Win-win Strategies of Global and Domestic Climate Change Policy for China, Asia and Japan*

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Kazuhiro Ueta : Kyoto University
Yoshihisa Inada : Konan University
Kiyoshi Fujikawa : Konan University
Akihisa Mori : Shiga University and Kyoto University
Sungin Na: Hiroshima Shudo University
Tadashi Hayashi : Takasaki City University of Economics

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1. Introduction

Negotiations for the stabilization of climate changes have been talking place, from Rio to Marrakech, for the last ten years. Kyoto mechanism was proposed in the COP3 that they should promote the reduction of GHGs emissions by doing cross-border technological cooperation and trading the emission rights by pricing GHGs. There are two systems of the international technical cooperation, that is, clean development mechanism (CDM) and joint implementation (JI). While CDM is the technological cooperation given from the advanced countries (called Annex I Parties) that have duty to cut emissions to the developing countries (called Non-Annex I Parties) that do not, JI is the cooperation between advanced countries with such duty. However, they have same basic principle. Anyway, the agreement at the Kyoto conference is made on the premise that there is "technological difference" or "difference in difficulties to cut GHGs emissions" among nations, and it is suggested that the elimination of the discrepancies would bring so-called win-win game that would benefit both the giver and the receiver of technologies[1].

The international rule for the enforcement of the agreed items was to be decided in the Hague Conference (COP6) in November 2000, however, the compromise could not be reached and the conference broke down. Then in November 2001, Marrakech conference (COP7) was held in response to that. The international rule for the enforcement of Kyoto mechanism was agreed with considerable difficulty[2], and Japanese government has come to ratify the treaty. In the Marrakech agreement, it is stated that the advanced countries should work for the accomplishment of the goal within the country first and emission-reduction outside the country would be secondary issue. Though we should not expect much from CDM in the light of this, Japan has been made China as potential target and taken hopeful view on GHGs as means of reduction.

This paper aims to analyze the possibility of win-win strategies for technological cooperation between China and Japan. In the Section 2, we summarize the current situation of energy and environment in China. We analyze in the section 3 the economic and environmental impact of technological transfer from Japan to China using GTAP model. How the technology transfer from Japan to China is realized? We discuss how we should use CDM project for promoting the technology transfer.

2. Energy and Environment in China

2.1 Energy Consumption and Its Composition

Here we shed a light on the recent situation of China’s economic growth and energy consumption.

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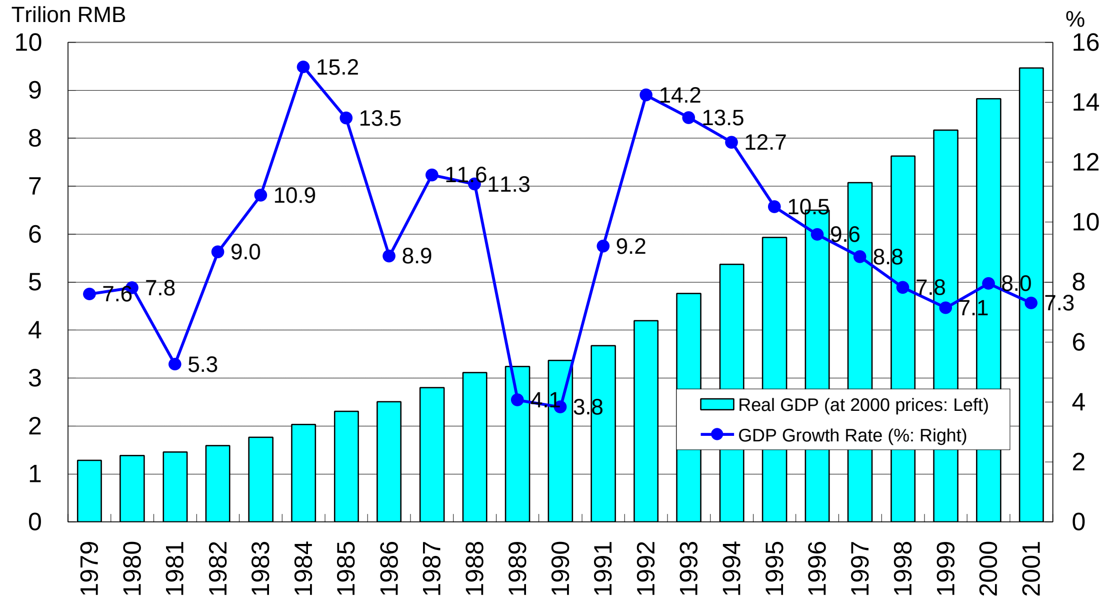
1 It was approved to buy and sell the emission rights of greenhouse gases in addition to such clean development mechanism and joint implementation. Generally these economic means are called the Kyoto Mechanism.

2 It cannot be denied that the United States having declared withdrawal from the Kyoto mechanism in January 2001 became the pressure for Japan and Europe to make compromise and reach mutual agreement in Marrakech.

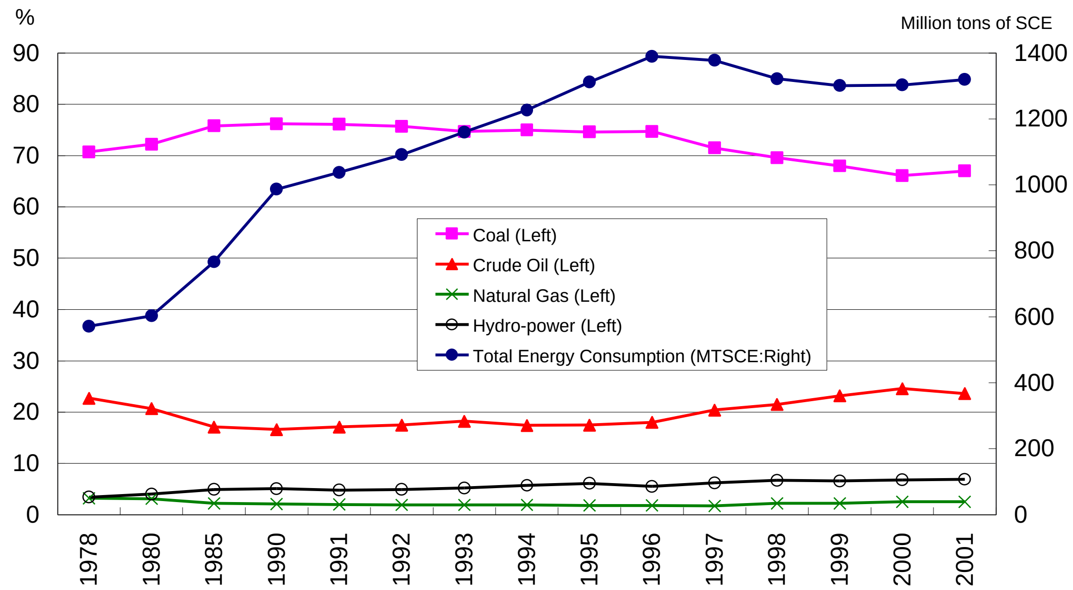
Figure 1 shows the recent trend of China's economic growth. China's economic growth has been slowing. But it should be noted that it is still higher than 7%.

Figure 1 Trend of China's economic growth



Source: National Statistics Bureau (2002), China Statistics Yearbook, China Statistics Press.

Figure 2 Trend of China's energy consumption pattern



Source: Same as the Figure 1.

Figure 2 shows the composition of energy consumption in the China, from 1978 to 2001. The energy consumption patterns by energy source have slowly changed in China over the last two decades. Coal was major energy sources, accounting for over 70% of the total primary energy consumption, although its share has gradually decreased since 1997. On the other hand, the shares of oil and hydropower have increased in the late 1990s'. Energy conversion policy started 1997 in China, because of the seriousness of environmental issues such as SOx pollution and acid rain due to the mass consumption of coal.

Table 1 Shares of China in the world

	1971	1997	2020
Primary energy demand	5%	10%	14%
Coal demand	13%	29%	36%
Oil demand	2%	6%	10%
CO2 emissions	7%	14%	18%
GDP(PPP base)	3%	13%	21%

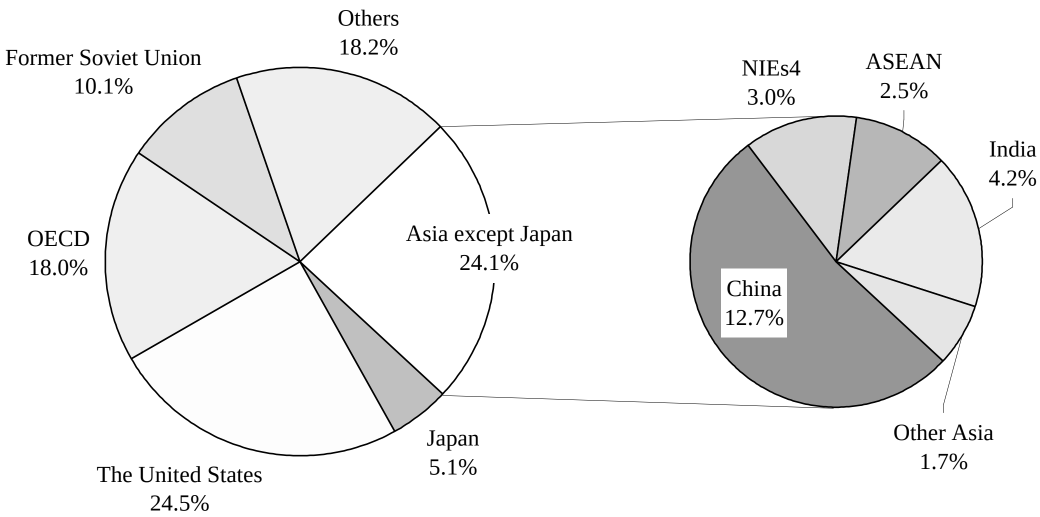
Source: IEA (2000), World Energy Outlook, OECD/IEA, Paris.

All indicators including economic, energy, and environment show that China's share will increase. According to IEA(2000), the share of China's primary energy demand to the total demand in the world will be 14%, and 21% in GDP. IEA also foresees the share of China's CO_2 emissions in the world will be 18% in 2020.

2.2 Energy consumption and CO_2 emissions in China and Japan

Figure 3 shows the share of CO_2 emissions in the world at the time of 1998. The United States is ranking in the first place, accounting for about a quarter of emissions of the entire world. Total emissions in the world were about 6 billion tons and those of the United States were 1.5 billion tons in 1998. As already mentioned in section 1, it can be seen from this figure how much impact the U.S.'s withdrawal from Kyoto Protocol gave. However, if CO_2 emissions in Asian region (except Japan) are summed up, they almost equal to those of the United States, and if the CO_2 emissions of Japan are added to this, they exceed the U.S. In the pie graph in the right of Figure 3, the emissions in Asian region were classified in detail by countries. How large China's share can be again confirmed here. China has emission share of 12% that equals to half of that of the United States, ranking in the second in the world. What comes in third is the former Soviet Union with about 10% and the fourth is Japan with about 5%.

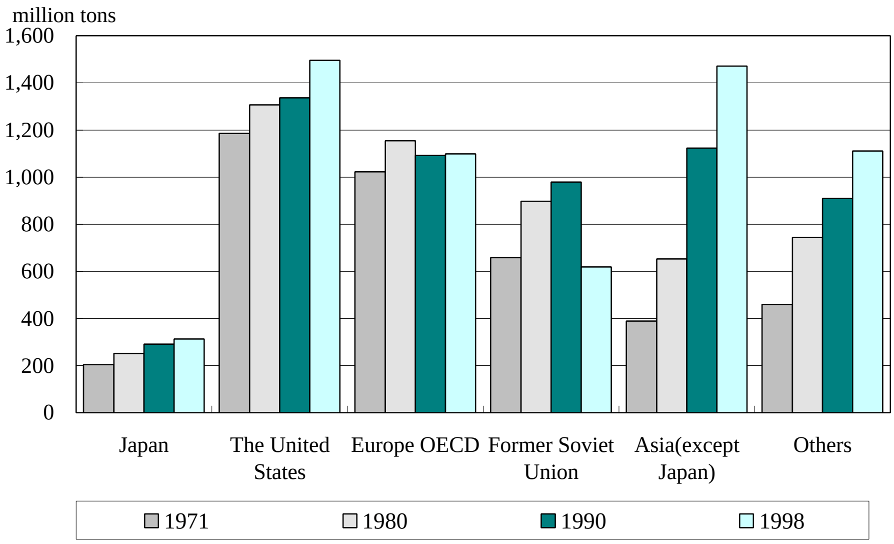
Figure 3 Share of CO_2 Emissions in the world (1998)



Source: EDMC (2001), Handbook of Energy & Economic Statistics in Japan.

Figure 4 shows the transition of CO_2 emissions for about 30 years (from 1971 to 1998) by countries. There is not much change in emissions of European OECD countries aside the benchmark. That might be explained by the low growth of the economy; however, the effort these countries are making to stabilize energy consumption also can be seen in the figure. In former Soviet Union, as depressed economy after the fall of the communist regime gave a serious impact, the situation is unusual where CO_2 emissions of 1998 falls below those of 1971. On the other hand, CO_2 emissions in Japan increased 50% though the amount itself is not large. The U.S. has increase of 25%.

Figure 4 Transition of CO_2 emissions by regions



Source: same as Figure 3.

What draws attention most countries might be China. CO_2 emissions in China has expanded from 185 million tons in 1971 to 537 million tons in 1998, making increase of more than 3 times.

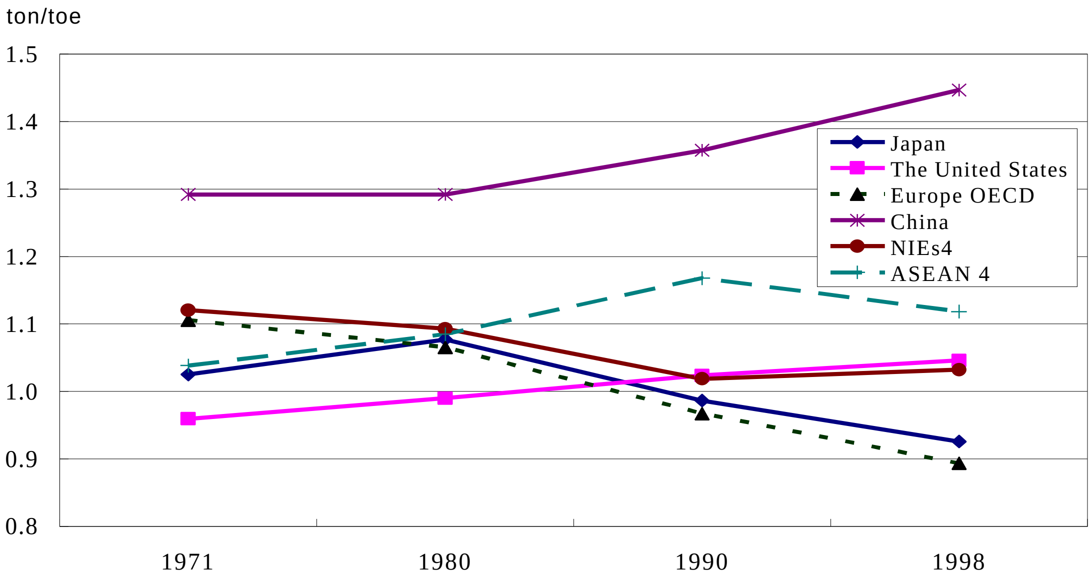
The following "Kaya's Identity" is often used for the factor analysis of the CO_2 emissions.

$$CO_2\text{emissions} = \frac{CO_2\text{emissions}}{\text{energy consumption}} \times \frac{\text{energy consumption}}{\text{GDP}} \times \text{GDP}$$

First, CO_2 emissions per energy consumption as in the first term in the right side is graphed out in Figure 5. The CO_2 emissions per energy consumption depend on the composition of the energy source. For instance, since generation of electricity by nuclear power or waterpower does not exhaust CO_2, countries where such energy sources have large shares have smaller CO_2 emissions. As for fossil fuel, the CO_2 emissions per unit calorie are large in the order of coal, oil, and the natural gas. So the CO_2 emissions per energy consumption increase in the countries where coal has the large share in the composition of energy.

The CO_2 emissions of European OECD countries, Japan and NIEs have a downward trend, reflecting the conversion to nuclear power and the natural gas has been advanced in these countries. However, a rising trend is apparently seen in China, and also slightly in ASEAN regions. Traditionally China is a country where the coal dependence is high and CO_2 emissions per energy consumption are large, and the dependence seems to be growing in recent years. Surprisingly disadvantaged to oil resource, China is an import country of oil. So "Large-scale western China development" has been planned to construct pipelines from the natural gas field in the Western area so as to supply natural gas in the city in the coast region.

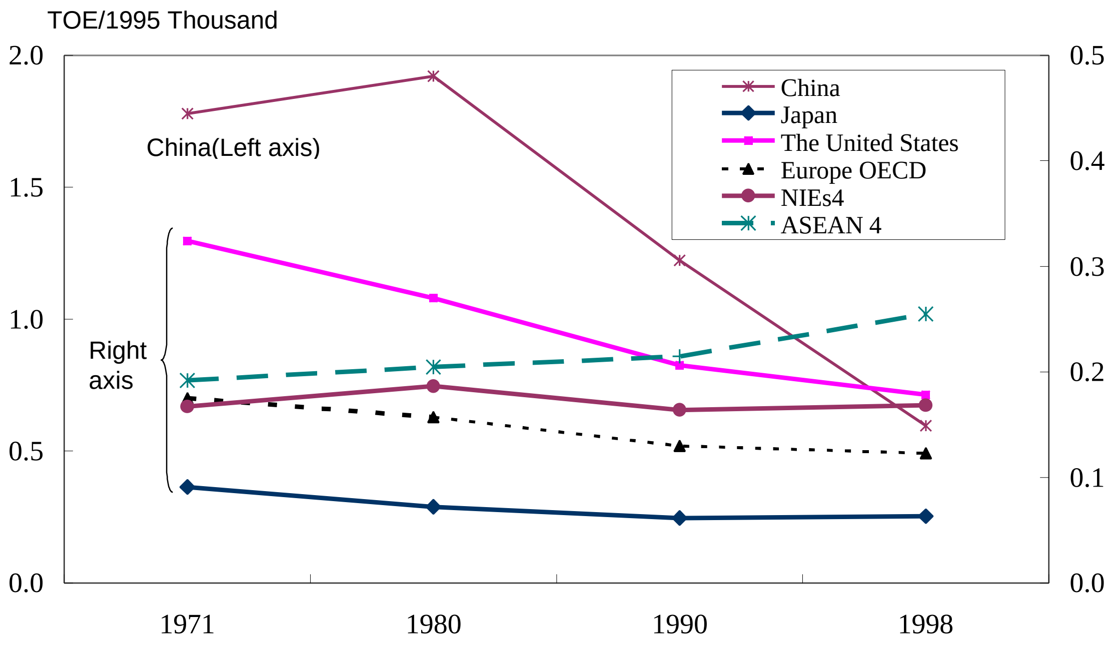
Figure 5 CO_2 emissions per energy consumption



Source: same as Figure 3

Then "energy consumption per GDP" as in the second term of the Kaya's identity is graphed out in Figure 6. This figure partly depends on the industrial structure of one country and partly on the energy efficiency. As for the former, it increases when it advances from the agriculture-centered stage to industrialization, and decreases when economic servicing is in progress. As for the latter, usually the energy efficiency is improved when equipment or machinery is renewed, whatever be it the production machinery or household electric appliances or private cars. Generally it is known that when the income level is set in the horizontal axis and the load of economy to environment in vertical axis, the environmental load increases in the economic development at the beginning and peaks before long then decreases, marking inverted U curve (environmental Kuznets curve). The same kind of curve would appear as for the energy consumption per GDP.

Figure 6 Energy consumption per GDP

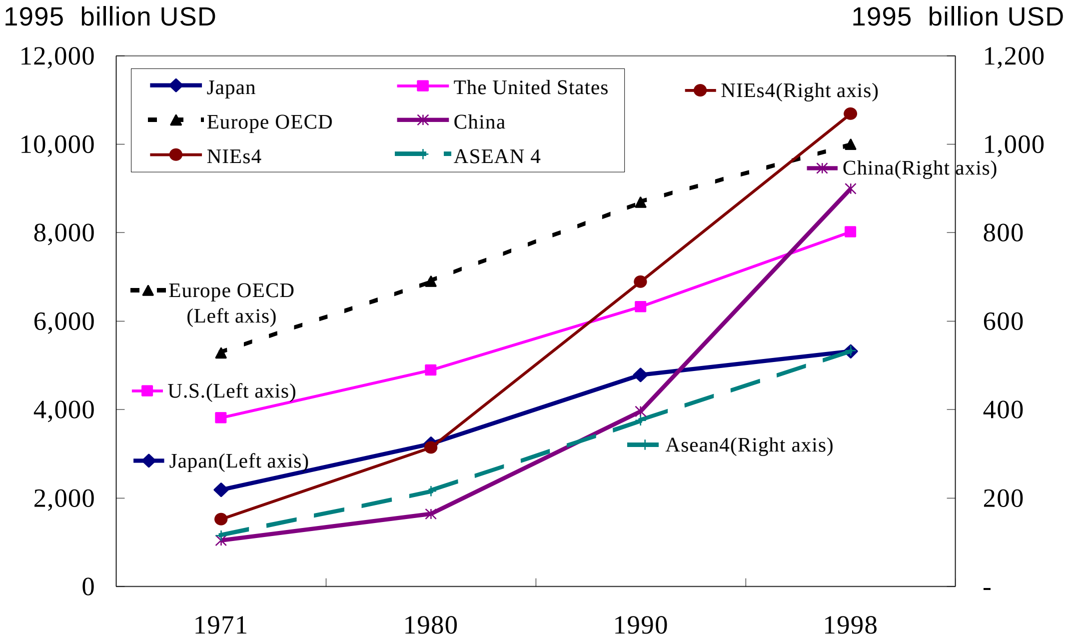


Source: same as Figure 3

As shown in figure 6, the energy consumption per GDP is a slight downward trend or level off in the industrialized countries such as the United States, European OECD, Japan, and NIEs (all measured by the scale marks on the right axis). The efficiency of Japan excels other countries remarkably and the energy consumption is half compared with the United States. European OECD is in the middle of Japan and the U.S. The influence of the progress of industrialization exceeds the effect of the introduction of the technology to improve efficiency in ASEAN region (measured by the scale marks on the right axis), and energy consumption per GDP shows increasing trend, which will be still noteworthy in the future. Note that only China is measured by the scale marks on the left in the figure 5. Though there might be a problem in the way GDP is measured in China, China's economy has very bad energy efficiency, and about twenty times more energy was used in 1971 for the same productivity compared with Japan whose efficiency was the best. However, energy efficiency is improving sharply owing to rapid capital investment in recent years. There still exist between Japan and China a gap of about ten times, even though it became smaller at the time of 1998. It is understood that there still is a potential of a further energy efficiency improvement.

Next, the transition of GDP as in the third term of the Kaya's identity is graphed out in Figure 7. Since the scales of GDP differ between the advanced country group and others, three regions (the United States, European OECD, and Japan) are measured on the scale marks on the left axis, and the other three regions (NIEs, China, and ASEAN) are measured on the right axis. As for the advanced country group, transition is almost parallel expect for Japan leveled off in 1990's. As for NIEs and China, however, it is apparent that the trend is obviously growing more than the advanced countries. When Japan and China are compared, Japan's GDP exceeded twenty times of China's GDP in 1971; but the difference is rapidly getting smaller in 1998 to the extent that Japan's GDP become six times of China's.

Figure 7 Transition of GDP by regions



Source: same as Figure 3

Based on the Kaya's identity, the CO_2 emissions are examined by three factors, that is, energy consumption, energy efficiency and economic development. As a result, though there is a good sign of improving energy efficiency in China, on the other side it is also found there are many bad materials: its energy consumption is comprised mostly of coal and the standard of energy efficiency is bad, and economic development is still high.

In this paper, we try to verify to what degree the improvement of China's energy efficiency is effective to reduce the CO_2 emissions on the ground of above-mentioned facts.

Though we should not expect much from CDM in the light of this, Japan has been made China as potential target and taken hopeful view on GHGs as means of reduction. Moreover, taking advantage of the fact that the goods dealt in the market change its volume of transaction more or less depending on the price, Scandinavian countries readjusted the established energy levy since around 1990 and introduced the levy to the fossil energy (or carbon contained). Other European countries have been following them. It is an approach to cut greenhouse gas emissions by promoting the control of fossil energy consumption and substitution for new energy. Table 2 shows the example of introducing the carbon tax in Scandinavian countries. As the "levy of 1500 yen for each carbon ton" equals to "levy of one yen a liter by conversion into gasoline", it is levied about 5 yen a liter of gasoline in Finland, and about ten yen in Sweden.

Table 2 Rate of Carbon Taxes in North European Countries*

	Dollar / ton Carbon	Yen / ton Carbon
Finland	53.9	6,807
Sweden	113.5	14,315
Norway	at least 40.1	at least 5,009
Denmark	43.0	5,357

*Exchange rates are those in May 2001.

Source: Ministry of Environment (2001). http://www.env.go.jp/earth/report/h13-05/index.html

In Japan, the introduction of carbon tax is actually being discussed as an urgent and crucial concern. As there has been spurting backlash in industrial world against compulsory measures including the introduction of carbon tax, and voluntary plan has been designed, it is often regarded as of limited effect. As Tax Research Commission strongly suggests the introduction of the carbon tax and Ministry of the Environment is organizing the study group for the issue, and it is highly likely that the carbon tax will shortly be introduced in some form.

Table 3 shows simulation results according to leading global econometric model. The rows in right shows rate of a carbon tax necessary for 1% reduction of carbon emissions. Though Japan promised to attain goal of cutting emissions 6% below 1990 levels at Kyoto conference, there is already 10% or less increase of emissions at the point of 2001. Therefore, it is inevitable that Japan should reduce emissions10% or more even if the Kyoto mechanism is used. So the required levy would be about 2,700 yen with Goto model which has the lowest tax rate and about 19,200 yen with Yamazaki model which is the highest when converted in 1$=100 yen rate.

Table 3 Simulation of Carbon Tax by Global models

Model	Loss of GDP (%)	Carbon tax rate *
Goto (Univ. of Tokyo)	0.02	$2.7
Ban (Osaka Univ.)	0.05	$5.6
Mori (Tokyo Science Univ.)	0.22	$17.0
Yamaji (Univ. of Tokyo)	0.23	$18.5
Ito (EDMC)	0.29	$16.5
Yamazaki (CRC Research)	0.41	$19.2
Nihon Keizai Shinbun	0.16	$51.8
Shishido (Internationl Univ.)	1.16	$55.0

* Dollar / ton Carbon to reduce 1% of the carbon emissions.
Source: Amano (1994)

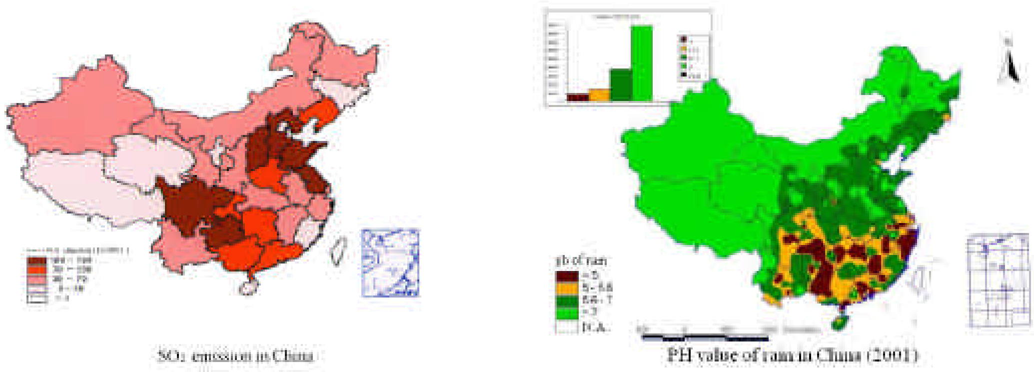
Japan promised in COP3 Kyoto 6% reduction of GHG emissions from the 1990 basis but they already increased by 7% during the decade of 1990's. Therefore the required reduction during the decade after 2000 is about 13%. Suppose Japan realize those reduction through only carbon tax, the requisite tax rate will be 35$/tC to 715/tC.

2.3 SOx Pollution in China

In 1998 China introduced a new regulation to specify two control regions: Acid Rain Control Regions and Sulphur Dioxide Control Regions. The former mainly covers the south of Yangtze River and the latter includes the cities of the middle northern and the southern parts which suffer from the serious sulfur dioxide pollution (See Figure 8).

This regulation enables to charge stricter levy on SO_2 emissions in the control regions. At the same time, existing pollution charge of SO_2 emissions was reformed experimentally in both control regions. The emission charge may change depending on the amount of the discharge in case the discharge surpass the control level

Figure 8 SO_2 emissions and PH values of rain in China



3. The economic impacts of the corporation between Japan and China

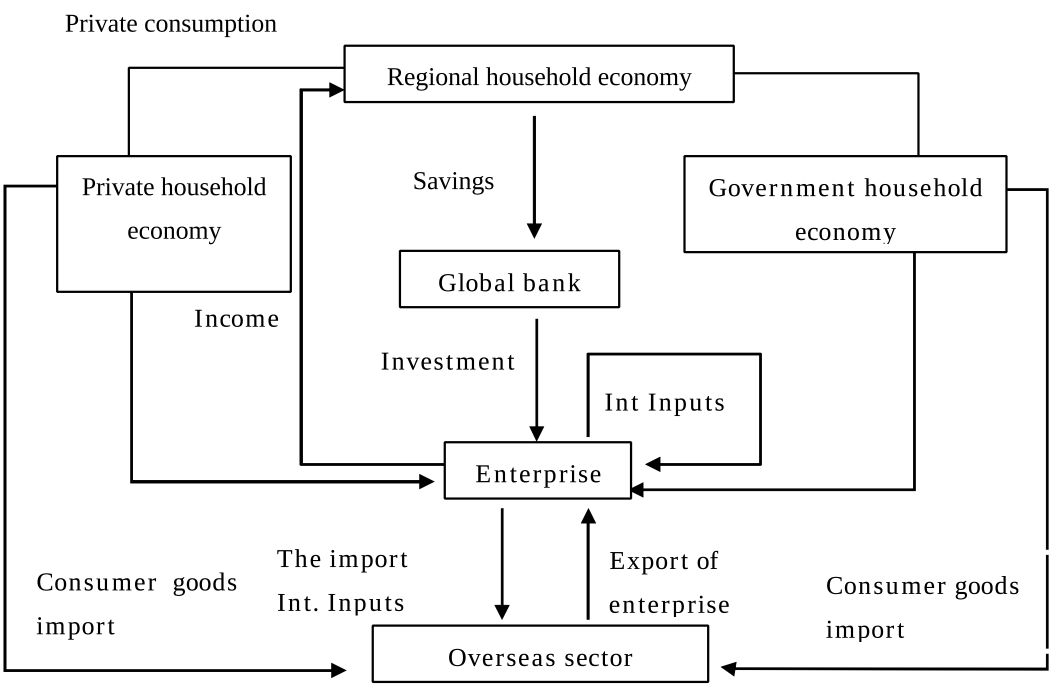
This section analyzes the potential effect of technology transfer from Japan to China, using GTAP model. We have done a simulation analysis to estimate the economic impact not only to Japan and China but also to the world economy.

3.1 Structure of GTAP model

In the database of GTAP model, data such as an indirect tax, trade tax, customs duties, labor, capital stock and the natural resources are provided in addition to the input and the production data of each country.

The macro structure of GTAP model is shown in Figure 9. Though GTAP model is a multi-country model, it is described here as that of one country and overseas sector. The arrow in the Figure 8 shows the direction of payment and is not the flow of goods and service.

Figure 9. Macro structure of GTAP model

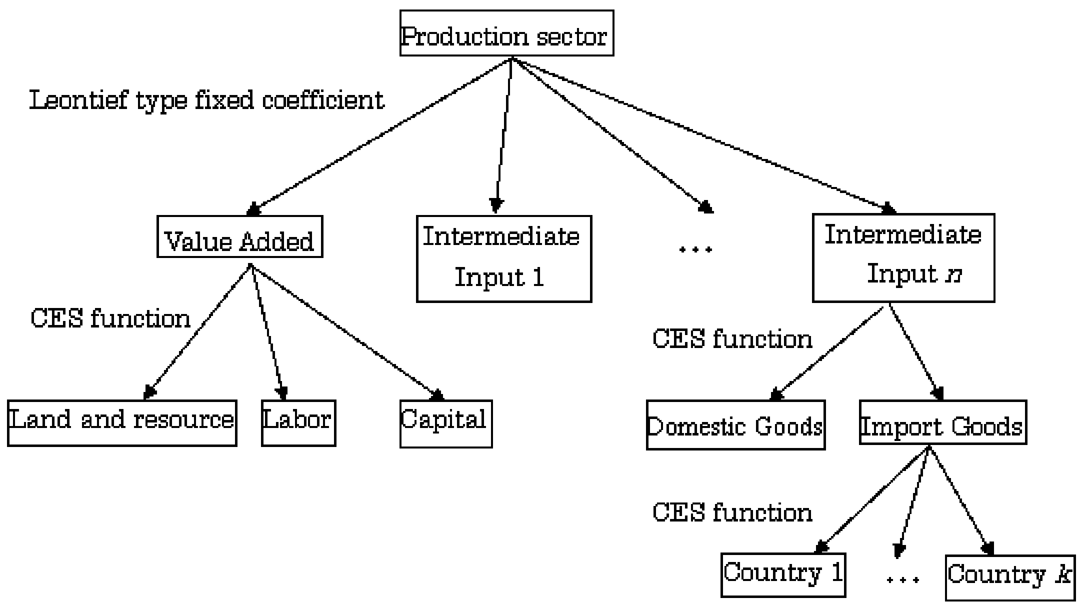


The domestic sector of GTAP is divided into production sector and the one called "regional household economy". The regional household economy consists of private household and the government sector. The regional household economy may maximize the utility function whose elements are private consumption, government expenditure and saving. While the government expenditure is used as an exogenous variable in so-called macro econometric models, what is remarkably characteristic is that it is used as an endogenous variable in the GTAP model.

Moreover, the starting point of the argument is "market equilibrium", and the economic effect means the shift from the present equilibrium point to the new equilibrium point, which is common to applied general equilibrium models. Therefore, the concept of "government expenditure multiplier" that assume beforehand the disequilibrium such as unemployment etc. does not exist.

Figure 10 shows the structure of the production sector. In the Figure, '*i*' stands for sector of input goods and '*j*' for production sector, and '*s*' for region. First of all, as for intermediate inputs, each input is based on the fixed coefficient production scheme but the breakdown of the domestic and imported goods is based on the CES function where the share changes corresponding to the change in the relative price. Moreover, the breakdown of the imported goods to the import partner countries is also based on the CES function, so the international price change may change the trade partners. On the other hand, the value added sector consists of labor, capital, and land, and the breakdown is based on the CES function.

Figure 10 Production sector of GTAP model



The production and consumption are determined as mentioned above, while the amount of the investment is determined as the residual of production and consumption: Since GTAP is a multi country model, it has an unique assumption regarding the investment that the saving is once deposited in the bank which is supposed to be "financial institution of the entire world" and the bank decides the distribution of saving, i.e. investment of the entire world.

There are two options in the investment; the one follows the investment pattern of each country and the other decides an international distribution of the investment so that the rate of profit of each country may be equalized. The former corresponds to the case where capital movement is not liberalized, and the latter corresponds to the case where the international flow of capital is liberalized. In this simulation, capital movement is not liberalized as assumption in order to focus on environmental problems.

So far the rough structure of the GTAP model has been explained. In the following section, more details of GTAP model is going to be described under the condition that the economy is closed and the number of the industry sector is one.

3.2. GTAP model with one sector in a closed economy

3.2.1 Budget constraint and Walras' law

Here, the simplified model of the closed economy is considered as follows. Industry sector consists of only one sector, and the goods are demanded as consumption of the household sector, and as investment and as intermediate input of industry sector. The government is omitted for simplification. The production factors are assumed to be only two kinds, labor and capital.

Walras' law holds true in the general equilibrium model. Walras' law defines that when there are *n* markets, it is not necessary to define the equilibrium conditions for all of *n* markets and if *n*-1 markets are in equilibrium, the rest one market certainly is in the equilibrium. In other words, as each economic agent acts within the budget constraint, one will not be independent among *n* markets equilibrium equation. However, this means the *n* prices cannot be decided corresponding to *n* markets, when seen from the opposite side. Therefore, the general equilibrium model takes the method of assuming price of a certain goods to be a numeraire, and the price of other goods is expressed as the relative price measured by the numeraire.

First let's start from the budget constraint equation of the household. The household supplies labor and the capital to the industry sector, expends the obtained income for consumption, and saves the remainder. The savings demand here means demand for investment goods at the same time. Investment is decided by the banking sector, and its amount is defined by *QSAVE* and the price is defined by *PSAVE*. This time, the budget constraint equation of the household can be expressed as follows.

$$WL^S + RK^S = PC + PSAVE \cdot QSAVE^d \tag{1}$$

Here, *W* stands for the rate of wage, L^S for labor supply, *R* for the rate of rental, K^S for capital stock, *P* for price of goods, and *C* for consumer demand, and $QSAVE^d$ for the savings demand.

Next, the supply function of the industry sector (zero profit condition) can be expressed as follows.

$$PQ = WL^d + RK^d + P \cdot QF \tag{2}$$

Here, Q stands for the amount of production of goods, L^d for labor demand, K^d for capital stock demand, and QF for intermediate input demand.

Next, let's explain the bank. Here the role of the bank is to invest in place of the household economy, using savings collected from the household economy as the source of capital. If $QSAVE^S$ stands for savings supply and $QCGDS^d$ stands for the investment demand, the budget constraint equation of the bank is as follows.

$$PSAVE \cdot QSAVE^S = P \cdot QCGDS^d \tag{3}$$

If sides of the above mentioned equation (1) and (2) are added and adjusted, then we get the Walras' law expressed as the equation (4). The equation (4) expresses the sum of the excess demand of goods, of labor, and of capital stock equals to the difference of the savings investment. In other words, it shows that the market of the investment goods will reach equilibrium without fail if 3 markets on the left side reach equilibrium

$$\begin{aligned} &W(L^d - L^S) + R(K^d - K^S) + P(C + QF + QCGDS^d - Q) \\ &= P \cdot QCGDS^d - SPAVE \cdot QSAVE^d \\ &= PSAVE(QSAVE^d - QSAVE^s) \end{aligned} \tag{4}$$

3.2.2. Behavior of each economic agent

Behavior of production sector

The production sector produces goods by using capital, labor, and intermediate input. It is assumed that the structure of production is Leontief type as for the total input of capital and labor and for the intermediate input, and is CES type as for capital and labor. If the total input of production factor is expressed by QV, production function can be expressed as follows:

$$Q = \min\left\{\frac{QV}{a}, \frac{QF}{b}\right\} \tag{5}$$

$$QV = \left[(q)^{\frac{1}{s}} (L^d)^{\frac{s-1}{s}} + (1-q)^{\frac{1}{s}} (K^d)^{\frac{s-1}{s}}\right]^{\frac{s}{s-1}} \tag{6}$$

Here a and $ß$ stands for input coefficient of the total input of production factor and the intermediate input, s for the elasticity of the substitute of capital and labor in CES type production function, and θ for distribution coefficient.

The producing sector decides each amount of demand so that the cost would be minimum while production *Q* is given. In the first stage, the demand of the total input of capital and labor and the intermediate input is decided, using the production *Q* as given. Then in the second stage, demand of capital and labor is decided using the amount of demand of the total input as given. First of all, demand for the total input of production factor and the intermediate input is as follows:

$$QV = aQ \tag{7}$$

$$QF = bQ \tag{8}$$

Next, in second stage the demand for *L* and *K* is decided so as to minimize cost under the condition that *QV* is given. The demand equation of the industrial sector is obtained by solving the question of cost minimization of the equation (9) with (6) as the restriction

$$Min. \quad PQV = WL^d + RK^d \tag{9}$$

The demand function of labor and capital is defined respectively as follows:

$$L^d = q\left(\frac{W}{P_V}\right)^{-s} aQ \tag{10}$$

$$K^d = (1-q)\left(\frac{R}{P_V}\right)^{-s} aQ \tag{11}$$

In addition, price function *P* of the total input of production function is defined as the binary of the CES production function as follows. P_V is a minimum cost to produce one unit of the total input of production function.

$$P_V = \left[qW^{1-s} + (1-q)R^{1-s}\right]^{\frac{1}{1-s}} \tag{12}$$

Behavior of households

As for the utility function of the households, Cobb=Douglas type utility function is assumed as follows:

$$U = (C)^d (QSAVE^d)^{1-d} \tag{13}$$

The demand for the goods of the household and that for savings are obtained as follows by solving the question where (13) is maximized under the budget constraint of equation (1).

$$C = \frac{d\left(WL^S + RK^S\right)}{P}$$

(14)

$$QSAVE^{d} = \frac{(1-d)(WL^{S} + RK^{S})}{PSAVE} \qquad (15)$$

Equilibrium

As mentioned in the confirmation of Walras' law in the equation (4), there are three markets, which is independent among the equilibrium conditions of 4-piece-market (equilibrium of goods, labor, capital stock and the savings investment). If the market equilibrium condition of goods, labor, and capital stock are put explicitly, the model (with one sector closed) can be expressed as follows:

(i)Price of goods

$$PQ = WL^{d} + RK^{d} + P \cdot QF \qquad (2)$$

(ii)Demand-supply concordance in labor market (wage)

$$L^{S} = L^{d} \qquad (16)$$

(iii) Demand-supply concordance in capital stock market (rental)

$$K^{S} = K^{d} \qquad (17)$$

(iv) Demand-supply concordance in goods market

$$Q = C + QF + QCGDS^{d} \qquad (18)$$

(v)Labor demand

$$L^{d} = q\left(\frac{W}{P_V}\right)^{-s} aQ \qquad (10)$$

(vi)Capital stock demand

$$K^{d} = (1-q)\left(\frac{R}{P_V}\right)^{-s} aQ \qquad (11)$$

(vii)Consumer goods demand

$$C = \frac{d(WL^{S} + RK^{S})}{P} \qquad (14)$$

(viii)Intermediate goods demand.

$$QF = bQ \qquad (8)$$

(ix)Value-added price

$$P_V = \left[qW^{1-s} + (1-q)R^{1-s}\right]^{\frac{1}{1-s}} \tag{12}$$

Here, L^s and K^s are given outside of the model as an exogenous variable (or, initial value) beforehand. Though there are 10 endogenous variables, such as *P*, *W*, *R*, *PV*, *Q*, and $QCGDS^d$, *QF*, L^d, K^d, and *C*, the equations are nine. For instance, if the price of goods *P* is assumed as numeraire, it is decided as the other price benchmark, that is the relative price to the price of goods.

Incidentally, substitute the equations (8) and (14) for demand function of goods, the equation (10) for the labor demand function, and the equation (11) for the demand function of goods respectively, and then express by the relative price measured by the price of goods *P*, the model can be consolidated in the following five equations:

$$Q = \left(\frac{W}{P}\right)L^S + \left(\frac{R}{P}\right)K^S + bQ \tag{19}$$

$$L^S = q\left(\frac{W/P}{P_V/P}\right)^{-s} aQ \tag{20}$$

$$K^S = (1-q)\left(\frac{R/P}{P_V/P}\right)^{-s} aQ \tag{21}$$

$$Q = d\left\{\left(\frac{W}{P}\right)L^S + \left(\frac{R}{P}\right)K^S\right\} + bQ + QCGDS^d \tag{22}$$

$$\frac{P_V}{P} = \left[q\left(\frac{W}{P}\right)^{1-s} + (1-q)\left(\frac{R}{P}\right)^{1-s}\right]^{\frac{1}{1-s}} \tag{23}$$

(19) is the supply function of goods (zero profit condition), and (20), (21), (22) are the market equilibrium equations, and (23) is the definitional equation of the value-added price P_V. It is interpreted that total of five equations decide three relative prices *W/P* (wage), *R/P* (rental fee), P_V/P (value added price), and two amounts *Q*(production), and $QCGDS^d$ (investment goods demand) are decided.

3.3. Simulation analysis

In this section, We will make some simulation analyses for CO_2 reduction with GTAP model, and the results are shown.

As already mentioned, GTAP model has 66 regional divisions and 57 industrial classification in the database. But it would be so complicated that the focus of analysis becomes obscure if the model were used as it is. So the regional division and industrial classification are aggregated as shown in Table 4 as follows for the analysis in this paper.

Table 4 Regional division and industrial classification in this paper

Regional division	
1	Japan
2	NAFTA
3	Europe OECD
4	China
5	ASEAN
6	Other region

Industrial classification	
1	Agriculture, forestry & fishery
2	Coal
3	Oil
4	Natural gas
5	Other mining
6	Chemical industry
7	Metallic industry
8	Machine industry
9	Other manufacturing
10	Electric power, gas & water service
11	Other industry

The following two simulations are compared and examined. The CO_2 emission-reduction and the size of its economic effect are assessed respectively. The change of GDP of the entire world is used as the index for the size of the economic effect.

Scenario 1: Improvement of energy consumption efficiency in China.

Scenario 2: Reduction of the amount of consumption by levying customs duties on the fossil fuel imports in Japan.

3.3.1. Improvement of energy consumption efficiency in China

In GTAP model, though the production function of each goods is a function of the production factor input and intermediate goods input, it is defined specifically as the fixed equation Leontief's type:

$$QO_j = e^{aot} \min[QVA_j e^{ava_j t}, QF_{1j} e^{af_{1j} t}, \cdots, QF_{nj} e^{af_{nj} t}] \tag{24}$$

The *QOj* stands for the production of *j* goods, *QVAj* for the primary production factor in the production of *j*, and *QFij* for the amount of intermediate input of goods *i* used in the production of the goods *j*. Technological progress parameters are *ao*, *avaj*, and *afij* appeared in the index of exponential.

For the case where neutral technological progress is assumed, you have only to change the first parameter *ao* in the right side of the equation (24). Since the assumption in this simulation is biased technological progress where the input efficiencies of coal, crude oil, and the natural gas as the input goods are improved for all products, the corresponding parameter *afij* has been changed.

The level of the energy efficiency improvement in China assumed in the simulation in this paper is as follows. As it was considered that the room for the efficiency improvement was especially larger as for the coal input, that part was assumed much more than other energy.

Table 5 Scenario 1

Case	Low	Middle	High
Improvement of coal input	3%	6%	9%
Improvement of oil input	1%	2%	3%
Improvement of natural gas input	1%	2%	3%

As stated in the section 2, the energy efficiency of China is about ten times "more energy consumed" compared with Japan as of 1998. The above efficiency improvement would not differ much from what is assumed in the clean development mechanism (CDM) project.

Table 6 shows the simulation results of the case when there was an efficiency improvement of the energy input in China. The improvement of the energy efficiency causes the decrease of a domestic price (except for energy) and the increase in the amount of the domestic production. In the standard course, it is expected that GDP increase about one billion (1,000,000,000) dollars, which is about 0.12% in rate. As for GDPs other than China, the total effect depends on the fact how much the effect that the decrease of competitiveness in the trade market due to the decrease of the price of

Table 6 Effect of improvement of energy efficiency of China (Middle case)
Changing of GDP in each country

	% change	Before	After	Change
China	0.12	854,694	855,692	998.6
Japan	0.00	4,255,525	4,255,538	13.0
ASEAN	0.00	2,068,059	2,068,052	-7.6
NAFTA	0.00	8,965,149	8,965,139	-10.0
EU	0.00	7,957,957	7,957,974	17.0
Others	0.00	4,880,402	4,880,363	-38.5
Total	0.00	28,981,785	28,982,758	972.5

Unit: Million dollars

Table 7 Effect of improvement of energy efficiency of China (Middle case)
Energy consumption and CO_2 emissions

	% change	Before	After	Change	CO_2 emissions
Coal	-4.81	10,082.04	9,597.27	-484.77	-34.03
Oil	-1.17	16,560.93	16,367.95	-192.98	-1.90
Natural gas	-1.69	524.89	516.05	-8.85	-0.20
Total	-2.53	27,167.86	26,481.27	-686.6	-36.12

Unit: Million dollars, million carbon tons

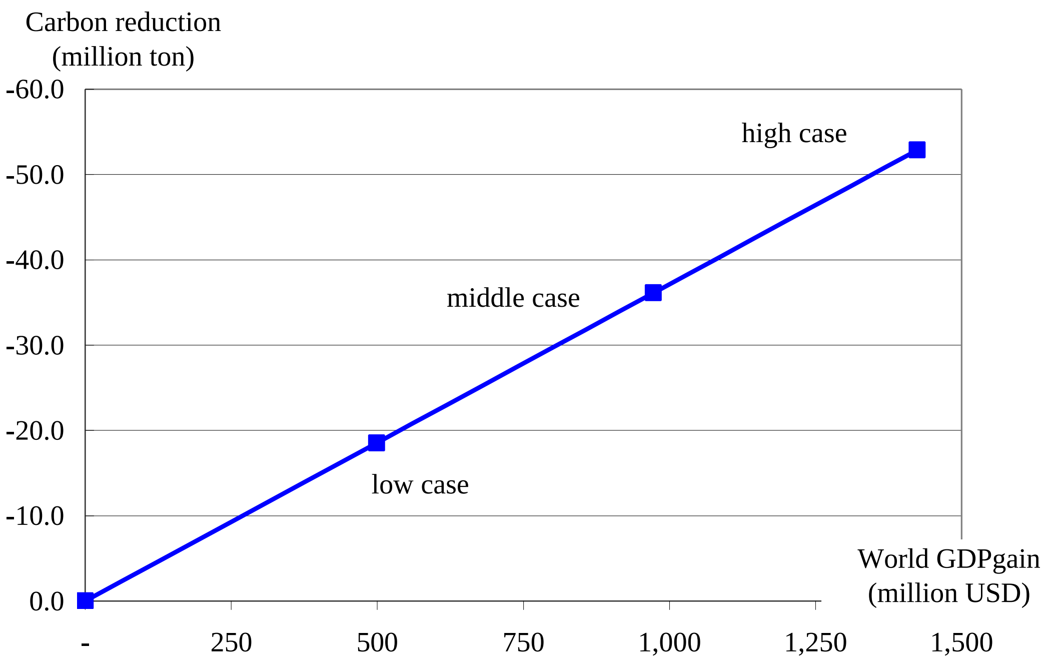
Chinese goods would counterbalance the effect of export increase due to the expansion of Chinese market. As for Japan and EU, the latter effect is larger giving positive effect to GDP. As for Asian regions and North American region, however, the former effect is rather stronger and gives negative effect to GDP. Although negative, it is insignificant amount compared to the positive effect of China, and the GDP of the entire world increases as total almost the same amount as the increase in China.

Table 7 shows the change in the amount of production of the energy industry in China and the change in the CO_2 emissions accompanied with it. Coal decreased about 4.8%, oil decreased about 1.2%, and the natural gas decreased about 1.7%. It is less compared to the assumed production improvement, which is 6%, 2%, and 2%. It is considered that it is attributed to the demand effect brought by the expansion of whole economy and the effect of consumer demand increase brought by the decrease of energy price.

The CO2 emissions decreased 34.0, 1.9, and 0.2 ton carbon millions respectively, and the total of the decrease reaches 36.1 ton carbon millions. As the CO^2 emissions in China are 849 ton carbon millions at the time of 1997, this figure equals to about 4.25%. Therefore it can be said that China will be able to achieve the energy efficiency improvement of about standard course level, if China belongs to the Annex I Parties of the Kyoto protocol (countries with the duty of the greenhouse gas reduction) since the reduction goal of the greenhouse gas emissions of the Kyoto protocol is 5%.

Figure 11 graphed out the relations of CO_2 emission-reduction due to the improvement of energy efficiency in China and the increase of the world GDP. It can be said that technology transfer from the advanced countries to the developing countries will make a scenario of win-win game reality.

Figure 11 Effect of energy efficiency improvement in China



3.3.2 The levy of carbon tax in Japan

Domestic sales tax, import customs duties, export customs duties, and the general consumption tax are considered as the levy to commodities in GTAP model. In the case when the simulation of the levy to the fossil fuel is made, for instance, taking the United States as subject, it is necessary to do levy on domestic products and import goods, and the refund of tax for the export goods. However, since most of the fossil fuel is imports in Japan, carbon tax was set as the levy of customs duties.

The assumption of the carbon tax by the simulation in this paper is as follows.

Table 8 Scenario 2

Case	Low	Middle	High
Import customs duties of coal	15%	30%	45%
Import customs duties of oil	10%	20%	30%
Import customs duties of natural gas	7.5%	15%	22.5%

Since the difference of the respective carbon content is reflected in the above table, the tax rate is different in respective energy. For reference, CO_2 emissions per ton oil of respective energy i.e. coal, oil, and natural gas are 1.080, 0.837, and 0.641 ton carbon.

Table 9 shows the change of GDP in each country, when 30%, 20%, and 15% levy is carried out for coal, oil, and the natural gas import in Japan. As for oil, if it is considered as the levy of about 20 yen of gasoline for oil, it corresponds to the levy of 30,000 yen per 1 ton of carbon; it is higher tax rate than the Yamazaki model in Table 2. If the effect of the levy of the carbon tax is measured by the change of GDP, Japan solely is the loser. Although it is little in the ratio, it is GDP decrease of about 1.3 billion (1,300,000,000) dollars. GDP increase in all countries in Table 9 except for Japan. This is because that the levy of carbon tax raises the price of the goods and service made in Japan, so that import to Japanese market increases and the competitiveness of Japanese export products decreases in Japan’s export market.

Table 10 shows the change in the CO_2 emissions in connection with the change in the amount of the fossil fuel import in Japan. The CO_2 emission-reduction is 0.70 ton carbon millions for the coal-origin, 3.51 for the oil-origin, 0.35 for the natural gas-origin, and it makes just about 4.56 ton carbon millions in total. Since the CO_2 emissions in Japan in 1997 were 320 ton carbon millions, the amount decreased only account for 1.42% that is far below from Japan’s reduction target 6%.

However, we should note that this figure is underestimated as a long-term effect. This simulation is pure static analysis. The effect here only includes the price effect that the consumption demand decreases because the price of the high energy-consuming industries rises, and a consequent income effect that the energy consumption decreases in the industrial sector. In a word, it does not include the effect such as the introduction of an energy saving technology due to the rise of energy price.

Since Japan has already attained quite advanced technology of energy conserving in the world, anyway it would be difficult for Japan to achieve 6% reduction of energy consumption just by levy in eight years before the goal-reaching year.

Table 9 Effect of carbon tax levy (Middle case) in Japan
Changing of GDP in each country

	% change	Before	After	Change
China	0.000	854,693.6	854,711.7	18.1
Japan	-0.030	4,255,524.5	4,254,181.0	-1,343.5
Asia	0.000	2,068,059.4	2,068,097.6	38.3
NAFTA	0.000	8,965,149.0	8,965,177.0	28.0
EU	0.000	7,957,957.0	7,958,179.5	222.5
Others	0.000	4,880,401.5	4,880,563.5	162.0
Total	0.000	28,981,785.0	28,980,910.3	-874.7

Unit: Million dollars

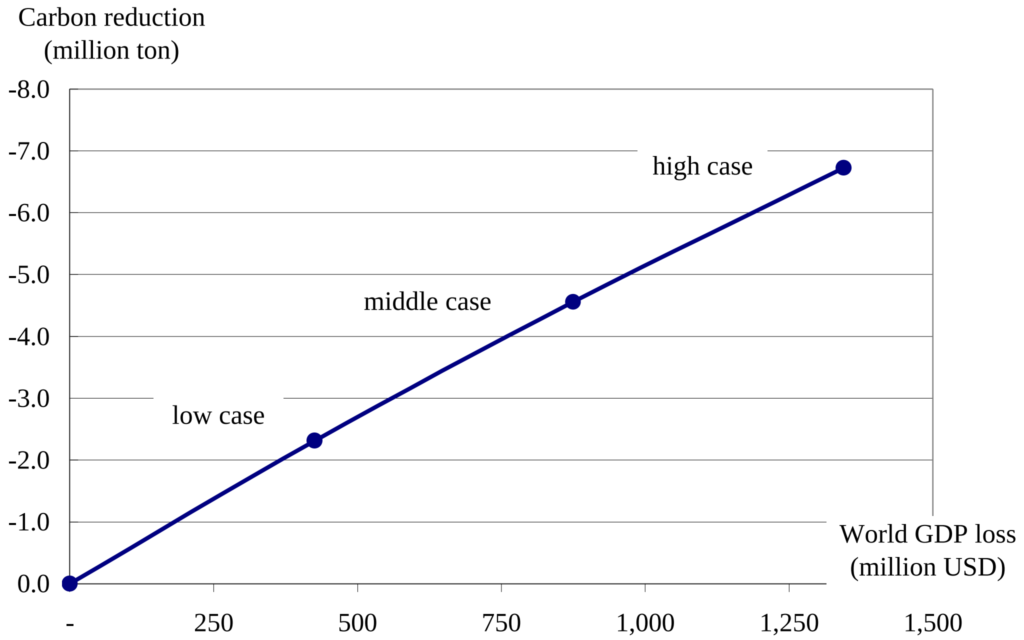
Table 10 Effect of carbon tax levy (Middle case) in Japan
Energy consumption and CO_2 emissions

	% change	Before taxes	After taxes	Change	CO2 emissions
Coal	-0.75	6350.1	6302.5	-47.6	-0.70
Oil	-1.54	29078.0	28629.0	-449.0	-3.51
Natural gas	-0.96	6549.0	6485.9	-63.2	-0.35
Total	-1.33	41977.15	41417.36	-559.8	-4.56

Unit: Million dollars, million carbon tons

Figure 12 is the graph that shows the effect of GDP reduction and CO_2 emission-reduction for other cases. Though it is levied to the energy consumption in Japan at such rate as 45% to coal,30% to oil, and 22.5% to the natural gas, the CO_2 emissions are only 6,73 ton carbon millions that is only about decreases of 2.10%. On the other hand, the decrease in GDP with this case becomes 2 billion (2,000,000,000) dollars for Japan only and 1.3 billion (1,300,000,000) dollars for the entire world.

Figure 12 Effect of Carbon Tax in Japan



3.4 The result of analysis

In this section, the effect of the CO_2 emission-reduction by technology transfer from Japan to China was analyzed with GTAP model. The result of analysis is as follows:

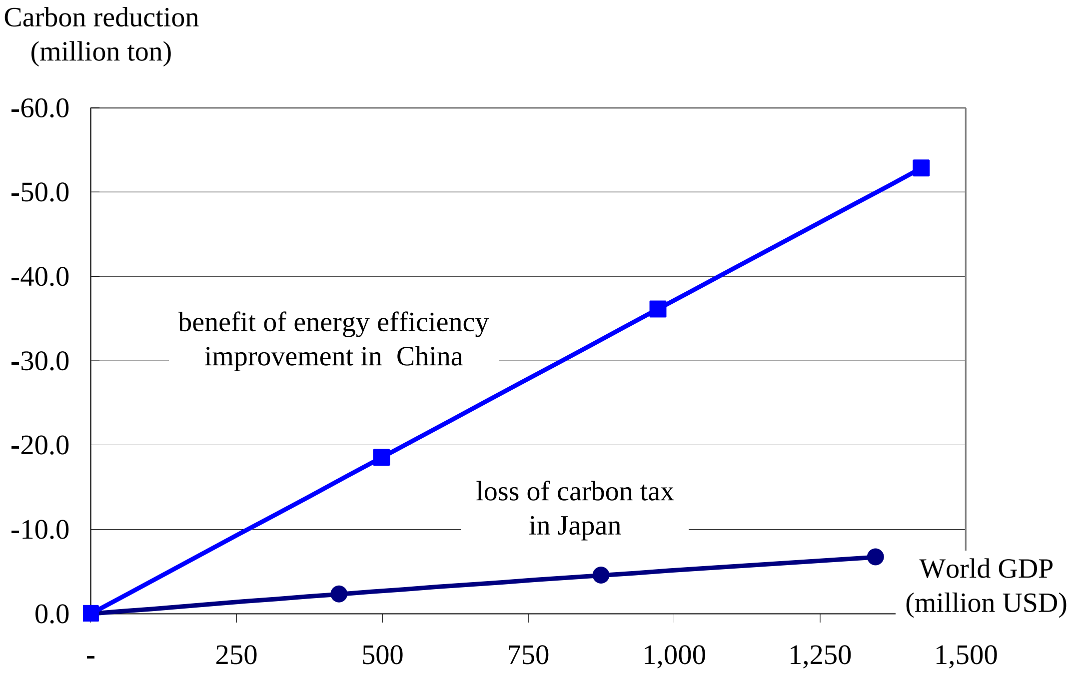
Figure 13 shows Figure 11 and Figure 12 that had been shown already written on the same area.

The upper line shows the relation between the GDP increase due to the energy efficiency improvement in China and CO_2 emission-reduction. If Japan is a technical donor country, it can be interpreted that Japan has donated GDP to China so that the CO_2 emissions were reduced.

The lower line shows the CO_2 emissions-reduction attained by the increase of production cost in the form of levy of carbon tax in Japan so as to cut back (or give up) its GDP. It is apparent from the figure that the technology transfer (or donation of GDP to China) is better contribution for the welfare improvement of the world, if the obligation costs the same.

However, it is necessary to apply some reservations to this conclusion. There is an argument if this kind of clean development mechanism can be put into practice. First of all, since it is stated that "the use of the Kyoto mechanism is supplementary" in the Marrakech agreement, it cannot serve as the central feature of CO_2 emission-reduction. Next, the problem is the position of China. China might owe the duty of the greenhouse gas reduction during the second period of greenhouse gas reduction target period starting from 2010. In that case, it is doubt whether China approves the advantageous CO_2 emission-reduction target as a clean development mechanism item of Japan.

Figure 13 Cost and benefit of technology transfer



In addition, the matter of argument is the effect of U.S.'s withdrawal from the Kyoto protocol. The United States was expected to be big purchaser in the trading market of emissions rights. However, it is said that the price of the emissions rights will drop drastically compared to the initial forecast because of this big purchaser's withdrawal. Therefore, it is also said that Japan will be able to buy the emissions rights from the sales countries such as Russia at quite a cheap price, and might be able to achieve goal without supporting China's technology.

Though there are such reservations, the effectiveness of technical cooperation is without question. The collection of more detailed information on the fields for the future technology transfer, and more researches on the cost and benefit are awaited.

4. Concluding remarks: collaboration of CDM with ODA and other domestic measures

The CDM is one of the Kyoto mechanisms endorsed by the Kyoto Protocol at the COP3 in 1997. It is the most important mechanism, as it allows developed countries to invest and implement emission reduction projects in developing countries. The purpose of the CDM shall be to assist developing countries in achieving sustainable development, and to assist developed countries in achieving compliance with quantified emission limitation and reduction commitments (Article 12 Kyoto Protocol).

However, it is recognized that the availability of CDM is rather low. There are some negative factors suffocate the promotion of CDM. Firstly, CDM project compete with JI and emission trading. Because of hot air, the price of emission right will be much cheaper than expected. Emission trading program is more cost-effective than CDM project. Secondly, Transaction cost in the procedure of CDM project is higher than the cost in JI. Thirdly, because of the so-called sink is much easier measure for Annex I countries to attain the reduction target, CDM project will be less attractive option than sink.

Even though there is positive effect of technology transfer from Japan to China, both countries have little incentive to promote current CDM. Our tentative idea to promote CDM is a collaboration of CDM with other measures such as ODA and other domestic measures. Additional ODA to reduce the transaction cost of CDM increase the availability of CDM. Domestic environmental policy such as SOx charge and subsidy scheme might be matched with CDM project to integrate the local benefit and global benefit of the project.

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