The Double Dividend of an Environmental Tax Reform in Japan

— a CGE Analysis based on the 1995 Input-Output Table —

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Abstract

This paper discusses the feasibility of the so-called “double dividend” of the environmental tax reform (ETR) in Japan using a computable general equilibrium analysis. The ETR not only introduces tax against the climate change but also recycles revenue in lowering some existing distortionary taxes. The CGE model with 16 production sectors and 27 commodities (including 14 energy products) based on the 1997 Input-Output Table avails in analyzing the necessary carbon and energy tax to meet Japan's goal of CO_2 reduction (here: 6% less than in 1990), and the economic cost or gain of the ETR. As a result, about 30,000 yen/tC of carbon-energy tax on fossil fuels such as coal will be necessary by 2010. This will cause a moderate economic impact. Consequently, an even more economic gain (more GDP-growth and employment) can be achieved if revenue is allotted to reduce labor cost. One of the reasons for this result is the assumption of the non-cleared labor market. The effects of special treatment on heavy industries are also analyzed. There will be more employment and growth when the halved carbon-energy tax rates are applied to the four heavy industrial sectors, but the tax rate for other sectors and consumers must be higher. It can also be shown that by dividing the consumption sector into five income classes, the change of prices by this energy taxation can in itself be regressive, but the overall effect of the ETR will be rather proportional.

Keywords : Environmental tax reform, Double dividend, Computable general equilibrium (CGE), Japan

0. Introduction

Although environmental tax such as carbon tax is widely recognized as a burden on the economy, it

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may even improve economic activity depending on how the environmental tax revenues are used. The idea of a so-called “double dividend” of an environmental tax reform (ETR) is one of the topics discussed and debated in recent literature of environmental economics. The double dividend consists of a “better environment” and an “improved economic activity”.

The double-dividend hypothesis has widely accepted among European policy makers (although the debate among specialists is not finished), which lead many European countries to introduce the ETR. Despite the fact that the policy of “killing two birds with one stone” has been popular in Europe, Japanese economists or policy makers do not seem to be interested in this hypothesis. The introduction of carbon tax here is mainly discussed in the context of a trade-off between economy and ecology. Some reports on environmental tax by the Ministry of Environment (the former Environment Agency) contain reviews of empirical studies that analyzed the effects and costs of carbon tax, but none of them have examined whether the specific type of revenue recycling leads to more growth or employment[1].

In this paper we investigate the possibility of economic gain through the ETR in Japan using a computable general equilibrium model (CGE). Namely, the CGE model is compatible with the neo-classical theory concerning the feasibility of the double dividend.

1. On the double dividend hypothesis

An environmental tax reform which consists of environmental tax (especially tax on environmentally harmful goods or resources) and revenue recycling through reducing the rate of existing tax or social security contributions may bring about the so called “double dividend”. The first dividend means the environmental benefit from internalizing external effects (better environment), and the second dividend means (non-environmental) economic benefits from reducing excess burdens of existing taxes (improved economic activity such as higher GDP or employment).

Until the beginning of the ’90s, it was taken for granted that a tax shift from economic goods (such as labor or capital) to the bads (pollution or resource intensive goods) will bring about the double dividend. In the middle of ’90s, however, negative arguments based on the well-built “theory of second-best taxation” became predominant. They insist that the ETR will exacerbate the distortion of existing taxes so that the second dividend will be more than offset (Oates 1995, de Mooij 1999).

According to de Mooij (1999), the second dividend can be decomposed into two factors in the theory of second-best taxation. The first factor is the revenue recycling effect (RE), which means the reduced excess burden is induced by reducing rates of existing taxes. The other is the tax interaction effect (IE), which results from the erosion of tax bases (e.g. reduced labor supply) because of the rise in prices or the decline in real wages induced by environmental taxation. In normal conditions, RE is positive and IE is negative. If RE>IE, there will be a positive effect on non-environmental welfare ("strong double dividend"). If RE<IE, the strong double dividend will not occur, but there will be a "weak double dividend", since revenue recycling through reduction of other distortionary taxes is more meaningful (RE>0) than through reduction of non-distortionary taxes, income transfer to households (so called lump-sum recycling) or government spending (RE=0). Positive employment effects of environmental tax reform is also possible regardless of the "strong" or "weak" double dividend, which may be socially or politically desirable (employment double dividend). On top of this, there is (and has been) almost no doubt among specialists on the feasibility of the first dividend (the so called Pigouvian Effect (PE)) in the current status with the external effect yet to be internalized, because the demand on additively taxed goods will decrease according to the simplest law of demand.

Table 1: Three definitions of the double dividend

DOUBLE DIVIDEND	FIRST DIVIDEND (environmental effect)	SECOND DIVIDEND (non-environmental economic effect)
strong double dividend	positive (PE>0)	non-environmental welfare higher than before ETR (RE+IE>0)
weak double dividend	positive (PE>0)	non-environmental welfare higher than with lump sum recycling (RE>0)
employment double dividend	positive (PE>0)	employment higher than before ETR

See e.g. de Mooij (1999)

As mentioned, in the middle of the '90s the feasibility of the strong (or employment) double dividend is almost rejected, that is, the IE was considered to be greater than the RE. On the contrary, since the end of the '90s papers that theoretically define specific situations under which the strong double dividend is possible can be found (Scholtz 1998, Bovenberg and van der Ploeg 1998, Parry and Bento 2000). Recent reviewers also show that many empirical works result in a strong or employment double dividend (Bosquet 2000, Bosello et al. 2001). According to Bosselo et al. (2001), the assumption of an imperfect labor market and especially the existence of involuntary unemployment contributes to this positive result. Accordingly it seems to be possible to say that the chance of the double dividend is quite promising under current Japanese economy. Furthermore, Goodstein (2003) strongly supported the possibility of the strong double dividend casting doubt on the alleged negative IE in the context of the theory of second best taxation.

The following section discusses the idea and the structure of the model. In section 3 the policy options are defined. And in the section 4 these results are presentated and evaluated. Section 5 consists of a conclusion.

2. The idea and the structure of the ETR-CGE Model

The purpose of this ETR-CGE Model is to analyze the effect of an ETR intended to reduce CO_2-emissions or energy consumption in the context of the double-dividend debate. The policy instrument to be introduced is the carbon-and-energy tax (hereafter referred to as C&E tax) that is once proposed by the EC Commission, whose tax base is both energy and carbon content of sources of energy. The environmental goal of this policy here is to reduce CO_2-emissions in 2010 by 6% under the level of 1990[2]. The rate of this tax will be adjusted to reach this goal. The revenue will either be allotted to government spending or recycled through boosting the social security payment or reducing the rates of taxes or social security contributions. The choice of revenue application has great implications for GDP-level and growth, income distribution and employment.

The ETR-CGE model is based on the 1995 Input-Output Table. Here only the outline will be shown (see the Appendix for more detail). There are 16 production sectors and 5 income classes of households in the Model. They supply and demand goods and factors according to their optimizing behavior. The production sectors and their cost shares are shown in table 2. Final demands consist of government spending (investment and consumption), private spending (investment and consumption), and the foreign sector (export minus import). The capital is fixed in production sectors in the short run, but it is flexible in the long run because sectors with a higher rate of return will invest more. Household income stems from labor income and capital income, which will be spent on goods and services or saved according to the interest rate. The behavior of the industry and households are rational in the short term but not intertemporally optimal. International trade is modeled by simply using an Armington function, namely without explicitly modeling the foreign economic subject.

In this model, prices of goods are adjusted to balance the supply and demand of all goods. The interest rate is also adjusted to match investment and savings, where no international capital flow is taken into account. The effect on employment is analyzed under the assumption of an imperfect labor market where the nominal wage rate is fixed and the supply of labor is higher than demand.

One of the special characteristics of this model is the detailed division of energy commodities and taxes. Fourteen energy commodities are treated as endogenous input factors. Demands on energies are determined by factor demand functions or consumption functions. The C&E tax will raise prices of energies; hereby change of price rates differ according to the sort of energy and to the sector in which it

Table 2: The production sectors and their cost share

		1	2	3	4	5	6	7	8
Costs	average of sector 1-13	agricult., forestry & fishery	mining	foods	fibers & textiles	pulp, paper & wooden-ware	chemical & other oil & coal products	ceramics, quarry., & cements	steel, iron, & nonfer-rous metals
Material	51.0%	41.7%	43.8%	62.2%	60.3%	61.5%	57.3%	51.4%	61.1%
Energy	3.1%	1.4%	3.1%	1.4%	1.8%	2.8%	7.8%	4.8%	4.2%
Labor	24.0%	11.0%	25.6%	15.1%	25.6%	20.4%	14.3%	24.4%	20.1%
Capital	18.4%	43.3%	23.9%	10.7%	9.6%	12.6%	16.0%	16.0%	11.8%
indirect tax	3.5%	2.6%	3.6%	10.7%	2.6%	2.6%	4.6%	3.4%	2.8%
main cost	--	capital	labr/cptl	material	labor	material	energy	enrg/labr	energy
		9	10	11	12	13	14	15	16
Costs	average of sector 1-13	machien-ery etc.	Construc-tion	Transpor-tation	non-trans-portation. services	not classi-fiable	fuel min-ing	oil & coal products	electrici-ty, gas, heat.
Material	51.0%	64.6%	53.1%	41.4%	29.7%	34.4%	43.8%	13.6%	27.6%
Energy	3.1%	1.2%	0.8%	8.4%	1.3%	0.9%	3.1%	35.9%	18.4%
Labor	24.0%	21.1%	35.1%	35.5%	40.2%	23.8%	25.6%	4.0%	13.1%
Capital	18.4%	11.4%	8.6%	12.1%	25.8%	37.8%	23.9%	6.7%	34.4%
indirect tax	3.5%	1.7%	2.3%	2.6%	3.0%	3.1%	3.6%	39.9%	6.5%
main cost	--	material	labor	labr/enrg	labr/cptl	capital	--	--	--

* The "main cost" factor depends on the comparison to the average of sectors except for energy sectors.
Abbreviation: labr=labor, cptl=capital, enrg=energy

is used. The private household is divided into five income classes, which enables the vertical distribution effects of an environmental tax reform to be analyzed. In this paper, as mentioned above, the labor market is assumed to be in a disequilibrium because the nominal wage is not flexible (in this model it is simply a fixed constant). This assumptions is crucial to the double dividend. The labor demand is determined by the factor demand of each sector but the labor supply is exogenously determined, and unemployment is defined by their gap[3]. The basic data used is from the government's statistics such as "*Input-Output Table (1995)*" including the Tables of Physical Quantity, the "*Annual Report on National Accounts (2000)*" and the "*Annual Report on the Family Income and Expenditure Survey (1995)*". Data of the specific CO_2-emmission are from the EDMC's "*Handbook of Energy & Economic Statistics in Japan (2000)*" or the former Environment Agency's data (1994).

The scale parameters or tax rates in this model are calibrated to the 1995 data, and the elasticity parameters are set exogenously (Table A1, A2). Some of the parameters refer to empirical studies (such as Tokutsu 1992), but most parameters are necessarily without empirical basis and are set low in order not to overestimate the feasibility of the double dividend[4].

3. Policy Options to be analyzed in the ETR-CGE Model.

In our analysis, we select a policy option, set the CO_2-emission target, and then run the computer program[5], which will give the result of production and demand levels, price and employment levels etc., and the carbon-energy tax rate necessary to reach the goal.

The carbon-energy tax (C&E tax) is taxed on energy commodities according to the carbon and energy contents (T yen per ton coal and the same T yen per 10^7kcal, which means about 50:50 taxation on both components for coal). The goal of CO_2-reduction is 6% reduction in 2010 compared to the 1990 level, according to (a strict interpretation of) the obligation of the Kyoto-Protocol. Because the emission was 287.2 million tC (ton in carbon) in 1990, Japan must reduce emissions from 311.6 million tC (1995) to 270.0 million tC (2010).

We set six policies to the ETR. The result of these scenarios are able to be anticipated according to the theory of second best taxation.

Table 3: The Reference Scenario

	1995	*2000*	*2005*	*2010*	*Annual Growth rate 2010/1995*
Real GDP Growth (per year)		1.31%	1.53%	1.45%	
Real GDP (trillion yen)	505	538.9	581.4	624.6	1.43%
Labor Demand (trillion yen)	293	312	337	360	1.39%
Labor Supply (trillion yen)	308	330	353	378	1.38%
Unemployment rate (%)	5.00%	5.39%	4.34%	4.79%	
Energy Consumption (10^{13}kcal)*	463	479	490	513	0.69%
Energy Intensity of GDP (1995=100)	100	96.9	91.9	89.6	
CO_2-Emission (Million tC)	312	322	330	344	0.67%

* The energy consumption is calculated from data in the Input-Output Table, and therefore not necessarily compatible to the other energy statistics.

(1) Reference Scenario: No CO_2-reduction and no energy taxation (see Table 3). This scenario is calibrated to the CO_2-emission forecast of the 'IEE Japan, Long-term Energy Demand and Supply Outlook' (EDMC 2000, p. 222).

(2) C&E Tax and Government Expenditure: a C&E tax is introduced to reduce CO_2-emissions. The additional revenue from C&E tax flows to additional government expenditure. All purchased items are increased proportionally so that the government's expenditure patterns are kept unchanged. In this scenario, no double dividend will occur ($PE>0$, $RE=0$, $IE<0$).

(3) C&E Tax and Redistribution: The whole C&E tax revenue is used to raise the social security

transfer. The social security benefit for all income classes is raised proportionally. Therefore this scenario will be advantageous for the lower income groups because they receive a higher proportion of income as a social security benefit. This may be an important option for Japan facing an aging society. In this scenario, too, there will be no double dividend (PE>0, RE=0, IE<0).

(4) C&E Tax and SSC Cut: The whole C&E tax revenue is used to reduce the social security contribution (SSC) on labor which is paid by employers and employees. The rate of social security contributions is assumed to be constant across all production sectors. The reduction rate depends on the scale of C&E tax revenue. In this scenario the weak double dividend is sure, because the reduction of the SSC-rate leads to a lower excess burden in the labor market (PE>0, RE>0, IE<0). Whether the strong double dividend really occurs, however, depends on the relative scale of the RE and the IE.

(5) C&E Tax and Income Tax Cut: The whole C&E tax revenue is used to reduce the rate of income tax (tax on the sum of labor and capital income). Tax rates are reduced by the same percentage point for all tax brackets[6] so that the effect of this reduction will be almost proportional among income classes. It should be noted that income tax *in this model* is not distortionary unlike social security contributions. Namely, income tax cannot be avoided e.g. by reducing the labor supply intentionally. Therefore there will be no double dividend in this scenario (PE>0, RE=0, IE<0).

(6) C&E Tax, SSC Cut, and Competitiveness: in addition to scenario 4, a special treatment is given to energy intensive sectors (sector 5, 6, 7, 8) so that they will not be put at a competitive disadvantage against foreign businesses without comparable burden[7]. The C&E tax rate for these sectors is reduced to the half of the normal rate that other sectors incur. In this scenario, too, the weak double dividend is sure, because the reduction of SSC-rate leads to a lower excess burden in the labor market (PE>0, RE>0, IE<0). It depends on the relative scale of the RE and the IE whether the strong double dividend really occurs.

In the Reference Scenario, it is assumed that the capital stock in production sectors increases about 1% per year, and there is an “energy-increasing” (=higher energy productivity) technological progress represented by scale parameters in production functions. The growth of labor supply is set in order to keep the unemployment rate at about 5%. Other parameters are set constant. The assumption of the Reference Scenario may now seem to be counterfactual, above all the coexistence of a relatively high unemployment rate and a relatively high growth rate. However as this is a simulation analysis the absolute level is not a crucial problem, as the effects of each scenario are evaluated on difference from the results of the reference scenario.

4. Results and evaluations

4.1. CO_2-emission and necessary carbon-energy tax rates

The CO_2-emission paths are set the same among five C&E-tax scenarios. But the necessary C&E tax rates differ according to the economic effect of scenarios (see Table 4). A scenario with a higher economic activity tends to require a higher C&E tax rate to meet the emission target, otherwise the energy demand will be boosted and CO_2-emissions will be higher than the target. For example, the SSC-Cut Scenario (4) leads to a relatively higher employment and GDP level, therefore the C&E tax rate also must be higher than in other scenarios. In the Competitiveness Scenario (6), the (normal) C&E tax rate must be higher not only because of a favorable economic effect but also because energy intensive sectors are assumed to pay only half of the normal rate of C&E tax and therefore other sectors have to compensate for this. The reason for preferable economic effect in scenario 4 or 6 will be discussed in the next paragraph.

Table 4: The CO_2-Emission and the Carbon-Energy Tax Rates (thousand yen/tC*)

Scenarios	*1995*	*2000*	*2005*	*2010*
Base-line CO_2-Emission（Million tC）	311.6	321.9	329.8	344.4
Restricted CO_2-Emission (Million tC)	311.6	311.6	290.8	270.0
Reduction Rate (% of Baseline)	--	-3.2 %	-11.9 %	-21.7 %
C&E Tax and ...				
2. Government Expenditure	0	2.87	11.74	23.95
3. Redistribution	0	2.93	12.10	24.86
4. SSC-Cut	0	3.01	12.63	26.33
5. Income Tax Cut	0	2.92	12.09	24.83
6. SSC-Cut & Competitiveness	0	4.03	16.88	34.92

* The sum of tax rates on carbon and energy component for coal

4.2. The GDP and Employment

Table 5 shows the result of the GDP, labor demand level and growth rates. The results of scenarios Government Expenditure (2), Redistribution (3) and Income Tax Cut (5) are very similar, and these results are worse than those of scenarios SSC Cut (4) or Competitiveness (6). This means that it is less important for the aggregate economic performance whom the carbon-energy tax revenue flows to (government, lower or higher income household) than whether the revenue recycling option reduces the labor cost. In scenario 2, 3, and 5, the GDP and employment level will be lower than the Reference Case (1). Higher production costs and household living costs caused by the environmental taxation lead to a lower economic activity level[8], and the revenue recycling in those scenarios is insufficient to compensate for the economic loss. Despite this, the loss is very small.

On the other hand, in scenario 4, the reduction of the rate of social security contribution leads to a lower employer wage, which results in a slightly higher labor demand and a higher economic activity level. That is, in this scenario the revenue recycling effect overwhelmed the tax interaction effect hence the strong- and employment double dividend was accomplished. The favorable result can be boosted by the special treatment for energy intensive sectors (scenario 6). It is not only due to the easing of the price hike of energy-intensive basic materials, but also because a greater C&E tax revenue has enabled the additional reduction of the SSC rate, which in turn leads to a lower excess burden in the labor market.

Table 5: The Real GDP and Labor Demand (Level and Growth)

Scenario		*1995*	*2000*	*2005*	*2010*	*Annual growth rate 2010/1995*
1. Reference	GDP（trillion Yen）	505.0	538.9	581.4	624.6	1.43%
	Labor Demand（tril. yen）	292.7	312.0	337.1	360.1	1.39%
2. C&E Tax and	GDP（tril. Yen）	505.0	538.5	578.4	616.9	1.34%
Government Expenditure	Labor Demand（tril. yen）	292.7	311.8	335.3	355.7	1.31%
3. C&E Tax and	GDP（tril. Yen）	505.0	538.4	578.4	617.2	1.35%
Redistribution	Labor Demand（tril. yen）	292.7	311.7	335.1	355.6	1.30%
4. C&E Tax and	GDP（tril. Yen）	505.0	539.1	582.0	625.5	1.44%
SSC-Cut	Labor Demand（tril. yen）	292.7	312.4	338.4	362.6	1.44%
5. C&E Tax and	GDP（tril. Yen）	505.0	538.4	578.4	617.2	1.35%
Income Tax Cut	Labor Demand（tril. yen）	292.7	311.7	335.1	355.6	1.30%
6. C&E, SSC-Cut &	GDP（tril. Yen）	505.0	539.3	583.1	628.3	1.47%
Competitiveness	Labor Demand（tril. yen）	292.7	312.6	339.4	365.1	1.48%

4.3. Sectoral Production

The change of sectoral production is shown in table 6. As the results of scenarios 2, 3 and 5 are very similar, those results are represented by the Scenario Government Expenditure (2). In each one of the scenarios, the production of energy sectors (14, 15, 16) has distinctly decreased, which is the main purpose of the energy taxation. In scenario 2, every sector produces less than in Reference Scenario (1). As can be observed, especially in energy-intensive sectors such as the chemical sector , production lose up to 3.2%, but non-energy-intensive sectors such as fibers (4) or non-transportation services (12) suffer only slightly.

Even in the SSC Cut Scenario (4) in which a strong double dividend occurred, the sectors that increased are minorities, that is, only two non-energy-intensive sectors (foods (3) and non-transportation services (12)) gain. Because the production share of sector 12 is very large, the increase of production in this sector compensated the loss of other sectors and therefore overall economic gain occurred (see also Table 5). In the Competitiveness Scenario (6), because the prices of basic materials were kept low, and because higher employment leads to a higher consumption demand, most of the non-energy sectors increased. Although energy extensive sectors and consumers have to pay higher C&E tax (see Table 3), the economy as a whole grows faster than in the Reference Scenario.

Table 6: The Sectoral Production

Sector	2010								
	1995	1. Ref-erence.	growth %	2. Govern-ment Expendi-ture	% de-vation from (1)	4. SSC Cut	% de-viation from (1)	6. Com-petitive-ness.	% de-viation from (1)
1. agricult. forest & fish.	16042	19322	1.25	19017	-1.59	19319	-0.03	19358	0.17
2. mining	1490	1835	1.40	1795	-2.20	1820	-0.87	1830	-0.34
3. foods	38857	46535	1.21	45936	-1.29	46680	0.31	46740	0.44
4. fibers & textiles	11142	12909	0.99	12819	-0.68	12883	-0.19	12910	0.02
5. pulp, paper & wood.	17800	22352	1.53	21841	-2.29	22207	-0.66	22393	0.18
6. chemical etc.	27309	33399	1.35	32321	-3.23	32798	-1.80	33056	-1.03
7. ceramics, cement, etc.	9696	12391	1.65	12076	-2.55	12266	-1.01	12395	0.03
8. steel, iron etc.	42144	52656	1.50	51177	-2.80	52068	-1.11	52558	-0.18
9. machinery etc.	156593	189737	1.29	185282	-2.33	189043	-0.35	190231	0.28
10. construction	88128	114659	1.77	112371	-2.00	114159	-0.44	115470	0.71
11. transportation	50114	61709	1.40	60076	-2.64	61098	-0.99	61238	-0.76
12. non-trans. services	441181	540900	1.37	536389	-0.84	542550	0.30	544675	0.70
13. not classifiable	5303	6461	1.32	6345	-1.80	6430	-0.49	6457	-0.07
14. fuel mining	169	159	-0.41	135	-15.37	135	-14.94	134	-15.49
15. oil & coal prod.	8962	10210	0.87	8328	-18.43	8348	-18.24	8086	-20.80
16. elec., gas & heat.	18810	20933	0.72	18579	-11.25	18711	-10.62	18441	-11.91

4.4. Distributional Implications

In this model, private households are divided into 5 income groups, each of which consists of 20% of the total households. This enables us to analyze the asymmetric effects of the ETR on different income classes. In the tables 6, 7 and 8, class I is of the lowest income and class V is the highest. Three indicators are chosen concerning the distributive effects, the index of household living cost, nominal- and real disposable income.

Table 7 shows the change of the index of household living costs. As the living cost differs among income classes, only the rate of deviation from the Reference Scenario is shown in the table. In spite of the fact that the C&E tax rate is high enough to more than triple the price of coal or crude oil, the increase of living costs is very small in every case (between 1 to 2 %), because the energy cost contributes to only a small part in most production sectors. The lower the income class is, the higher the increase of living costs, because the share of energy expenditure is larger in lower income households, but the difference is still very small.

Table 7: Change of the Index of Household Living Cost (% relative to Ref. 2010)

Income quintile groups	*I*	*II*	*III*	*IV*	*V*
1 Reference	0.00	0.00	0.00	0.00	0.00
2 C&E Tax and Gov. Expenditure	1.07	1.07	1.07	1.00	0.94
3 C&E Tax and Redistribution	1.15	1.15	1.15	1.08	1.02
4 C&E Tax and Labor Cost	1.13	1.14	1.13	1.06	0.99
5 C&E Tax and Income Tax	1.14	1.15	1.14	1.08	1.02
6 C&E, Labor & Competitiveness	1.63	1.63	1.61	1.53	1.44

Table 8 and table 9 shows the change of (nominal and real) disposable income, which depends highly on the method of revenue recycling. If the C&E tax revenue flows to government expenditure (scenario 2), the disposable income of all income classes is reduced because no household receives compensation of income loss induced by the C&E tax. The reason why lower income classes suffer less in terms of the nominal income is because the commodity pattern of government expenditure is relatively labor intensive and income there consists mainly of labor-induced income. Similarly, the case of Redistribution (scenario 3) is favorable for lower income households, but the reason is more direct. On the other hand, the option of income tax reduction increases the nominal income almost proportionally (scenario 5), but households have to bear the C&E tax burden reflected in higher prices and therefore the real income drops only slightly. When the revenue is used to reduce the labor cost (social security contribution), the increased after-contribution wage and the increase in employment leads to a higher income level especially for lower income households. This is due to the aforementioned higher proportion of labor income (scenario 4). When the C&E tax for energy intensive sectors is reduced to half (scenario 6), every income class gains almost proportionally (or rather regressive in real terms) because not only the labor income but also the capital income increases.

We can summarize here that the overall effect of an environmental tax reform on vertical distribution cannot be expected only by the change of household living costs, because different revenue recycling options bring about different income effects on each income class.

Table 8: Change of the Nominal Disposable Income (% relative to Ref. 2010)

Income quintile groups	*I*	*II*	*III*	*IV*	*V*
1 Reference	0.00	0.00	0.00	0.00	0.00
2 C&E Tax and Gov. Expenditure	-1.27	-1.37	-1.51	-1.53	-1.64
3 C&E Tax and Redistribution	2.20	1.31	-0.14	-0.03	-0.99
4 C&E Tax and Labor Cost	1.28	1.24	1.27	1.19	1.13
5 C&E Tax and Income Tax	0.19	0.17	0.16	0.15	0.17
6 C&E, Labor & Competitiveness	2.02	2.03	2.13	2.04	2.04

Table 9: Change of the Real Disposable Income (% relative to Ref. 2010)

Income quintile groups	*I*	*II*	*III*	*IV*	*V*
1 Reference	0.00	0.00	0.00	0.00	0.00
2 C&E Tax and Gov. Expenditure	-2.32	-2.42	-2.55	-2.51	-2.56
3 C&E Tax and Redistribution	1.04	0.16	-1.27	-1.10	-1.99
4 C&E Tax and Labor Cost	0.15	0.10	0.14	0.13	0.14
5 C&E Tax and Income Tax	-0.94	-0.97	-0.97	-0.92	-0.84
6 C&E, Labor & Competitiveness	0.38	0.40	0.51	0.51	0.59

5. Conclusion

We have analyzed the effects of an environmental tax reform (ETR) using a computable general equilibrium model. Greater attention is paid here on whether the “double dividend” is likely to be achieved. As we have discussed in section 4, the GDP and employment level will rise slightly in scenarios in which the revenue from C&E tax is used to reduce the rate of social security contributions in order to reduce the labor cost. In scenario 6, the special treatment for energy intensive sectors (reduction of C&E tax rate to 50 % of normal rate) have resulted in an enhanced positive effect shown by scenario 4. In other scenarios (2, 3, 5), there will be no double dividend because the C&E tax revenue will not be used to reduce the excess burden of existing tax or social security system. If there have been other existing distortionary taxes in this model, the reduction of them by using C&E tax revenue will have resulted in another (at least a “weak”) double dividend. It is often said that energy taxation has a regressive effect. But depending on the way of revenue recycling, the distributional effects can be made proportional or rather friendly for lower income groups. These results suggest that we should always take the revenue recycling side of the ETR into account.

Crucial for this analysis are the assumption of an imperfect labor market and constant nominal wage, which may not be usual in an ordinary computable general equilibrium model. In a sensitivity analysis assuming the labor market equilibrium, the GDP level increased in none of scenarios, but the employment has slightly increased in the SSC Cut Scenario (employment double dividend). Other sensitivity analysis (not mentioned here) has shown that the result depends on parameters of elasticity of substitution, that is, the strong second dividend may vanish if the factor substitution in the industry is supposed to be inelastic.

In this analysis, there are several shortcomings in the model building which could- or should be improved in the future. Firstly, the economic subjects are not supposed to be intertemporally rational. Secondly, the imperfect labor market is modeled by the assumption of a constant nominal wage and disequilibrium in labor supply and demand which may be too simple. In these points, better specifications and a better modeling strategy is required in future studies.

Appendix: the ETR-CGE Model

1. The Input-Output Table

Using the detailed *1995 Input-Output Table*, production sectors are integrated to 16 sectors. Three energy sectors (fuel mining (14), oil & coal products (15), and electricity, gas & heat (16)) are disaggregated into 14 energy commodities (3 primary energies, 8 coal and oil products, electricity, urban gas, and heat supply). Therefore there are 27 commodities including the 13 non-energy commodities. The primary production factors are labor and capital. Final demand sectors are private consumption, public consumption and investment, private investment, export and import. The private consumption is divided into 5 income classes. The quantity table enables us to calculate the quantity of sectoral energy consumption and CO_2-emission.

2. Equations of CGE Models (excerpt).

The Model is basically a static model. The calculations of the different time periods are connected only by capital accumulation and technological progress. Therefore, the time-index (t) is omitted in most of the following equations except for the equations of capital dynamics. Most uppercase letters are quantity variables and the lowercase letters are rate variables, and letters without suffixes often stand for the sum.

(1) Production of Sector j

a) CES production function and the profit maximization problem

$$X_j = \left[(A1_j M_j)^{-\rho_j} + (A2_j E_j)^{-\rho_j} + (A3_j L_j)^{-\rho_j} + (A4_j K_j)^{-\rho_j} \right]^{-\frac{1}{\rho_j}} \qquad (1)$$

$$\max P_j X_j - (P_{Mj} M_j + P_{Ej} E_j + wL_j) \quad \text{s.t.} K_j = K_{j0} \qquad (2)$$

X_j : production quantity, M_j : material (aggregate of materials, intermediate goods and services), E_j : energy (aggregate of energy commodities), L_j : labor, K_j : capital service (constant to the initial level K_{j0}), P_{Mj} : price index of aggregate material, P_{Ej} : price index of aggregate energy (see price index), w : employer wage rate, $A1_j$ -- $A4_j$: scale parameters, ρ_j : parameter related to elasticity of substitution, that is, $\rho_j = (1-\sigma_j)/\sigma_j$ (see table $A1$). The real variables are expressed in monetary units (yen), but the relative price is unitless. The production and factor demand functions are derived using first order conditions of profit maximization problem.

Table A1: Elasticity of Substitution (σ_j)

1. agricult. forest & fish.	0.8	9. machinery etc.	0.2
2. mining	0.2	10. construction	0.4
3. foods	0.6	11. transportation	0.6
4. fibers & textiles	0.1	12. non-trans. services	0.6
5. pulp, paper & wood.	0.6	13. not classifiable	0.5
6. chemical etc.	0.5	14. fuel mining	0.3
7. ceramics, cement, etc.	0.6	15. oil & coal prod.	0.8
8. steel, iron etc.	0.3	16. elec., gas & heat.	0.6

Table A2: Other Elasticity Parameters

elasticity of substitution: material (σ_{Mj})	0.1	Elasticity of substitution: consumption (μ_k)	0.5
elasticity of substitution: energy (σ_{Ej})	0.1	interest rate elasticity of saving rate (ε_{Sk})	0.4
elast. of subst.: transportation energy (σ_{EMj})	0.2	wage elasticity of labor supply (ε_{L1k})	0.1
elast. of subst.: non-transport. energy (σ_{ENj})	0.2	price elasticity of labor supply (ε_{L2k})	-0.1
excess-profit elasticity of investment (η_j)	1.0	Elasticity of substitution: Armington's function (for all sectors) (δ_i)	0.5

If the capital stock is constant in the short run, the production is determined by the initial capital stock (K_{j0}) and the price of this sector's product (P_j), price indices and wage.

b) Production

$$X_j = \left[1 - \left(\frac{P_{Mj}}{A1_j P_j} \right)^{\frac{\rho_j}{\rho_j+1}} - \left(\frac{P_{Ej}}{A2_j P_j} \right)^{\frac{\rho_j}{\rho_j+1}} - \left(\frac{w}{A3_j P_j} \right)^{\frac{\rho_j}{\rho_j+1}} \right]^{\frac{1}{\rho_j}} A4_j K_{j0} \qquad (3)$$

c) Factor demand

$$M_j = \left(\frac{P_{Mj}}{P_j A1_j} \right)^{-\frac{1}{1+\rho_j}} \frac{X_j}{A1_j}; \quad E_j = \left(\frac{P_{Ej}}{P_j A2_j} \right)^{-\frac{1}{1+\rho_j}} \frac{X_j}{A2_j}; \quad L_j = \left(\frac{w}{P_j A3_j} \right)^{-\frac{1}{1+\rho_j}} \frac{X_j}{A3_j} \qquad (4)$$

(2) Aggregate Input Factor (Material)

a) CES material aggregate function

$$M_j = \left[\sum_i (A_{ij} M_{ij})^{-\rho_{Mj}} \right]^{-\frac{1}{\rho_{Mj}}} ; \quad i = 1 \sim 13 \tag{5}$$

M_j : material aggregate, M_{ij} : quantity of individual input commodity, A_{ij} : a scale parameter, ρ_{Mj} : a parameter related to elasticity of substitution, P_{ij}^D : demander price of each commodity for sector j including an excise tax.

An individual material demand function is derived solving the cost minimization problem.

b) individual material demand function

$$M_{ij} = \left(\frac{P_{ij}^D}{P_{Mj} A_{ij}} \right)^{-\frac{1}{1+\rho_{Mj}}} \frac{M_j}{A_{ij}} \tag{6}$$

The energy aggregate has a similar CES function and individual material demand functions, and therefore the explanation is omitted here (a slight difference is that the energy aggregate has a two stage structure, aggregating transportation and non-transportation energies separately). The elasticities of substitution between individual commodities are kept very low (by material, 0.1; by energy, 0.2 for individual energy and 0.1 for substitutability of two sub-aggregates), supposing the substitutability is very limited.

(3) Behavior of Private Households

a) CES utility function with a separated leisure term

$$U_k = \left(\sum_i (B_{ik} C_{ik})^{-\mu_k} \right)^{-\frac{1}{\mu_k}} + B_{lk} LEIS_k \tag{7}$$

For the k-th income class from the lowest; U_k : utility, B_{ik} : scale parameter, C_{ik} : consumption of the i-th good, μ_k : a parameter related to the elasticity of substitution, B_{lk} : marginal utility of leisure, $LEIS_k$: leisure.

The whole time budget of a household (in monetary units) is assumed to be divided into labor and leisure by 1:5 ratio. Because there is only one kind of efficiency-unit-labor, we assume that a higher income household is able to supply more labor (or has larger time budget) in proportion to the work-place revenue in the "*Family Income and Expenditure Survey*". The capital holding is distributed according to annual revenue. Note that the annual revenue is more progressive than the work-place revenue.

b) Household income

$$HHI_k = (w - t_L) L_k + (1 - t_r) rK_k \tag{8}$$

HHI_k : household income, $w - t_L$: rate of employee wage, t_r : capital tax rate, r : average profit rate of all industries, K_k : capital holding

c) Pre-tax revenue

$$R_k = HHI_k + LST_k \tag{9}$$

R_k : pre-tax revenue, LST_k : social security benefit transfer

d) Income tax function

$$TI_k = \alpha_k + \beta_k \cdot HHI_k \tag{10}$$

TI_k : the income tax burden on the k-th income class. The marginal tax rate β_k is statistically estimated and differs according to income class.

e) Saving

$$S_k = s_k(ir) \cdot (R_k - TI_k - TOD_k) \tag{11}$$

S_k : saving, TOD_k : other indirect tax burden. The terms in the parentheses stands for the disposable income. $s_k(ir)$ is the saving propensity function depending on the market interest rate (ir).

$$S_k(ir) = S_{k0} \cdot (ir)^{\varepsilon_{Sk}} \tag{12}$$

ε_{Sk} is the interest rate elasticity of saving propensity.

f) Labor supply function

$$LS_k = LS_{k0} \left(\frac{w - t_L}{w_0 - t_{L0}} \right)^{\varepsilon L1_k} \left(\frac{CPI_k}{CPI_{K0}} \right)^{\varepsilon L2_k} \tag{13}$$

LS_k : labor supply, hereafter, suffix “0” means the initial level, $w - t_L$: rate of employee wage, w : rate of employer wage, t_L : social security contribution rate, CPI_k : index of household living cost, ε_{L1k} : wage elasticity of labor supply (positive), ε_{L2k} : living-cost elasticity of labor supply (negative).

g) Consumption expenditure (Y_k)

$$Y_k = R_k - TI_k - TOD_k - S_k \tag{14}$$

h) Consumption budget restriction

$$Y_k = \sum P_i^C \times C_{ik} \tag{15}$$

P_i^C: consumer price of the i-th good, C_{ik}: consumption of i-th good.

i) Consumption function for i-th good

$$C_{ik} = \frac{Y_k \left[\left(\frac{B_{ik}}{B_{1k}} \right)^{\mu_k} \cdot \left(\frac{P_i^C}{P_1^C} \right) \right]^{-\frac{1}{\mu_k + 1}}}{\sum_h P_h^C \left[\left(\frac{B_{hk}}{B_{1k}} \right)^{\mu_k} \cdot \left(\frac{P_h^C}{P_1^C} \right) \right]^{-\frac{1}{\mu_j + 1}}} \tag{16}$$

P_h^C : consumer price of the h-th good, B_{*k} : scale parameter

(4) The Government Account and Taxes

There are taxes in our model derived from "*the Annual Report on National Accounts*" and "*the Input-Output Table*". Their tax rates are computed in relation to the tax bases on our data set.

Table A3: The Government Revenue

Type of Taxes	*How they are derived from the SNA-Data*	*Revenue (million yen)*
social security contribution on labor (TL)	social security contribution of households (except for the lump-sum national pension contribution)	48,014,400
capital tax (TK)	corporate direct tax and penalties	18,155,600
product & consumption tax (TP)	indirect tax minus subvention for all sectors (in I-O table)	32,159,124
import tax (TM)	tariff, import consumption tax (in I-O table)	2,878,586
private income tax (TI)	income tax on private household income	28,480,400
other direct tax (TOD)	household's other direct taxes, contributions and penalties	3,624,054
government's asset income (GAI)	residual of government revenue minus tax revenue	17,058,406
Sum		150,370,570

a) Government revenue

$$GR = TL + TK + TP + TM + TI + TOD + GAI + ECOTAX \tag{17}$$

GR: government revenue. The revenue consists of 7 tax revenues and the government's asset income. Tax revenue consists of each tax rate and tax base. In C&E Tax scenarios, the $ECOTAX$ (carbon-energy tax) is added.

b) Government expenditure

$$GEX = GR - LST = CG + IG \tag{18}$$

The government expenditure is equal to the government revenue (GR) minus social security transfer (LST). The expenditure is divided into the government consumption (CG) and the government investment (IG) in fixed proportion. CG and IG are again allotted to each commodity in fixed proportion. It is assumed that this equation always holds and the government's budget is balanced.

c) Government's asset income

$$GAI = r \cdot K_G \tag{19}$$

K_G : government's capital holding

d) Carbon and energy tax payment

$$ECOTAX_{hj} = (tene \cdot cal_{hj} + tcoal \cdot col_{hj}) \cdot E_{hj} \cdot Burdr_j \qquad j = 1 \sim n+3+1 \tag{20}$$

$ECOTAX_{hj}$: the h-th energy commodity consumed in sector j (E_{hj}). The cal_{hj} is the energy intensity and col_{hj} is the carbon intensity. The tcoal and tene is the rate of carbon-energy tax, each on carbon or energy component of the energy commodity. $Burdr_j$ is the burden rate of the sector j (used in the Competitiveness scenario), e.g. 0.5 for energy intensive industries and 1.0 for other sectors.

(5) Wage, Price and Price Indices

a) w: rate of wage paid by employers; $w - t_L$: wage rate after tax and contribution

A reduction of labor cost enabled by the ECOTAX benefits both employer and employee, reducing w and increasing $w - t_L$ by the same rate

b) Numerair: Index of pre-ecotax price of all commodities

c) Pre-ecotax price of a domestic product i: $P_i^S + t_i^P$

P_i^S : producer price, t_i^P : excise tax (specific duty)

d) Demand price of j-th sector

$$P_{ij}^D = P_i^d + (tene \cdot cal_{hj} + tcoal \cdot col_{hj}) \cdot Burdr_j \tag{21}$$

P_i^d is price of domestic supply of i-th good including import (see (6) Foreign trade). The second term stands for the rate of the ecotax. This price is written P_i^C for final demand sectors.

e) GDP price index

$$P_{GDP} = \frac{\sum_i P_i^C \left(C_{ik} + CG_i + IG_i + IP_i + EX_i - IM_i \right)}{\sum_i \left(\sum_k C_{ik} + CG_i + IG_i + IP_i + EX_i - IM_i \right)} \tag{22}$$

P_{GDP}: GDP price index, i : commodity number, P_i^C : final demand price, C_{ik} : houshold consumption, CG_i : government consumption, IG_i : government investment, IP_i : private investment, EX_i : export, IM_i : import

f) Investment price index

$$P_I = \frac{\sum_i P_i^C \cdot IP_i}{\sum_i IP_i} \tag{23}$$

g) Index of household living cost: $$CIP_k = \frac{\sum_i P_i^C C_{ik}}{\sum_i C_{ik}} = \left[\sum_i \left(\frac{P_i^C}{B_{ik}} \right)^{\frac{\mu_k}{1+\mu_k}} \right]^{\frac{1+\mu_k}{\mu_k}} \quad (24)$$

h) Price index of material aggregate: $$P_{Mj} = \frac{\sum_i P_{ij}^D M_{ij}}{M_j} = \left[\sum_i \left(\frac{P_{ij}^D}{A_{ij}} \right)^{\frac{\rho_{Mj}}{1+\rho_{Mj}}} \right]^{\frac{1+\rho_{Mj}}{\rho_{Mj}}} \quad (25)$$

(6) Foreign Trade

This model doesn't explicitly include the foreign sector as an economic agent. Foreign trade is represented by the Armington function. From equation a) and b), the following equations are derived.

a) The Armington function

$$Sup_i = \left[(G1_i X_i^d)^{-\delta_i} + (G2_i IM_i)^{-\delta_i} \right]^{-\frac{1}{\delta_i}} \quad (26)$$

Sup_i : domestic supply (combined good of domestic and imported good), X_i^d : domestic production, IM_i : import, $G*_i$: scale parameters, δ_i : parameter related to the elasticity of substitution, P_i^d : price of domestic supplies, $P_i^S + t_i^P$: price of domestic products, $(1+t_i^m)P_i^F$: price of imported goods including import tax rate (t_i^m).

b) Hypothetical cost restriction

$$P_i^d Sup_i = (P_i^S + t_i^P) X_i^d + (1 + t_i^m) P_i^F IM_i \quad (27)$$

c) (Pre-ecotax) price of domestic supply

$$P_i^d = \left[\left(\frac{P_i^S + t_i^P}{G1_i} \right)^{\frac{\delta_i}{\delta_i+1}} + \left(\frac{(1+t_i^m)P_i^F}{G2_i} \right)^{\frac{\delta_i}{\delta_i+1}} \right]^{\frac{1+\delta_i}{\delta_i}} \quad (28)$$

d) Quantity function of domestic supply

$$Sup_i = X_i^d G1_i \left(\frac{P_i^S + t_i^P}{P_i^d G1_i} \right)^{\frac{1}{\delta_i+1}} \quad (29)$$

e) Quantity function of import

$$IM_i = \left[\frac{(1+t_i^m)P_i^F}{P_i^d G2_i} \right]^{-\frac{1}{1+\delta_i}} \frac{Sup_i}{G2_i} \quad (30)$$

The trade surplus is assumed to be constant, that is, the sum of export is calculated by the sum of import adding the surplus. This model has no exchange rate mechanism.

(7) Capital Dynamics

a) Investment function

$$IP_j = inv_{j0} \cdot X_j \left(1 + z(r_j - ir)\right)^{\eta_j} \tag{31}$$

inv_{j0} : initial investment rate (I_{j0}/X_{j0}), Xj: production, z : ad-hoc coefficient, rj : profit rate of sector j, ir : market interest rate, η_j : elasticity parameter. This equation means the investment of sector j depends on the production and net profit rate.

b) Sum of investment: $IPD = \sum IP_j$

c) Capital dynamics of sector j

$$K_{j,t+1} = K_{jt} + \left(IP_{jt}/PI_t - DEP_{jt}\right) \bullet \kappa \bullet \tau \tag{32}$$

K_{jt} : capital service, PI_t : investment price index, DEP_{jt} : depreciation, κ : parameter relating the capital service with capital stock (properly calibrated), τ : parameter related to the time interval.

d) Demand for a investment good: $IPD_i = sinv_i \cdot IPD$, $sinv_i$: share of i-th good in investment

(8) The Model Solving

Most parameters and tax rates are calibrated to the initial data set, but the elasticity parameters or some other parameters are set outside the model's framework (table A2). The parameter assumption may have influence on the result quantitatively, but according to a sensitivity analysis that is not shown in this paper, there is no critical qualitative difference concerning the double dividend possibility.

This model has 4 time periods with 5 year intervals (1995, 2000, 2005, 2010). In each period, prices, and the market interest rate are adjusted to clear all commodity markets and the financial market (market of investment and saving, without international capital flow). The rate of carbon-energy (C&E) tax is adjusted to meet the CO_2-emission restriction of each period. The revenue of carbon-energy tax is recycled in different ways according to scenarios, where the exact amount is spent by the government (scenario 2), transferred to the family (scenario 3), or used to reduce income tax rates (scenario 5) or social security contribution rates (scenario 4 and 6).

There is no adjustment in the labor market (pre-contribution wage is fixed), and the sectoral capital is fixed in the short-run. The labor supply grows autonomously and labor demand increases in accordance with economic growth. The investment decision for production sectors is also myopic, based only on the net profit rate of each period concerned. Sectors with a higher profit rate invest more, which leads to more capital stock and a lower profit rate in the next period. The parameter τ in equation 7-c (above) is set to 5.1, because the time interval is 5 years and annual growth rate of every sector is assumed to be about 1% (1.01^5 1.051). There is also improvement of energy efficiency in production sectors, which is represented by the autonomous increase of the scale parameter $A2_j$ in production function.

NOTES

1 See, Environment Agency (1996, 1997, 1998) or Ministry of Environment (2001).

2 It is based on a rigorous interpretation of the Kyoto-Protocol, according to which Japan has to reduce 6 different greenhouse gas emissions by 2008-2012 by 6% under the level of 1990. Because several mechanisms such as tradable emission permit, CDM, JI or sink (recognition of forestry absorption) are available, the goal will not be so hard.

3 Here, the labor income is gained only by formal work and (also involuntary) non-working time is regarded to be a part of leisure.

4 By and large, the higher the elasticity parameters, the bigger the revenue recycling effect (RE), which leads to a higher feasibility of strong double dividend.

5 This program is written in the VBA of the Microsoft Excel®. Data necessary for the calculations has been input in the spreadsheet.

6 For example by reduction of 5%, the highest quintile: 40%=>35% and the lowest: 10%=>5%. In model, five income groups have different tax rates, but each income group has single flat tax rate.

7 This is confined only to internationally competing non-energy sectors. The sector 5 (pulp, paper & wooden ware) is not energy intensive in the table 2. But the pulp industry is a typical energy intensive sector, and therefore the sector 5 is as a whole treated as energy intensive in this analysis.

8 In the same way as many previous studies, it is assumed here that the labor supply decreases when the general price level rises so that the IE is negative. However, it should be mentioned that this assumption is not necessarily supported by empirical studies (Goodstein 2003)

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日本における環境税制改革の二重の配当

（平成７年産業連関表に基づく応用一般均衡分析）

朴　　勝　俊

要　　約

本論文では，日本において環境税制改革が実施された場合に，いわゆる「二重の配当」が成立しうるかどうかを，応用一般均衡分析（CGE）を用いて検討する．ここでいう環境税制改革とは，温暖化対策のための税を導入するだけでなく，その税収を用いて経済に歪みを与えている既存の税を引き下げる政策である．本稿の CGE モデルは 1997 年の産業連関表に基づいた多部門モデルで，16 の生産部門，27 種の財（うち 14 種がエネルギー関係）を含むうえ，民間消費部門が所得階層別に５分割されており，分配効果を見ることもできる．これを用いて京都議定書の温室効果ガス削減目標（1990 年比６％削減）の達成に必要な炭素・エネルギー税率と，それが経済に及ぼす影響を推計する．結果としては，2010 年までに必要となる税率は炭素トンあたり 30000 円前後となるが，経済全体に与える影響は概して軽微である．しかも，税収が労働コストの引き下げのために活かされれば，経済にとっても若干プラスの影響（GDP ・雇用の増加）が生じるが，これには非自発的失業の仮定が重要な役割を果たしている．さらに，重工業部門に対する特別措置（炭素・エネルギー税率の半減）の効果を分析した結果，雇用と GDP への好ましい影響は拡大したが，他の産業部門や消費者にはさらに高い炭素・エネルギー税率が必要となる．分配効果に関しては，環境税制改革による物価上昇そのものは低所得層に不利であるが，税収還元も含めた政策全体が所得に与える影響はおおかた比例的であるとみられる．