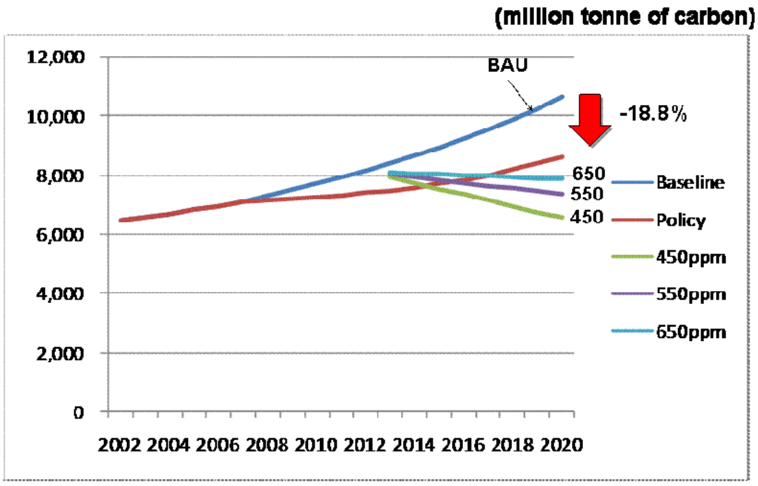
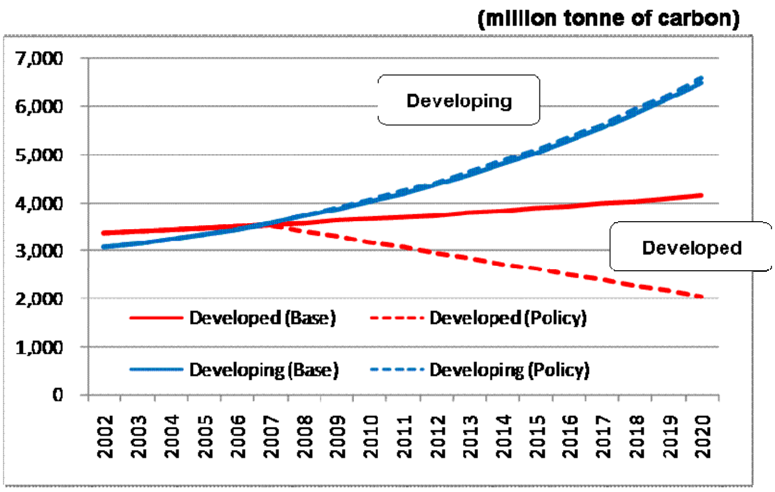


Figure 3 Global Emissions

Figure 4 shows emissions of developed and developing countries under the uncontrolled scenario and the Kyoto-type scenario. Under the BAU scenario, emissions of developing countries exceed developed countries in 2007. Under the simulation scenario, emissions from developed countries will deviate sharply from the baseline, but developing countries' emissions will increase compared to the baseline due to carbon leakages.



Note: The red line represents emissions of developed countries and the blue line represents emissions of developing countries. Solid lines represent BAU (business-as-usual) and broken lines represent the Kyoto-type scenario.

Figure 4 Global Emissions

4. Global Emission Trading Scheme

Promoting participation may be the greatest challenge for the design of climate policy architecture. No policy architecture can be successful without the United States, Russia, China, and India taking meaningful actions to slow their greenhouse gas emission growth and eventually reduce their emissions (Aldy and Stavins 2007b). Developing countries will be the source of big increases in emissions in the coming years according to the business-as-usual path. However, developing countries point out that it was industrialised countries that created the problem of global climate change, and developing countries should not be asked to limit their economic development to pay for it. To overcome these problems, Stern (2008) proposes international cap-and-trade systems as an alternative to the Kyoto Protocol for three reasons: i)Managing risks of dangerous climate change by imposing an absolute limit on emissions, ii)Reducing the costs of action, and iii) Generating private sector financial flows to developing countries, which can be used for low carbon development. In the simulations, a global emission trading scheme was introduced in 2013 with credible commitment to keep it in place over the long run, adjusting the rate as necessary to achieve the profile of global emissions depicted in Figure 5.5. There is no agreed upon global emission path to stabilize climate change. Hence, we take den Elzen and Hone (2008) 450ppm scenario, 25% above 1990 in 2020.

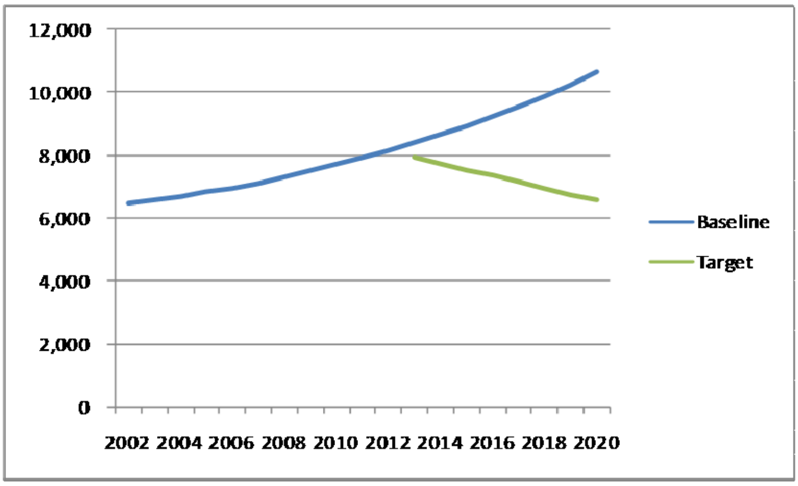


Figure 5 Global Emissions Targets and Paths, 2002-2020 (million tonnes of carbon)

The pattern of international transfers and the macroeconomic effect of cap and trade are highly sensitive to how emission rights are reallocated (IMF 2008). In the simulations, we assume two types of initial allocation methods of emissions rights. Each economy receives emission rights according to its population or GDP.

4.1. GETS (per capita)

In this section, we describe key results of the Global Emission Trading

Scheme with per capita allocation. Under the scheme, every single person has a right to emit the same amount of carbon.

Firms change their technology, substituting away from carbon-intensive inputs and into capital and labour. Households change their consumption patterns from energy intensive goods. The macroeconomic impact of major economies is depicted in Figure 6. Changes of GDP depend on how intensively it uses carbon intensive energy to make goods and services for the domestic market and exports. China is the least efficient in the use of energy. It is producing nine times more emissions per unit of output than Japan, seven times more than Western Europe, five times more than the United States, and three times more than Eastern Europe and Russia and other emerging and developing economies (IMF 2008). As a result, China will be highly affected in terms of GDP. The GDP loss of Japan will be lower than other countries due to the country's high energy efficiency and high dependency on imported fuels.

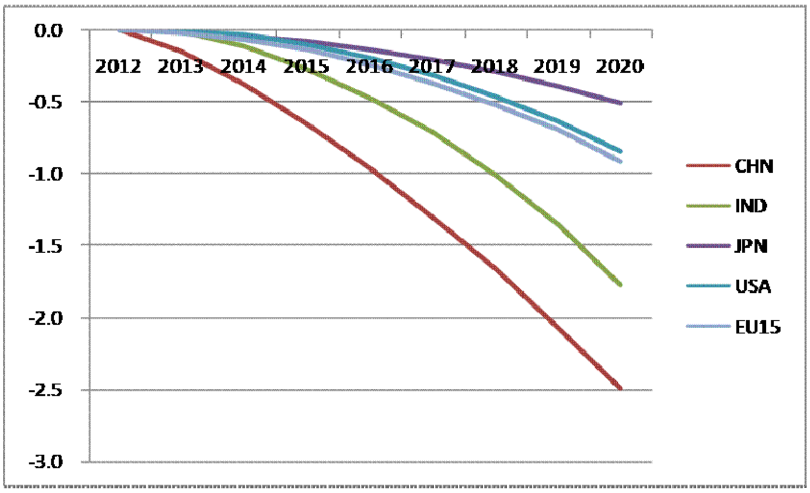


Figure 6 Macroeconomic Impact (GDP) (% deviation from the baseline)

Table 2 shows cumulative international transfers under the GETS from 2013 to 2020. India is the biggest recipient with transfers reaching 96,964 million US$. India is a low energy efficient country, which means she can reduce her own emissions at a lower price compared to developed countries. In addition, India's per capita emission is much lower than the world average. In 2005, India's population was 16.8% of the world total, but its emissions were 4.5%. India can sell surplus emission rights to other countries. In the same year, China's population was 20.4% of the world total and its emissions were 19.0%. China's surplus emission rights are much lower than India's. As a result, international transfers of China were smaller than India.

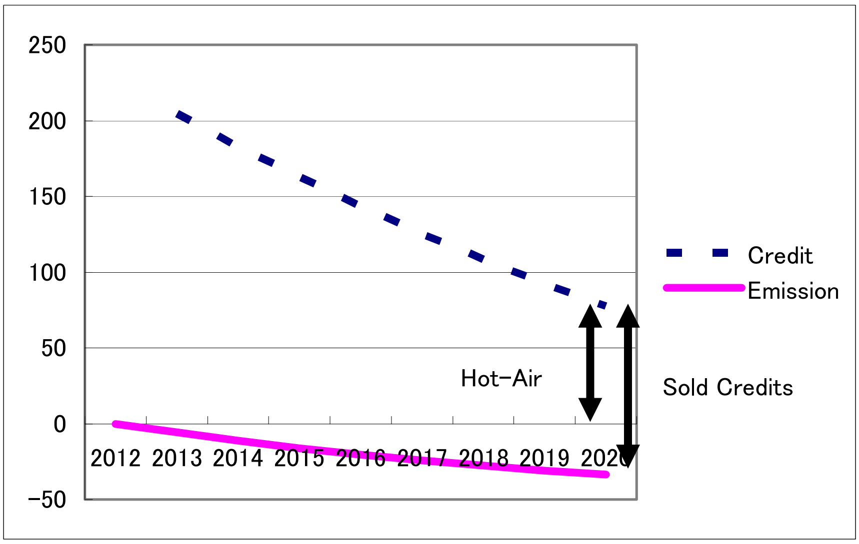
Table 2 International Transfers under the GETS (2020)

(million US$)

China	32,367
India	96,964
Japan	-12,788
US	-107,503
Canada	-11,221
EU15	-46,170

Note: This table shows the net value of international payment for emission rights. A positive value denotes a receipt of transfers.

Figure 7 shows India's actual emissions and allocated emission rights. The gap between allocated emissions and baseline represents hot-air, and the gap between actual emissions and baseline represents actual reduced emissions in India. In other words, India is allocated more credits than she actually emits under the baseline scenario and India can sell the hot-air to other countries. In addition, India has a lot of low cost mitigation options, and under one carbon price she can sell emission reductions from the baseline as well.



Note: Cumulative Deviations (%) from the Baseline

Figure 7 India's Actual Emissions and Emission Rights

We compare key results of the Kyoto-type and GETS with per capita allocation in Table 3. Except China and India, which have no binding targets under the Kyoto type, GDP in GETS scenario improves compared to the Kyoto-type scenario.

Table 3 Comparison between Kyoto and GETS (2020)

(%)

		Kyoto Type	GETS
GDP	China	0.0	-2.1
	India	0.0	-1.4
	Japan	-1.7	-0.4
	US	-1.3	-0.6
	Canada	-3.9	-1.2
	EU15	-2.1	-0.7
Emissions		-18.8	-33.9

Note: Cumulative Deviation from the Baseline

If the GETS is introduced, climate change can be stabilised without imposing heavy damage on each country's economy compared to the Kyoto-type framework. GETS encourages both developed and developing countries to price carbon emissions in the country. Excluding developing countries from carbon mitigation activities is very costly. GETS with per capita allocation increases additional financial flow to developing countries, and developing countries can spend the budget for mitigation and adaptation to climate change.

4.2. Comparison of Different Allocations

The pattern of international transfers and the macroeconomic effect of cap and trade are highly sensitive to how emission rights are allocated (IMF 2008). Table 4 shows differences of international transfers amongst different allocations of emission rights. In per capita allocation, developing countries receive more credits than developed countries, because per capita emission of developing countries is much lower than developed countries. Hence, developed countries have to pay to buy credits from developing countries. Conversely, in per GDP allocation, developing countries have to pay to buy credits from developed countries, because emission per unit of GDP of developing countries is more than that of developed countries.

Table 4 International Transfers under GETS (2020)

(million US$)

	GDP	Capita
China	−104,471	32,367
India	−39,166	96,964
Japan	93,172	−12,788
USA	125,259	−107,503
Canada	4,412	−11,221
EU15	114,856	−46,170

Note: 2020 figure

Table 5 represents GDP change. There are no significant differences in GDP between the two allocation methods, but GDP in India is relatively sensitive to the allocation method of emission rights because the amount of international transfer differs significantly depending on the allocation method.

Table 5 GDP Change (2020)

(%)

	GDP	Capita
China	−2.1	−2.1
India	−1.7	−1.4
Japan	−0.4	−0.4
USA	−0.6	−0.6
Canada	−1.1	−1.2
EU15	−0.5	−0.7

Note: Cumulative Deviations from the Baseline

5. Conclusion

The IPCC Fourth Assessment Report finds that human actions are "very likely" the cause of global warming—meaning a 90% or greater probability—and stabilising climate change is an emergency issue to be addressed by the international community. Under the existing Kyoto Protocol, the principle of CBDR has been translated in practice into a set of specific, quantitative emission mitigation obligations for industrialised countries, and no emission mitigation obligations for developing countries. However, our modeling exercise shows that it is very costly to mitigate carbon emissions without developing countries, which will be a major source of global emission increases in the coming decades. If the GETS is introduced, climate change can be stabilised without imposing heavy damage on each country's economy compared to the Kyoto-type framework.

GETS encourages both developed and developing countries to price carbon emissions in the country. GETS with per capita allocation increases additional financial flow to developing countries, and developing countries can spend the budget for mitigation and adaptation to climate change.

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