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Environmental Taxation as a Solution to Global Warming

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ABSTRACT

Currently, Japan is seeking practical measures toward meeting the stringent obligations to reduce greenhouse gas emissions stipulated by the international framework of the Kyoto Protocol. For the past ten years, "environmental tax" has been discussed as a means to address this issue, but concrete steps toward its adoption have just recently begun. The Ministry of Economy, Trade and Industry (METI), reviewing its energy special-accounts, has adopted a coal and oil tax as of April 2003—a tax that includes hitherto unaccounted for coal consumption, and has even made an allotment for global warming measures in its annual expenditures. Meanwhile, as of the writing of this report (November 2003), the Ministry of the Environment (MOE) has proposed concrete plans for a new carbon tax, and has begun to poll public opinion on this measure.

A general divide in the approach toward environmental taxes can be seen in the different measures taken by these two government divisions: while METI's plan for environmental taxation is the greening of current energy taxes, the MOE plans instead to introduce an entirely new tax for carbon emissions, leaving the current tax system untouched. The following report compares the effectiveness of these two approaches through a simulation analysis using a general equilibrium model.

As a result of the analysis, the following facts are confirmed: (1) both approaches would put a tremendous burden on high-consumption industries, and would greatly reduce the production volume of the iron and steel industry in particular; (2) compared to the carbon tax measure, however, greening moderates the reductions in production volume for many industrial sectors (excluding the iron and steel industry); (3) greening also moderates the reduction of gross energy use in the industrial sector, and effectively encourages the switch to alternate energies. Findings (2) and (3) show that greening, more than carbon taxing, has the least effect upon the economy and brings about the most effective progress in the reduction of greenhouse gases. Thus, an increase and enhancement of current greening measures is the most ideal plan under consideration.

However, some problems resulting from greening have still to be addressed: (1) the lack of accountability in the domestic sector, (2) the loss in international competitiveness of high-energy consumption industries due to the curtailment of their production (the same issue also applies to the levying of new taxes), and 3) the undermining of domestic efforts to reduce greenhouse gases by the consequent rise in the emissions of foreign countries. As for a solution to (1), it is argued that a new tax directed solely at the domestic sector, implemented in conjunction with the greening of

energy taxes, would ensure sufficient and satisfactory reductions. As for the closely related issues of (2) and (3), however, there is no ready solution. Though a tax exemption may be applied to the iron and steel industry as a means for restoring competitiveness (Problem 2), this measure has the perverse effect of increasing the use of fossil fuels and thus the amount of emissions in foreign countries, thereby contributing to (3). At the same time, this analysis has found that tax exemption measures for the coal and oil industry would cut greenhouse gas reduction results in half. These are some of the main issues that still need to be addressed. Matters such as the most effective way to use the tax revenue will also become important in carefully considering the best plan of action.

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1. Introduction

Environmental taxation is one of many economical environmental policies. Conventionally, such environmental protection fees have been underrated. Instead, economical strategies that have been introduced to moderate the cost and accomplish burden sharing (i.e. the internalization of external diseconomy) can be divided into four categories: (1) taxes/levies, (2) subsidies, (3) trading emissions reduction credits, and (4) a deposit system. As global environmental problems became apparent in the late 1980s, the OECD began counseling the implementation of economically feasible environmental policies. The merits of these economical policies, such as high cost-effectiveness, mean that even in countries such as Japan—where direct regulation is the mainstream—the importance of economical environmental plans is beginning to gain recognition. There has been much discussion about environmental taxation, and its versatility yields many possibilities, such as (1) tax-burdens for polluters, (2) tax-burdens for polluters with the imposition of additional earmarked taxes[1] combined with environmental policies, and (3) benefit-assessment[2] taxation. The benefits of (2) have been drawing attention for the high level of effectiveness through both tax revenue and environmental policy[3].

There is a great deal of movement toward environmental-tax policies, but it is local efforts that are particularly active. In April of 2000, the Devolution of Power Law was passed; as a result, taxes not stipulated by laws have become comparatively easy to introduce. Introducing local discretionary taxes for special purposes[4] has also become

[1] In relation to the introduction of a tax, there are three possibilities: (1) neutrality of tax revenue through the lowering of the tax rates for other taxes, (2) treat tax revenue as general revenue, and (3) handle tax revenue as an earmarked revenue. (3) is called an "earmarked tax". An earmarked tax implies that usage is clearly defined and that the impact on citizens is minimized (as it has a high level of effectiveness), and thus it is easy to gain public support. However, environmental taxation is primarily the internalization of external diseconomy and is aimed at correcting distortion in the market, and thus some argue that an environmental tax as an earmarked tax is not desirable.

[2] There are also instances where, in cases where the polluters are not clearly identifiable, beneficiaries carry the tax burden. For example, in local areas where wellhead taxes on water are implemented, beneficiaries who use the wellhead carry the burden of costs for wellhead protection. This is called a beneficiary tax.

[3] The environmental tax discussed by the MOE as a global warming countermeasure also taxes polluters, and further, it lowers the cost burden for its citizen through the use of earmarked taxes.

[4] Tax items not legally specified are called non-stipulated taxes. Tax revenue that is considered general revenue is designated non-stipulated general tax, and tax revenue

possible, and the introduction of taxes on industrial waste and for the protection of forest and water resources are beginning to gain momentum. Introducing an environmental tax to local areas, when adapted to local characteristics, allows for minute institutional design and thus represents an effective policy. In regards to global warming as well, if an environmental tax is to be an efficient method of taxation, it would be recommendable to introduce it at a local level. However, due to such issues as the trans-border nature of such a policy, as well as problems of distinction between polluters, victims, and beneficiaries, introducing such a tax is difficult[5]. Therefore, the current debate centers on environmental taxation at a national level as a global warming countermeasure.

Within in the international framework of the Kyoto Protocol Treaty, Japan faces strict reduction targets for greenhouse gas (GHG) emissions. To reach these targets, effective global warming countermeasures are called for[6]; as one possible measure to promote effective countermeasures, the introduction of an "environmental tax" is being investigated. Thoughts regarding possible forms of environmental tax can be divided into two camps: the implementation of a new tax on carbon emissions, and the "greening" (introducing environmental consideration) of the existing tax system. In the realm of introducing an environmental tax, it is not necessarily the case that new taxes need be introduced. Rather, within the framework of existing taxes that are not currently intended as global warming countermeasures, it may be possible to accelerate environmental countermeasures and reduce GHG emissions indirectly by making certain taxes (such as those taxes related to automobiles and energy)[7] more environmentally oriented. Figure 1 represents the two existing concepts for an

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that is earmarked revenue is called non-stipulated earmarked tax. Before April 2000, local governments recognized only non-stipulated general tax. It became possible for the burden of polluters to consider tax revenue as earmarked revenue, and for earmarked tax to be considered non-stipulated earmarked tax. Thus, the diversity of local governments' application of the environmental tax expanded.

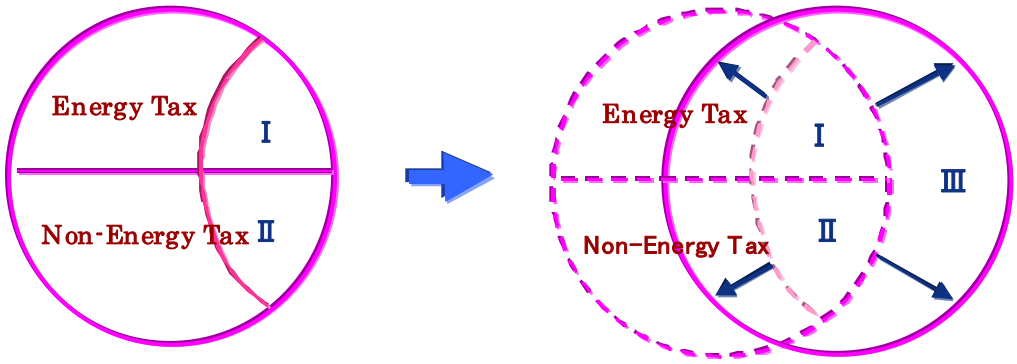
[5] There is a high possibility of introducing an environmental tax as a global warming countermeasure at the national level. However, according to Morotomi (2000), there is also a possibility of introducing local environmental taxation cooperatively (i.e. a cooperative tax) in various regions (or at the national level,) with usage adjusted for the particular circumstances of each local government. This report focuses only on the process of taxation, and debates the establishment of a tax system at a national level.

[6] Japan has the highest standards of energy efficiency in the world, and thus it is extremely challenging to reach the targets stipulated in the Kyoto Protocol. Indeed, when compared with European nations, the reduction costs required for Japan to attain the protocol's targets are estimated to be exceedingly high.

[7] If these taxes are eliminated, it is thought that it will cause an increase in GHG emissions, and thus they are considered to indirectly contribute to global warming countermeasures.

environment tax. Regions I and II represent the environmental contribution levels of existing energy taxes and existing non-energy taxes, respectively. With the introduction of an environmental tax as a global warming countermeasure, Figure 1 depicts the greening[8] of the expanded existing tax system in regions I and II, and the creation of a new carbon tax (III).

Figure 1. Visualization of Environmental Tax as Global Warming Countermeasure



Source: Ishi, Hiromitsu. 1999. *What is Environmental Taxation?* Iwanami Shoten.

This report will focus on the environmental contribution of energy taxes (I). The next section will clarify Japan's energy tax system from the perspective of its environmental contribution level. Section 3 will present a comparative analysis of the effects of introducing new carbon emission taxes versus greening existing taxes, and will examine the concept of the environmental tax as a global warming countermeasure.

2. Concerning Japan's Energy Tax System

This section will examine Japan's energy tax system from the perspective of its environmental contribution level. First, in order to elucidate the environmental contribution level of the existing energy tax system, this section will explain implicit

[8] This report focuses on the greening of energy taxation. Taxes related to automobiles, such as the vehicle tonnage tax (state tax, earmarked revenue for road improvement), vehicle tax (prefectural and city government tax, general revenue), vehicle income tax (prefectural and city government tax, earmarked revenue for road improvement), light vehicle tax (municipal tax, general revenue), and others also exist. In the cases of the vehicle tax and the vehicle income tax, greening would be introduced by adjusting the tax rate depending on the environmental impact of the type of vehicle and usage.

carbon taxes and introduce existing research on international comparisons. Next, this section will clarify Japan's energy tax system, and will consider the recommended characteristics of the current environmental tax propositions.

2. 1 Concerning Implicit Carbon Taxation

The implicit carbon tax actually signifies how heavy the tax burden is for GHG emissions under the current energy tax system, and the tax rate is calculated based on the carbon content of the energy used. The higher the carbon tax is, the greater the tax burden of GHG emissions will become, and thus the environmental contribution level of the energy tax system would be considered high. Figure 2 shows the implicit carbon taxes for OECD members as calculated by Hoeller and Wallin (1991). In 1988, Japan's implicit carbon tax ranked third lowest amongst the OECD countries, after the U.S. ($28/tC) and Canada ($52/tC) with a price of $79/tC. This suggests that the environmental contribution level of Japan's energy tax system is extremely low. Under Japan's legacy of industrial protection measures, taxes on coal—the fuel with the worst environmental impact—have been excluded, and various other distortions[9] of the tax system have been spawned.

[9] According to Ishi (1999), preferential tax policies that are present in Japan's industrial policies, such as the tax exemption of coal, can be thought of as a negative implicit carbon tax.

Figure 2. Implicit Carbon Tax and Year of Environmental Tax Implementation

COUNRY	IMPLICIT CARBON TAX（US$/tC）	YEAR OF IMPLEMENTATION
Finland	107	1990
Sweden	214	1991
Norway	182	1991
Denmark	147	1992
Britain	106	2001
Switzerland	198	2005（Expected）
Germany	95	1999
France	229	Ruled Unconstitutional
Holland	89	1990、1996
Italy	223	1999
Japan	79	2003

Source: Ishi, Hiromitsu. 1999. *What is Environmental Taxation?* Iwanami Shoten.

Additionally, European countries accepted the OECD's recommendations on introducing economical measures and, beginning around1990, the establishment of environmental taxes as global warming countermeasures—such as the greening of energy taxes—are progressing (Figure 2). As a result, European countries' implicit carbon tax has become increasingly high. Both Japan and the European countries have formidable GHG emissions reduction targets set by the Kyoto Protocol. However, when compared with European countries, Japan still has considerable leeway for the tax burden that would be imposed by an environmental tax. Furthermore, distorted tax policies such as the tax exemption of environmentally burdensome coal must be abolished swiftly. Exchanging such energy sources with environmentally friendly energies is recommendable.

2. 2 The Movements of Japan's Energy Tax System and the Environmental Tax

In this scenario, as we summarize Japan's energy tax system from the perspective of its environmental contribution level, let's consider the natures of the Ministry of Economy, Trade, and Industry (METI)'s proposed greening of the energy tax system, and the Ministry of the Environment's environmental tax.

First, let's summarize Japan's energy tax system (Figure 3).

Figure 3. Current Energy Tax System

TAX ITEM	OBJECT OF TAX	TAX RATE	TAX REVENUE (100 mln yen)	TYPE OF TAX	USE OF TAX
Custom on Crude Oil	Crude Oil Imports	215 yen/kl	527	Customs Tax	Primarily Coal Countermeasures
Oil Tax＊	Crude Oil、Imported Petroleum Products、Hydrocarbon Gas	2,040 yen/kl 720 yen/kl 670 yen/kl	4,880	National Tax	Measures for Sophistication of Oil and Energy Demand
Gasoline Excise Tax	Gasoline	48,600 yen/kl	28,365	National Tax	National Road-Use Revenue
Local Road Tax	Gasoline	5,200 yen/kl	3,035	National Tax	Local Authority Road-Use Revenue
Petroleum Gas Tax	Automobile LPG	17,500 yen/ton	280	National Tax	National/Local Authority Road-Use Revenue
Diesel Transaction Tax	Diesel	32,100 yen/kl	12,472	Metropolitan Area Tax	Local Authority Road-Use Revenue
Aircraft Fuel Tax	Jet Fuel	26,000 yen/kl	1,064	National Tax	Airport Maintenance/Local Authority Airport Measures Costs
Electric Power Tax ＊	Electricity	445 yen/ 1,000kWh	3,799	National Tax	Promotion of Power Resources Development Tax

Sources: Compiled from various sources by FRI.

In Japan's energy tax system, taxation is determined from a benefit assessment standpoint targeted at energy and electricity consumers and road users. The use of tax revenues raised in this way is restricted as a special-purpose revenue sources, such as to cover energy sophistication, encourage the development of power resources, and road maintenance.

In December 2002, METI reexamined the special account fund for energy and

initiated the gradual greening of the energy tax system. Taxes on oil and the development of power resources were the objects of this greening, as indicated by the tax items marked with * on Figure 3. As of April 2003, METI raised the tax rate of oil and imposed a new tax on heretofore-exempted coal; together this new tax structure was called the coal-oil tax. The tax rate is set to rise gradually until April 2007, and so that tax revenues remain neutral, the tax on the promotion and development of energy resources will be lowered at a measured rate (Figure 4[10]). However, it must be noted that coal used in the production of steel will remain exempt from the coal-oil tax until April 2005.

Figure 4. The Greening of the Energy Tax System

TAX ITEM	OBJECT OF TAX	TAX RATE			
		Current	October 2003	April 2005	April 2007
Coal-Oil Tax	Oil	2,400 yen/kl	Continuation of Current Level		
	LPG	670 yen/t	800 yen/t	940 yen/t	1,080 yen/t
	LNG	720 yen/t	840 yen/t	960 yen/t	1,080 yen/t
	Coal	---	230 yen/t	460 yen/t	700 yen/t
Promotion of Power Resources Dev. Tax (yen/1000kWh)	Electricity	445	425	400	375

Sources: Compiled by FRI from Ministry of Finance data.

Furthermore, the government has also reevaluated annual expenditure and allocated a portion of tax revenues for global warming countermeasures. In other words, the greening of annual expenditure has also been undertaken. Concretely, the revenue generated from increasing the coal-oil tax is limited to use for global warming countermeasures under the co-jurisdiction of the Ministry of the Environment. It is anticipated that, through raising the rate of tax for oil and by applying the new tax to coal, the increased revenue from the coal-oil tax was as much as 10 billion yen (approximately $93.5 million).

[10] Since April 2005, the tax-exemption treatment for raw coal used in steel production is unclear. This report employs the final post-2007 tax rate for determining the effects of greening. However, in cases where there are no explanatory notes, analyses treat steel as fundamentally being not tax-exempt. Moreover, when handling the tax exemption of the steel sector, the nature of the model used in these analyses prevents a distinction between coal used as raw material and coal used for energy. As a result, tax exemption of all coal use is analyzed.

Let us now examine the implications of METI's greening of the energy tax system from the perspective of environmental contribution level. Previous energy taxes also imposed indirect regulation of GHG emissions; calculations of the environmental contribution level of the implicit carbon tax were already introduced in Section 2.1. This section will calculate the tax burden of GHG emissions for each kind of energy. The implicit carbon tax for each kind of energy is calculated from the heat value and emissions of CO2. (Figure 5). The "→" indicates the change in the tax ratio as a result of greening; the last tax rate from the year 2007 is depicted.

Figure 5. Tax Burden by Energy Type[11]

ENERGY TYPE[12]	TAX ITEM	TAX RATE	HEAT VALUE	CO2 EMISSION (gC/Mcal)	TAX BURDEN (yen/tC)
Crude Oil	Crude Oil Customs Tax Oil Tax＊	215 yen/kl 2,040 yen/kl	9,400 kcal/l	80.23	2,900
Heavy Oil	Oil Tax＊	- -	8,000 kcal/l	80.46	- -
Diesel	Diesel Transaction Tax	32,1000 yen/kl	9,200 kcal/l	78.39	44,510
Kerosene	Oil Tax＊	- -	8,000 kcal/l	78.39	- -
Jet Fuel	Aircraft Fuel Tax	26,000 yen/kl	8,700 kcal/l	77.47	38,989
Gasoline	Gasoline Excise Local Road Tax	48,600 yen/kl 5,200 yen/kl	8,400 kcal/l	76.65	83,635
Automobile-Use LPG	Petroleum Gas Tax Oil Tax→	17,500 yen/ton 670→1,080 yen/ton	12,000 kcal/kg	68.33	22,160→ 22,660
Natural Gas	Oil Tax	720→1,080 yen/ton	9,800 kcal/kg	56.39	1,303→ 1,954
Imported LNG	Oil Tax	720→1,080 yen/ton	13,000 kcal/kg	56.39	982→1,473
Coal	Coal-Oil Tax	0→700 yen/kl	6,350 kcal/kg	99.60	0→1,107

Sources: Compiled from various sourced by FRI.

[11] - - indicates taxes applied at the crude oil stage where it is difficult to determine the tax rate, and thus is not presented.

[12] In the case of electricity usage, there are additional taxes on electric power development. This tax differs depending on the energy used for power generation, but when a CO2 emission level of 0.091tC/1000kWh is assumed, the tax burden from energy use drops from 4,890 yen/tC before greening to 4,121 yen/tC after greening.

The figure confirms that the indirect tax burden varies greatly depending on the kind of energy[13]. Furthermore, the figure reveals the distortion of the energy tax system, as there was no taxation on coal before the greening. As noted in Footnote 9, the tax exemption for the heavily environmentally damaging use of coal resulted in a negative implicit carbon tax (e.g. the tax exemption of coal was a factor lowered the environmental contribution level of the energy tax system). In response to this, METI's countermeasure implies that through greening this kind of distortion of the energy tax system was removed.

Next, let's examine movements in the Ministry of the Environment's environmental tax. At the time of this writing in December 2003, the Ministry of the Environment presented a concrete plan for the environmental tax system and polled public opinion. According to the revised step-by-step approach[14] advocated by the General Framework for the Promotion of Measures to Cope with Global Warming presented in March of last year, Step One is to be completed by the end of 2004, and if the effectiveness is deemed unsatisfactory, the enforcement of Step Two's reevaluation period will be investigated[15]. Therefore, METI's greening of the energy tax system introduced the environmental tax ahead of the Ministry of the Environment. However, according to the mutual statement released by METI and the Ministry of the Environment, the revision of annual revenue from special accounts will impose a new tax on coal in order to equalize tax burdens, and is thus completely separate from the

[13] There is also discussion concerning the uniformity of tax burdens by switching to a pure carbon tax; the effects of this are discussed In Yokoyama et al. (2000). However, since existing energy taxes are levied (for a different purpose) at the polluters' expense, a discussion of a desirable form of greening is important. This report does not intend to discuss these issues, and analyzes only METI's greening as an energy-tax system greening plan.

[14] Step One is to take place between April 2002 and March 2005, Step Two is from April 2005 to March 2008, and Step Three is planned to start in April 2008. In order to achieve the GHG emission reductions target (a 6% cut from 1990 levels), the General Framework for the Promotion of Measures to Cope with Global Warming is packed with over 100 measures and policies. Step One is aimed to promote these various measures, whereas Step Two will evaluate the progress of the measures and policies and conduct reevaluations where necessary. Beginning in Step Three, which coincides with the first period promised in the Kyoto Protocol, Japan's GHG emissions reduction obligations are expected to be met.

[15] Aside from the investigation of taxes, the Central Environment Council and the MOE also carry out investigations of: measures for the promotion of steady, autonomous planning for industry, the strengthening of countermeasures in the consumer livelihood and transportation sectors, clean development mechanisms (CDM) developed by businesses within an international framework, the support of joint implementation (JI), the emissions-trading system, energy saving that uses oil special-accounts, alternative energy countermeasures, etc.

Ministry of the Environment's environmental tax that is being investigated as part of Step 2 in the step-by-step approach.

The environmental tax presented by the Ministry of the Environment aims to introduce a new carbon tax[16]. The tax rate presented is low (3,400 yen/tC), and based on the current state of the economy and labor, it will seems that it will not dramatically change the shape of the economy. If taxes are converted to earmarked taxes, and tax revenue is effectively utilized for global warming countermeasures, it is calculated that Japan can reach the targets set by the Kyoto Protocol. Furthermore, if taxes are not adjusted to earmarked taxes and there is only a price incentive to reach the target numbers, it is calculated that a tax rate as high as 45,000 yen/tC will be necessary[17]. In the case of a low tax rate and earmarked taxation, issues such as introducing the tax and forming consensus are thought to be comparatively easy. However, just how to effectively re-circulate taxes in order to achieve the Kyoto Protocol targets is an uncertain factor. During the reexamination of countermeasures conducted through 2004, a proactive evaluation of the effect of global warming countermeasures from the perspective of the efficacy of tax revenue use must be made.

This report presents a comparative analysis of two forms of taxes within the energy tax system: greening existing taxes and applying a new carbon tax. This discussion does not, however, focus on the use of the taxes, but rather on the effect of taxation (the effects of price incentive). As recommendations for institutional design, this report also examines what kind of tax structures are desirable, and includes discussion of how the environmental tax should be formulated. As previously mentioned, according to memorandums by METI and MOE, the greening of the existing energy tax system and MOE's investigations of an environmental tax are wholly independent; however, in further memorandums it is noted that the reevaluation of the tax rate for the oil tax is to be included in future discussions regarding taxation rate changes that will be conducted jointly under both ministries. Accordingly, the greening of the energy tax system should be used to a large extent in the design of the MOE's future tax

[16] Methods considered for levying this tax include top-phase taxation on fossil fuels (taxation at the time of importation and the time of extraction), and upper-phase taxation (taxation after the conversion of energy). Considering the ease of combining the price incentive effect of taxation with other policies, taxation at the lower taxation (at the level of the very last consumer in the process) is desirable, but this idea has been abandoned due to problems of enforceability by the tax office.

[17] According to the AIM model (a bottom-up style model) developed by the National Institute for Environmental Studies and Kyoto University, the cost of reducing GHG emissions by 2% for the year 1990, without earmarked taxes, was 45,000 yen. If tax revenue is refluxed by using it to subsidize environmentally friendly investments, however, a low tax rate of 3,400 yen is possible.

system.

3. Model Analysis

Through simulation analysis, this section will compare the effects of greening the energy tax system versus the introduction of a new carbon tax.

3.1 Explanation of the Model

First, the model used for analysis will be introduced. This study incorporates the GTAP-E model, a general equilibrium model developed by Dr. Truong of the University of New South Wales. According to conventional general equilibrium (GTAP) models, introduction of a carbon tax is not thought to have a suitable effect in encouraging the substitution for environmentally friendly energy. The accompanying materials indicate the framework of corporate behavior (production function) according to the GTAP and GTAP-E models. Within businesses' production activities, production factors (value added goods) and intermediate output goods are included and when the prices of these change, the framework of corporate behavior expresses to what extent other goods are substituted. In the framework of the GTAP-E model, substitution between energy goods[18] is a carefully considered structure, and the use introduction of a carbon tax results in such substitution[19]. Further development of the GTAP-E model conducted jointly by FRI and Dr. Truong, published in Hamasaki (2002), made possible the application of taxes by section. This report further improves GTAP-E's capability to apply taxation by energy type and makes it possible to evaluate the effects of greening the energy tax system.

The GTAP-E database employs the GTAP version 4 database using 1995 data (exchange rate is 94 yen/$1)[20]. As a result, effects of the environmental tax are estimated by using the 1995 database to hypothetically represent the year 2010. Also,

[18] Exchange of energy goods with production factors (land, labor, capital) is also considered.
[19] Due to the nature of the GTAP-E model, the effects of introducing a carbon tax are more pronounced than in the GTAP model. For example, when calculating the cost for achieving the reduction targets stipulated in the Kyoto Protocol, the GTAP-E model predicts less than 1/10 of the cost compared to the GTAP model. More detailed studies of the values of price elasticity substitution used by the GTAP-E and GTAP models are necessary.
[20] Additionally, the reduction targets incorporate the substantive reduction targets (as measured by the EIA) for BAU in the year 2010.

eight country/regional divisions are employed, consisting of U.S., China, former Soviet Union, Japan, India, EU, net energy exporting countries, and net energy importing companies. Sectors are divided into ten types: coal, crude oil, gas, oil, petroleum products, electrical power, steel, chemicals, other manufacturing, forestry and fisheries, and services.

3.2 Analysis Results

This report does not evaluate METI's greening and MOE's environmental tax proposals separately, but rather aims to compare the effects of each system. To this end, the tax rate of MOE's proposal is not used. Instead, the rate of a new tax that would result in the same reduction effect as METI's greening is employed, and the economic effects and implications are analyzed comparatively.

First, the GHG reduction effects of METI's greening will be calculated. In this calculation, the final tax rate starting from 2007 is used. Due to constraints in the database's categorical divisions that render it impossible to handle rises in the LPG or LNG tax rates, the effects of new taxes on coal and reductions in electricity taxes will be evaluated[21]. Also, tax-exemption for the steel sector is ignored.

According to the results of simulation analysis, the GHG reduction effect of greening was confirmed to be 2.4% (see Figure 6). At the same time, within the General Principles Concerning the Promotion of Measures to Cope with Global Warming, the energy-use related reduction target for the BAU (business as usual) case for 2010 is 7%[22], and yet it is determined that the reduction effect would bring about almost 30% of the target energy-use related reductions.

Next, in order to develop an argument regarding future institutional design, the effects of additional greening will be evaluated. Reduction by energy source to the target level of 7% was verified as possible through the increase of the coal tax (by 4220 yen/tC) and the reduction of the electricity tax (by 267 yen/1,000kW).

[21] Actually, the coal-oil tax's increased portion is calculated as being used for global warming countermeasures, and the effects of tax reflux are thought to be extremely large. However, the model used here is not capable of evaluating the effects of macroeconomic reflux (e.g. subsidies for introducing technology).

[22] The General Principles Concerning the Promotion of Measures to Cope with Global Warming assumes a 14% GHG reduction target for BAU in the year 2010, but of this 7% is assumed to be energy-use related reduction targets.

Figure 6. Tax Rates for Greening and New Taxes

TAX STRUCTURE		GREENING	NEW CARBON TAX	ADDITIONAL GREENING	NEW CARBON TAX
TAX RATE	Across-the-board (yen/tC)	--	450	--	1,600
	Carbon (yen/tC)	1,107	--	4,220	--
	Electricity (yen/1,000kWh)	-70	--	-267	--
REDUCTION EFFECT		2.4%		7.0%	

Source: FRI.

As shown in Figure 6, the taxation rates of greening/additional greening and a new carbon tax with the same GHG reduction effects are 450 yen/tC (2.4% reduction effect) and 1,600 yen/tC (7.0% reduction effect), respectively.

Next, Figure 7 displays the percentage of change to the production levels for each sector as a result of introducing an environmental tax. The decrease in production of the energy-intense steel industry brought about by greening and the introduction of a new carbon tax is prominent. As a result of greening, other sectors show a decrease in production of between 5-6 times this is a common issue for both greening and new taxation. In most other sectors[23], excluding the steel sector, greening shows more potential for marginalizing the decrease in production. In the case of additional greening (i.e. a 7.0% reduction effect), it is possible to contain the decrease in production by 1/2 to 1/3 as compared to the introduction of a new carbon tax. Furthermore, the use of greening can control total reduction in energy use by the manufacturing industry. This implies the efficient supplementation of environmentally friendly energy. From the standpoint of both the impact on the manufacturing industry and the efficiency of energy substitution, greening represents a superior tax system

[23] In the case of the introduction of a new carbon tax, the expansion of production volume in the service sector is confirmed, but factor analysis is necessary.

Figure 7. The Effects of Greening and Supplemental Taxes

REDUCTION EFFECT	TAX STRUCTURE	CHANGE IN OUTPUT (%)					TOTAL ENERGY
		Steel	Chemicals	Other Mfg.	Agri.	Service	
2.4%	Greening	-0.10	-0.02	-0.02	-0.02	0.00	-1.03%
	New Carbon Tax	-0.08	-0.04	-0.03	-0.03	0.01	-1.55%
7%	Add'l Greening	-0.33	-0.05	-0.06	-0.05	-0.01	-3.01%
	New Carbon Tax	-0.28	-0.15	-0.11	-0.10	0.03	-4.45%

Source: FRI.

Though greening demonstrates an efficient reduction of GHG, in order to attain the targets set by the Kyoto Protocol, further measures are necessary. However, compared with the targets of European countries, the cost of attaining Japan's GHG reduction targets[24] are extremely high, and domestic support for countermeasures is difficult to earn. Figure 8 expresses the reduction costs for both Japan and European countries. According to the results of the simulation analysis, the post-additional greening reduction costs will fall to the same level as European countries, and thus domestic support for countermeasures can be anticipated.

[24] Reduction costs here refer to the achievement of the reduction targets stipulated by the Kyoto Protocol through exclusively domestic measures. Actually, use of the Kyoto Protocol mechanisms in order to reduce GHG emissions overseas is also accepted as one method of achieving reduction targets. However, since the promotion of domestic policies is seen as a good opportunity for the development of environmental industries, institutional design focused on domestic policies is key.

Figure 8. Reduction Cost of Achieving Targets, Before and After Greening (Cost of CO2)

COUNTRY	REDUCTION TARGET[25]	COST of CO2 (yen/tC)		
		Current Tax System	After Greening	After Additional Greening
JAPAN	6%	7,400	6,900	5,600
EU	8%	5,700	5,700	5,700

Source: FRI.

As shown above, greening is confirmed as an extremely efficient countermeasure. However, even within greening various problems remain. First, the most important issue is that greening does not call for reduction effects at the individual household level. As expressed in Figure 9, when comparing greening to a new carbon tax with commensurate reduction effects (2.4%), whereas the carbon tax demonstrates a 3% reduction for households, greening's reduction effect is virtually zero. Further, even with the 7% reduction effect of greening and a new carbon tax, the same results are confirmed. As a possible solution to this problem, the introduction of a carbon tax limited to households in addition to greening is thought to be effective (compound policy approaches are noted in Figure 9). The introduction of a household-only carbon tax (at a taxation rate of 1,600 yen/tC) in addition to additional greening will result in a reduction of 8% at the household level. Moreover, the effect on the manufacturing industry of new taxation limited to the household level is negligible, thereby retaining a major merit of greening as part of the compound policy measure.

[25] In this table, reduction targets for Japan and the European countries are set at a 6% and 8% reduction from 1990 levels, respectively. However, according to the EIA, the real reduction-target values for Japan and the European countries' BAU levels in the year 2010 is said to be 20.3% and 17.5%, respectively. This report employs the EIA's real reduction-target value to calculate reduction costs. In this regard, however, EIA and MOE projections for BAU differ: the MOE real reduction-target value is cited at 14%. Assuming the EIA's value, the real reduction-target value will also differ from the energy-use related reduction targets put forth by the General Principles Concerning the Promotion of Measures to Cope with Global Warming.

Figure 9. Household Level Reduction Effects

REDUCTION EFFECT	2.4%		2.9%	7.0%		8.2%
TAX STRUCTURE	Greening	New Tax	Compound Policy Measure	Additional Greening	New Tax	Compound Policy Measure
HOUSEHOULD REDUCTION EFECT	0.0%	3.1%	3.12%	-0.1%	8.2%	8.3%

Source: FRI.

A second issue with greening concerns the particularly large effect accorded to energy-intensive industries such as the steel sector. This problem is similar to that of the introduction of a new carbon tax, and implies a loss of competitiveness for Japan's energy-intensive industries. Furthermore, this is related to the outflow of energy-intensive industries overseas, which hinders the reduction of GHG on a global scale. As a result of industries spilling overseas, overseas GHG emissions will actually rise.

The increase of GHG emissions overseas accompanying the reduction of domestic emissions is called "leakage". The effects of leakage can be evaluated as[26]:

$$\text{Leakage Rate} = \frac{\text{Increase of Overseas GHG Emissions}}{\text{Decrease of Domestic GHG Emissions}}$$

In the case of the introduction of a new carbon tax, the leakage rate is over 40%, thus the 40% domestic reduction is cancelled out as a result of the increase in overseas GHG emissions. Therefore, when the reduction effects are viewed on a global scale it cannot

[26] The equation given here is for the introduction of an environmental tax (or the promulgation of reduction targets) in Japan only. However, if environmental taxes (or the promulgation of reduction targets) are introduced in several countries, the denominator would be the cumulative reduction rate of those countries and the numerator would be the increase in emissions in other countries. In actuality, if reduction targets are set in Japan as well as in the European countries, the value of the leakage rate will actually decrease. This report does not argue the absolute amount of the leakage rate, but rather evaluates the relative value of the leakage rate through the comparative analysis of different systems.

be deemed an effective policy. As for greening, the leakage rate would be as high as 80% and is thus an even less effective policy (see Figure 10).

Figure 10. Effects of Leakage

TAX METHOD	New Tax		Greening		Additional Greening	
			No Exemption	Steel Exempt	No Exemption	Steel Exempt
REDUCTION EFFECT	2.4%	7.0%	2.4%	1.4%	7.0%	4.1%
LEAKAGE RATE	40%	44%	81%	83%	82%	82%
EFFECT ON PRODUCTION IN STEEL INUDSTRY	-0.08%	-0.28%	-0.10%	--	0.33%	--

Source: FRI.

As means to resolve these problems, there is a possibility of reducing the leakage of industry overseas through the use of preferential tax system policies to protect energy-intensive industries. For example, tax exemption for the steel industry has been proposed[27]. However, as Figure 10 shows, though tax exemption would control the loss of production for the steel industry, the leakage rate would remain at over 80%. As a result, this policy would not be effective in reducing leakage[28]. Furthermore, as a result of tax exemption, GHG emissions reduction would drop from 2.4% to 1.4% (or 7% to 4% in the case of additional greening). Not only would exemption warp the taxation system, but it would also hinder the domestic reduction of GHG emissions.

[27] Other propositions include special measures for the alleviation of businesses' social welfare expenses and the corporation tax, etc. According to Hamasaki (2001), alleviation measures for the social welfare expenses of businesses are undesirable in that they have little effect on the rate of change of industrial production volume. Furthermore, when viewed from the perspective of industry as a whole, excessive alleviation measures for high energy-consumption industries are connected with the deterioration of welfare, and thus such policies are not recommendable tax system.

[28] It is thought that the spillage of high energy-consumption industries overseas is connected to a multiplication of the leakage rate. However, industry protectionism as a result of tax exemption does not solve the leakage problem, and thus other major factors must be present; the decrease in energy demands in Japan, decreasing energy prices overseas, and other factors are also thought to play a role.

4. Summary and Future Issues

The environmental contribution of Japan's energy tax system is low. As result of the tax exemption of coal and other forms of distortion in the tax system, GHG emissions have been implicitly allowed to rise. In order to promote global warming countermeasures, it is imperative to expunge these distortions and to green the energy tax system.

Methods of environmental taxation as a global warming countermeasure include greening the current energy tax system and introducing a new carbon tax, but in order to determine the optimal future institutional design from the perspective of economic impact versus policy effect, a comparative analysis of simulations was conducted. The results of this analysis show that the GHG emissions reduction effect of greening is extremely high and that its economic impact is lower than that of the introduction of a new carbon tax. At the same time, greening also contributes to the efficient promotion of alternative energy. By pursuing additional greening it is possible to achieve the reduction targets stipulated in the Kyoto Protocol, while at the same time lower the reduction cost to the same level as European countries, and thus domestic support is anticipated.

Problems with greening include (1) no reduction effect at the household level, (2) loss of competitiveness for energy-intensive industries, and (3) an increase in overseas GHG emissions resulting in unfavorable reduction effects on the global scale. As a means of resolving issue (1), the application of a new, household-limited tax in addition to greening could be pursued. The exploration for solutions to issues (2) and (3) are matters for later research. Though (2) ad (3) seem to be intimately connected, tax exemption for the steel industry as a way to solve (2) does not solve the issue of leakage for (3), and would also serve as a hindrance to the domestic reduction of GHG emissions.

In order to find solutions to these problems, it is necessary to analyze the factors that cause an increase in the leakage rate. The leakage rate resulting from greening is overwhelmingly larger than that of a new carbon tax. Moreover, even if the steel industry is exempted from taxes, there is absolutely no decrease in the leakage rate. By elucidating the causes of leakage aside from the outward flow of energy-intensive industries, it may be possible to find methods for the efficient recycling of taxes and hints that will result in better institutional design. Additionally, institutional designs that harness the benefits of a new carbon tax and greening are also necessary.

Lastly, within the framework of the Kyoto Protocol, Japan and the European

nations are the only countries with set reduction obligations. These conditions make it difficult to balance improved domestic institutional design with GHG emissions reductions on a global scale. In order to reduce emissions on a global scale, while continuing to explore domestic institutional design, Japan should offer proposals on the international level in preparation for the next scheduled period of the Kyoto Protocol.

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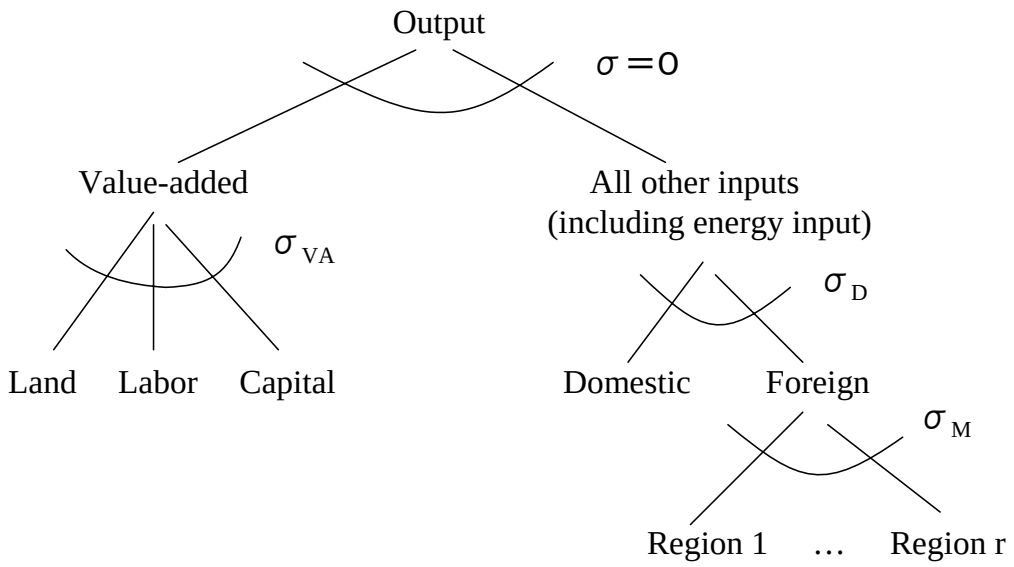
Appendix: The Framework of Corporate Behavior for GTAP and GTAP-E

The framework of corporate behavior (production function) expresses to what extent a change in the price of production factors (value-added products) and intermediate input products within businesses' production activities will cause substitution for another good. However, as discussed in Section 3.1., conventional GTAP models do not sufficiently consider the substitution effect that the introduction of a carbon tax would have on adoption of environmentally friendly energy. The actual framework of corporate behavior within GTAP and GTAP-E will be proven here.

As shown in Figure A and Figure B, a Leontief-type production function is the final phase of production within the framework of GTAP and GTAP-E models. In a Leontief-type production function, the promotion of substitution declines as the price of goods changes, and the price substitution rate (σ) becomes zero. Conversely, in a CES (Constant Elasticity Substitution)-type production function, as value changes, product substitution is encouraged in proportion to the price substitution rate. When the production function of a production factor[29] is a CES-type function, prices will change and product substitution will occur. At the same time, regarding the production function of intermediate goods, import goods will be substituted for domestic goods, but substitution between domestic goods will not occur.

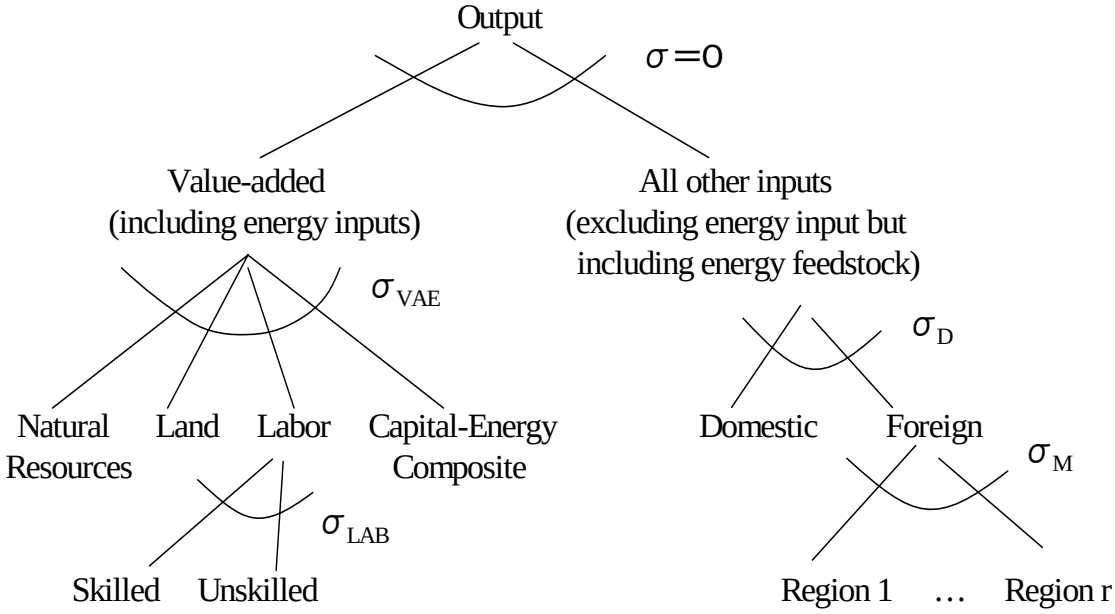
Figure A. The Framework of Corporate Behavior within the GTAP Model



[29] This supposes no transfer of production factors between countries and regions, however.

In conventional GTAP models, the factors of production are land, labor, and capital, and substitution as a result of price changes between these factors occurs. Energy goods and intermediate input goods are handled in the same fashion, and neither substitution between energy goods nor substitution of production factors occurs. As shown in Figure B, in GTAP-E, energy goods are handled in the same framework as other production factors, and both substitution between energy goods and substitution between other production factors can be considered. As a result, it is possible to accurately assess the effects of the introduction of a carbon tax.

Figure B. The Framework of Corporate Behavior within the GTAP-E



Furthermore, when the structure of the substitution of energy goods within the GTAP-E model is examined, it becomes extremely complex. Out of the factors of production, energy goods take the shape of a Capital-Energy Composite, as shown in Figure C. The framework of the construction of the Capital-Energy Composite reflects the ease of substitution between energy goods.

Figure C. The Framework of the Capital-Energy Composite within the GTAP-E