Water Right Fee and Green Tax Reform
–A Computable General Equilibrium Analysis

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Abstract

This study uses a single-country water resources CGE model, WATERGEM, to investigate the double dividend effect of imposing water right fees. WATERGEM is developed based on ORANI model with a SAM data structure. The water resources considered in the model are tap water, surface water, and ground water. Water company is treated as a sector, surface water and ground water are treated as two primary inputs. The substitution among three water resources is also formulated.

The green tax reform is getting its popularity in the advanced countries. Due to the environmental concerns, more and more environmental taxes have been levied. The collected environmental tax revenue could be used to reduce the distorted taxes. This generates two effects, improvement in environmental quality and reduction in distortion, known as double dividends. The water right fee is usually collected under the user pays principle to increase the efficiency of water use. We consider it as an environmentally-based tax.

For policy simulation, we assume that the water right fee revenues could be earmarked, or used to deduce household income tax, corporate profit tax. The results of simulation show that the double dividend effect does exist, and the double dividend effect of deduction in corporate profit tax is higher than the others. In the meanwhile, the simulation results also show that water demand reduces when water right fee is imposed.

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1. Introduction

There has been a great concern about the environmental issues since the last few decades. Different policy instruments have been applied to correct economic inefficiencies caused by environmental externalities. Lately, more and more environmental taxes and fees such as carbon taxes, energy taxes, disposal fees etc., are imposed to internalize the externalities associated with production and consumption activities. In 1995, the environmentally related taxes accounted for between 3.8% and 11.2% of total tax revenue in OECD countries. These taxes count for between 1% and 4.5% of GDP. (Zhong and Majocchi, 1999)

It was initially believed that environmental taxes have a double dividend. According to the double-dividend hypothesis, the introduction in environmental taxes combined with revenue neutral reductions in existing distortionary taxes (such as income or factor taxes) can improve the quality of environment and reduce the existing tax distortions. This is known as revenue-neutral green tax reforms. Due to the persistent high unemployment rates, some advanced countries have started to conduct the green tax reforms. For example, in her 1991 tax reform, Sweden imposed several environmental taxes and reduced income taxes in a revenue-neutral fashion. Furthermore, Swedish government formed the Swedish Green Tax Commission in 1995 to provide an evaluation of a tax system with a stronger environmental profile. (Brannlund & Gren, 1999).

While the green tax reforms have been putting in practices, the existence of double dividends, on the other hand, is still puzzling the researchers. The double dividend effect is not so promising as previously thought. Bovenberg and de Mooij(1994), Bovenberg and van der Ploeg (1994), and Pearce (1991) suggest the shift of green taxes to distortionary taxes would reduce the inefficiency in the economy. Nordhaus (1993) concludes that the efficient use of green taxes has a substantial gain. Under the revenue-neutrality assumption, some authors (for example, Goulder (1995), Koskela and Schob (1999), Schob (1996)), conclude that the double dividend may not be the case if the existing tax system and the choice of tax rate cuts are considered.

The focus of current research on green tax reforms has been put in environmental taxes. In their work, Repetto et al. (Repetto et al., 1992) suggest that substituting green fees, such as charges on pollution, waste and congestion, for existing taxes could bring a cleaner environment and reduce economic disincentives of current taxes. The *green taxes* normally refer to the "polluter pays principle" type of taxes and fees. However, when the eco-system has become an increasing concern of the public, we believe that the green tax reforms should include not only "polluter pays principle" type of taxes/fees, but also include "user pays principle" type of taxes/fees. Therefore, in this study we investigate the double dividend effect of water right fee and its impact on improving water use efficiency.

Section 2 describes the water resources in Taiwan and associated issues. In section 3, we outline a single-country water resources general equilibrium model, WATERGEM, in which three water resources are formulated. Section 4 discusses the data structure, policy simulation design, and simulation results. Finally, we conclude in section 5 that the recycle of water right fee has a double dividend effect. In addition, the water right fee would also reduce the use of water in all sectors.

2. Water Resources in Taiwan

Like all of the other natural resources, water resources are very limited in Taiwan. Water is unevenly distributed in terms of season, region and user. Rainfall varies widely, from an annual average in excess of 2100mm in the north to less than 1800 mm in the south and 1500mm in the middle. In addition, it is difficult to retain water due to the mountainous terrain and steep slopes.

To solve the water-scarcity problems, the efforts had been put in increasing water supply by constructing infrastructure, such as dams and reservoirs, in the early stage. The rapidly economic and population growth has continuously increased pressures on water availability and on the water development potential. It becomes harder and harder to find new sites for dams and reservoirs. In the meanwhile, the changes in the value system and socio-economic goals push water management toward water conservation and efficiency use. In particular, water transfer/trading and water fees are two main mechanisms designed to improve the efficiency of water use.

Water transfer refers to the trade of the right to use water. It is a market mechanism in allocation and reallocation of water to enhance water use efficiency. Water transfer has been implemented in the areas with high water scarcities, and it has been proved to be an effective way in improving the efficiency of water use. However, it has difficulties being accepted by the society and law in Taiwan because the majority is still considering water as a common and public good instead of a tradable commodity. On the other hand, when water is recognized as a scare resource, the water fee is designed, based on the user pays principle, as an instrument for water rational use and conservation. Both of water transfer and water fees are believed to be useful mechanisms to encourage economically efficient water applications.

In Taiwan, while water transfer still is not accepted by the majority, water right fee is mandated by the water law. According to the Water Law, water users need to apply a water right for use of surface water and groundwater. Under the same law, water right fees should be levied, and the revenues are earmarked to secure the public funding for constructing infrastructure aimed at improving the water efficiency. Although water right fee is mandated by law, government is not able to collect the fee mainly due to the resistance from the water users, particularly the agricultural and industrial users. One of the main reasons to against the imposition of water right fees is that the water right fees would increase cost, and thus bring a negative impact on the economy. The imposition of water right fees would, no doubt, increases the economic cost on efficiency grounds. However, if the revenues of water right fees could be used to replace existing distortionary taxes and bring a double dividend effect, then it may increase welfare level of the economy and reduce the resistance of imposition of water right fees.

3. The Model – WATERGEM

A computable general equilibrium model, known as WATERGEM (water resources general equilibrium model), is constructed under the financial support of Water Resources Bureau in Taiwan. The purpose for constructing WATERGEM is to provide Taiwan water authority, Water Resources Bureau, an analytical instrument for evaluating the economic impact of various water policies. In order to utilize the analytical results for further policy implementation and water management, WATERGEM has also been linked to a geographic information system (GIS). Though it is an ongoing project, a single-country water resources CGE model (WATERGEM) and a multi-region water resources CGE model (MR-WATERGEM) have been established.

This study uses WATERGEM to evaluate the impact of imposition of water right fees and the revenue recycle effect. WATERGEM is a single-county CGE model adopted from the Australian ORANI model (Dixon, Parmenter, Sutton and Vincent, 1982). The structure of WATERGEM is discussed as follows:

3.1 Production Technology

We assume that each industry produces only one commodity. The production technology can be described by figure 1. The lower part of figure 1 represents the input-output relationship. It contains a four-level nested structure. At the first level of the lower part, we assume that there is no substitution between intermediate-input composites and the primary-factor composite. At the second level, we assume that intermediate inputs are a CES combination of domestically produced and imported inputs. However, the composite of primary factors (including labor, capital and land) and water resources composite are combined by a CES specification. At the third level, we assume that primary factory input is a CES composition of labor, capital and land, and water resources is a CES composition of surface and ground water. At the last level, the labor composite is a CES aggregation of O types of labor, including managers, professional specialists, white-collar workers, skilled workers and unskilled workers.

The top part of figure 1 shows the specification of industries' transformation frontiers. It consists two levels with standard ORANI assumptions and specifications.

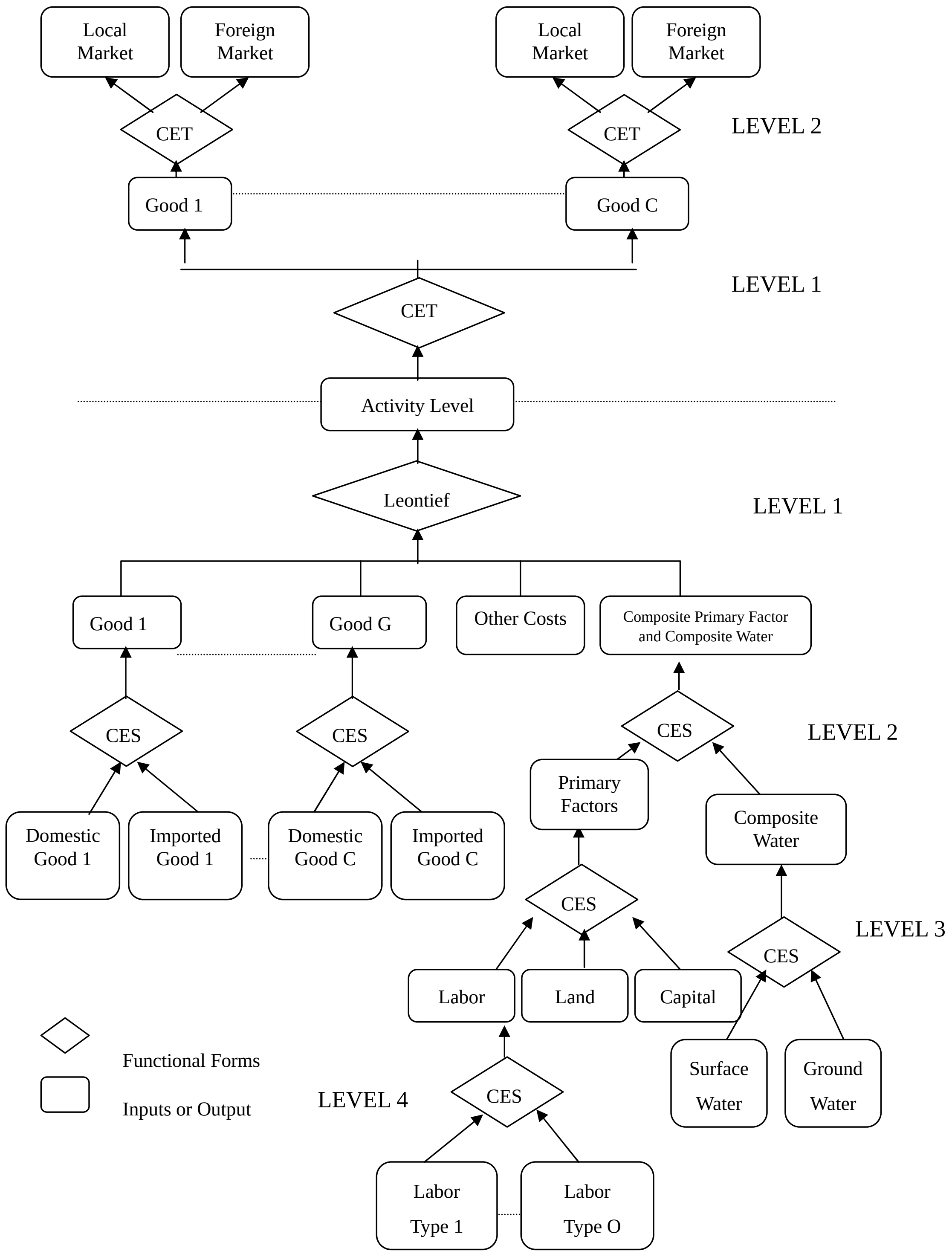

Figure 1. Production Technology of WATERGEM

2.2 Water Resources

We consider three types of water resources, i.e., surface water, ground water and public water. Due to a low substitutability between composite water (including surface water and ground water) and other primary factors, we separate composite water from the other primary factors. Surface and ground water are combined by a CES specification into composite water. The public water provider, water company, is treated as a sector. The demand for and the prices of surface and ground water are specified as follows:

$$x1wat_{i,w} = x1wat\_i_w - \sigma_i (p1wat_{i,w} - p1wat\_i_w)$$

$$p1wat\_i_w * VWPUR\_I_w = \sum_i VWPUR_{i,w} * p1wat_{i,w}$$

where *i* and *w* represents industry and water type respectively, xlwat and p1wat are quantity demanded and prices of water resources respectively, x1wat_i and plwat_i are water quantity demanded and prices of water by industry, σ is the elasticity of substitution of surface water and ground water, VWPUR is industry input demand for water resources in value term.

Though water company is treated as a separated sector, we take the substitution of public water and composite water into account, and formulate the substitution relationship as below:

$$x1wat\_w_i = x1prim_i - \sigma_i^1 (p1wat\_w_i - p1prim_i) - \sigma_i^2 (p1wat\_w_i - p1wat\_t_i)$$

$$x1\_s_i("Public\ Water") = x1tot_i - \sigma_i^2 (p1\_s_i("Public\ Water") - p1wat\_t_i)$$

$$\begin{aligned} & p1wat\_t_i * (V1PUR_i("Public\ Water") + V1WAT\_W_i) = \\ & \quad V1PUR_i("Public\ Water") * p1\_s_i("Public\ Water") + V1WAT\_W_i * p1wat\_w_i \end{aligned}$$

where x1wat_w is the sum of surface and ground water, p1wat_w is the price of composite water, x1_s(“Public Water”) and p1_s(“Public Water”) are the quantity demanded and price of public water respectively, x1prim and p1prim are the quantity demanded and price of composite primary factors respectively, p1wat_t is the weighted price of public water and composite water, V1PUR("Public Water") is industrial input demand for public water, and V1WAT_W is industrial input demand for composite water.

Water right fees are imposed in a specific tax manner. Consequently, the imposition of water right fees increases the price of industrial water use.

2.3 Final Demand

Household consumption demand is specified by a simplified version of the linear expenditure system. The linear expenditure demand function is derived from maximization of a Klein-Rubin utility function subject to houshold's budget constraint. Industrial demand for fixed capital is assumed to be created according to the Leontief production function. The goal of government, based on the median voter model, is to provide the amount of government services preferred by the median voter at the least cost, given the tax revenues. The taxes considered in the model include household income taxes, corporate profit taxes, commodity taxes, water right fees, and various transfers. We assume Taiwan is a small open economy, and apply the Armington assumption on the import demand.

4. Data and Policy Simulation

The database of WATERGEM is complied from 1994 Taiwan's Input-Output tables and relating data. The industries are aggregated into 24 sectors (see table 2). The manufacturing sectors' use of surface and ground water is collected and estimated by a survey (Chou et al., 1999). The optimal water right fees are adopted from a study by Huang(1997). According to Huang's study, water right fees are suggested to be levied by water type and by industry. Water right fee for ground water is higher than for surface water because the use of ground water tends to have higher environmental costs.

In order to evaluate the green tax reforms by imposing water right fees, the data structure of WATERGEM has been changed into a SAM database instead of an

ORANI. The current tax structure of Taiwan economy is represented in the SAM table, and taxes include household income taxes, corporate profit taxes, tariffs, commodity taxes, water right fees and various transfers between public and private sectors. The data structure of WATERGEM can be described by figure 2.

In figure 2, household income is generated by providing primary factors and receiving transfers from government or industrial sectors. Household is obligated to pay income taxes, water right fees and receive transfers. On the other hand, industry is obligated to pay corporate profit taxes, commodity taxes, water right fees and pay or receive transfers. Government generates revenues from collecting taxes and transfers. The incomes of institutions in excess of expenditures are saved.

4.1 Policy Simulation Scenarioes

In order to evaluate the double dividend effect of green tax reforms by imposing water right fees, we assume revenue neutrality, and the collected water right fees could be used (1) to earmark funding for construction of water infrastructure (refers to as simulation 1); (2) to reduce corporate profit taxes (refers to as simulation 2); (3) to replace household income taxes (refers to as simulation 3); and (4) a half to refund corporate profit taxes and a half to refund household income taxes (refers to as simulation 1).

Based on the double dividend hypothesis, the second dividend is the cost reduction obtained by using the green tax revenues to cut an ordinary, distortionary taxes. This is the reason that we choose household income taxes and corporate taxes as the targets for tax recycling. Besides, according to the Water Law in Taiwan, the revenues from water right fees are supposed to provide funds for water infrastructure construction. Therefore, we also include the earmarking in the policy simulation for a complete evaluation and comparison.

4.2 Closure

Closure is the mechanism to solve the problem of over-identification of the model. In this model we use Keynesian closure to set money wage and capital as

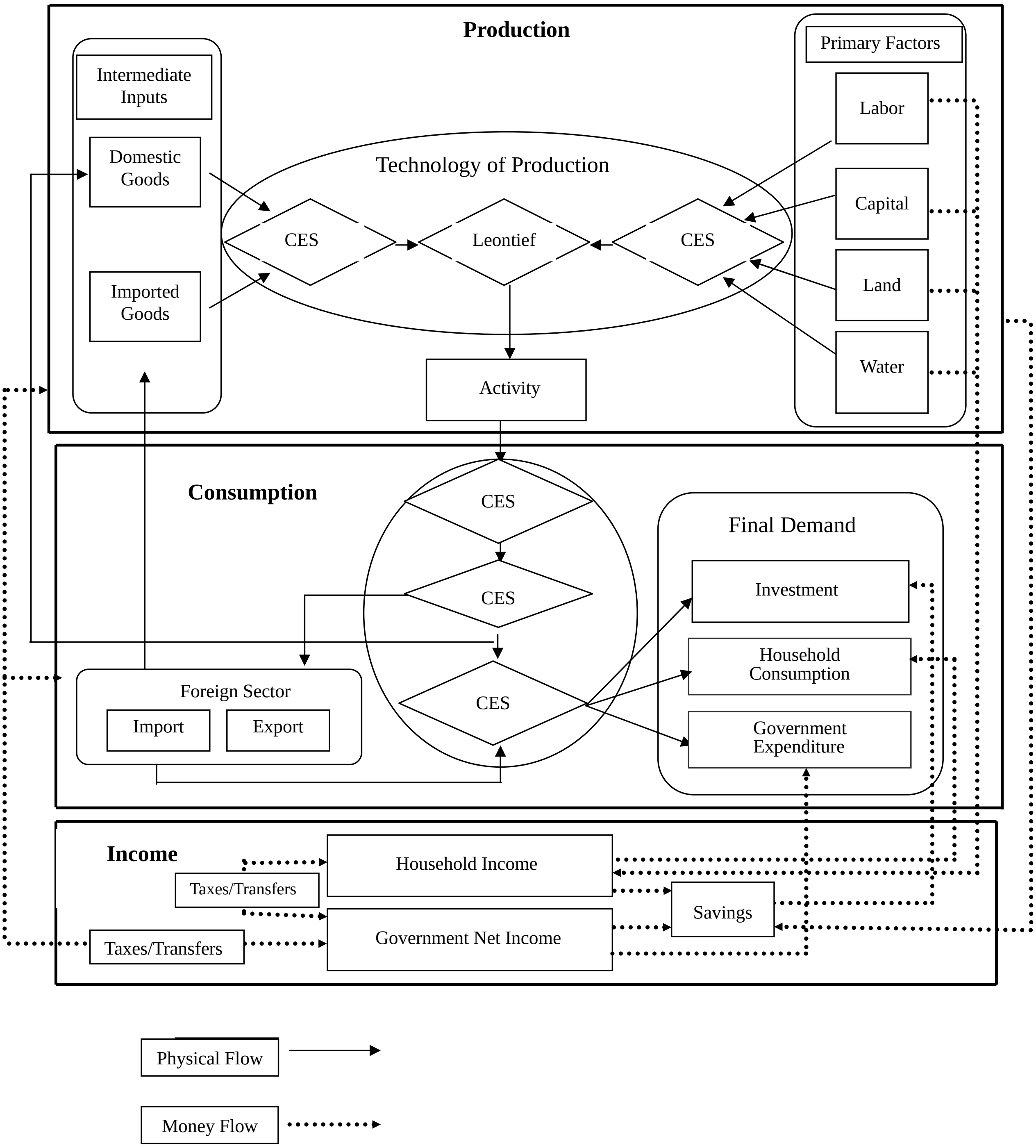

Figure 2. Data Structure of WATERGEM

exogenous variables due to the short-run nature of the green tax reforms . That is the labor employment and the rate of capital return are set endogeneously. In addition, the prices of composite water and imported commodities, exchange rate, tariff rates, water right fees are set to be exogenous variables.

4.3 Simulation Results

The simulation results are presented in Tables 1 through 3. From table 1, we can find that the real GDP is reduced in simulations 1 and 3, but real GDP increases in simulations 3 and 4. Similar patterns can be detected in variables of total output and employment. From the results, we can conclude that the replacement of green taxes for different distortionary taxes has different impacts. In other words, the replacement of green taxes for corporate profit taxes has higher positive impacts on major macro variables than the other simulations. Earmarking as the current water law regulated has the least effect on the macro variables. To be more specific, we do find the second dividend of green tax reforms on employment.

Table 2 gives the simulation results of green tax reforms on each single sector. The double dividend of green tax reforms is not so conclusive as the macro results, if we look into the individual sector. Some sectors have negative impacts on employment, while the others have positive impacts. Thus we may conclude that the second dividend may be affected by not only the existing tax structure, but also by the industrial characteristics.

The first dividend of green tax reforms, i.e., reducing the use of water, or increasing water use efficiency, is presented in Table 3. For ground water, the withdrawal reduces in almost every industry. However, for surface water, the impact is not conclusive due to the various water right fees and the substitutability between surface water and ground water.

5. Conclusions

In this study, we use a single-country water resources CGE model to investigate double dividend effect of green tax reforms by imposing water right fees. Under tax revenue neutrality assumption, we found that green tax reforms have a double dividend effect. However, the magnitude of the effect depends on not only the existing tax structure, but also the structure of industry. In the meanwhile, the simulation results also show that the water demand reduces as the water right fees are collected.

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Table 1 Macro Economic Impacts of Green Tax Reforms
(percentage change)

Macro Variables	Sim 1	Sim 2	Sim 3	Sim 4
Nominal GDP	0.026	0.150	0.106	0.128
Real GDP	-0.047	0.012	-0.013	0.000
GDP Deflator	0.073	0.138	0.119	0.128
Total Output	-0.046	0.013	-0.011	0.001
Investment	0.395	0.320	-0.034	0.142
Household Consumption	-0.098	0.063	0.099	0.081
Import	0.133	0.136	0.060	0.098
Export	-0.064	-0.103	-0.089	-0.096
Employment	-0.068	0.025	-0.014	0.005

Table 2 The Impact of Green Tax Reforms by industry (percentage change)

Sector No	Sector	Employment				Total Output Volume				Investment			
		Simu. 1	Simu. 2	Simu 3	Simu 4	Simu. 1	Simu. 2	Simu 3	Simu 4	Simu. 1	Simu. 2	Simu 3	Simu 4
1	Paddy Rice	-0.25	-0.15	-0.12	-0.13	-0.30	-0.21	-0.18	-0.20	-0.39	0.07	-0.20	-0.06
2	Other Cereal	-0.29	-0.25	-0.24	-0.25	-0.24	-0.21	-0.20	-0.21	-0.48	-0.12	-0.42	-0.27
3	Livestock	-0.67	-0.42	-0.38	-0.40	-0.27	-0.16	-0.15	-0.16	-1.03	-0.35	-0.62	-0.48
4	Forestry	-0.02	0.00	-0.03	-0.01	-0.01	0.00	-0.02	-0.01	-0.05	0.33	-0.09	0.12
5	Fishery	-2.46	-2.31	-2.27	-2.29	-1.34	-1.26	-1.24	-1.25	-3.71	-3.17	-3.45	-3.31
6	Mineral	-0.12	-0.06	-0.13	-0.09	-0.08	-0.04	-0.09	-0.06	-0.24	0.21	-0.26	-0.02
7	Processing Food	-0.42	-0.29	-0.26	-0.28	-0.28	-0.19	-0.17	-0.18	-0.66	-0.14	-0.41	-0.27
8	Textile	-0.04	-0.03	-0.03	-0.03	-0.03	-0.02	-0.02	-0.02	-0.08	0.27	-0.06	0.11
9	Leather	-0.08	-0.02	-0.01	-0.01	-0.06	-0.02	-0.01	-0.01	-0.14	0.29	-0.02	0.13
10	Wood, Bamboo and Rattan Products	-0.02	0.05	0.00	0.02	-0.02	0.04	0.00	0.02	-0.05	0.39	-0.02	0.18
11	Pulp, Paper and Paper Products	-0.09	-0.03	-0.03	-0.03	-0.07	-0.02	-0.03	-0.02	-0.15	0.27	-0.07	0.10
12	Chemical Materials	-0.06	-0.07	-0.08	-0.07	-0.03	-0.03	-0.03	-0.03	-0.11	0.19	-0.13	0.03
13	Chemical Products	-0.06	-0.02	-0.04	-0.03	-0.04	-0.01	-0.03	-0.02	-0.11	0.28	-0.08	0.10
14	Non-Metalic Products	-0.06	0.25	-0.06	0.09	-0.03	0.14	-0.04	0.05	-0.11	0.71	-0.11	0.30
15	Iron, Steel and Aluminum	0.02	0.05	-0.07	-0.01	0.01	0.02	-0.04	-0.01	0.00	0.40	-0.12	0.14
16	Metallic Products	-0.01	0.03	-0.03	0.00	-0.01	0.02	-0.02	0.00	-0.03	0.36	-0.06	0.15
17	Machinery	0.31	0.08	-0.08	0.00	0.23	0.06	-0.06	0.00	0.45	0.45	-0.13	0.16
18	Electronic Products	-0.01	0.02	-0.02	0.00	-0.01	0.01	-0.01	0.00	-0.03	0.35	-0.05	0.15
19	Transport Equipment	0.00	0.05	0.01	0.03	0.00	0.03	0.00	0.02	-0.01	0.40	0.00	0.20
20	Precision Instruments and Other Manufactures	0.12	-0.01	-0.02	-0.02	0.09	-0.01	-0.02	-0.01	0.17	0.30	-0.05	0.12
21	Electricity	-0.12	0.07	0.04	0.05	-0.04	0.02	0.01	0.02	-0.20	0.40	0.04	0.22
22	Water	0.00	0.15	0.16	0.15	-0.06	0.04	0.04	0.04	-0.01	0.52	0.22	0.37
23	Construction	-0.02	0.37	0.01	0.19	-0.01	0.29	0.01	0.15	23.81	0.89	0.00	0.44
24	Service	-0.06	0.03	0.03	0.03	-0.04	0.02	0.02	0.02	-0.09	0.35	0.03	0.19

Table 3 The Impact on Water Use by Industry (million tons)

Sector no.	sector	Simulation 1		Simulation 2		Simulation 3		Simulation 4	
		Surface Water	Ground Water	Surface Water	Ground Water	Surface Water	Ground Water	Surface Water	Ground Water
1	Paddy Rice	12.85	-60.21	17.32	-58.27	19.00	-57.84	18.44	-58.05
2	Other Cereal	3.54	-19.20	4.07	-19.00	4.25	-19.00	4.25	-19.00
3	Livestock	-5.45	-7.04	-5.38	-6.97	-5.36	-6.96	-5.37	-6.96
4	Forestry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Fishery	-17.30	-68.26	-16.04	-67.01	-15.89	-66.69	-15.89	-66.85
6	Mineral	-1.92	-3.43	-1.91	-3.42	-1.92	-3.43	-1.92	-3.42
7	Processing Food	-0.35	-15.69	-0.35	-15.60	-0.35	-15.58	-0.35	-15.59
8	Textile	-0.16	-9.97	-0.16	-9.97	-0.16	-9.97	-0.16	-9.97
9	Leather	0.00	-2.14	0.00	-2.13	0.00	-2.13	0.00	-2.13
10	Wood, Bamboo and Rattan Products	0.00	-1.37	0.00	-1.37	0.00	-1.37	0.00	-1.37
11	Pulp, Paper and Paper Products	-1.40	-12.19	-1.39	-12.14	-1.39	-12.15	-1.39	-12.14
12	Chemical Materials	-6.95	-6.45	-6.95	-6.45	-6.95	-6.45	-6.95	-6.45
13	Chemical Products	-8.69	-20.91	-8.66	-20.86	-8.67	-20.90	-8.66	-20.88
14	Non-Metallic Products	-0.16	-3.73	-0.16	-3.69	-0.16	-3.73	-0.16	-3.71
15	Iron, Steel and Aluminum	-0.03	-11.25	-0.03	-11.24	-0.03	-11.27	-0.03	-11.25
16	Metallic Products	-0.05	-2.79	-0.05	-2.78	-0.05	-2.79	-0.05	-2.78
17	Machinery	-0.05	-11.37	-0.05	-11.52	-0.05	-11.62	-0.05	-11.57
18	Electronic Products	-35.65	-13.39	-35.60	-13.37	-35.65	-13.39	-35.63	-13.38
19	Transport Equipment	-0.39	-8.09	-0.39	-8.07	-0.39	-8.09	-0.39	-8.08
20	Precision Instruments and Other Manufactures	-0.06	-0.17	-0.06	-0.17	-0.06	-0.17	-0.06	-0.17
21	Electricity	-5.91	0.00	3.94	0.00	3.94	0.00	3.94	0.00
22	Water	-171.62	-64.11	-169.23	-63.36	-169.23	-63.36	-169.23	-63.36
23	Construction	-1.26	-3.40	-1.24	-3.36	-1.26	-3.39	-1.25	-3.38
24	Service	-1.39	-0.23	-1.36	-0.23	-1.36	-0.23	-1.36	-0.23
	TOTAL USAGE	-242.42	-345.41	-223.68	-340.97	-221.74	-340.49	-222.26	-340.72