Is a Double Dividend Better than a Single Dividend?

by

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It has been argued that the revenue-raising (RR) environmental policies are more efficient than the non-revenue-raising (NRR) policies because of the revenue-recycling effect. When the goal of the environmental protection is subject to the influence of interest groups, we find that the NRR policies may be more efficient than the RR policies. By endogenizing the goal of environmental protection, although the RR policies can exploit the revenue-recycling effect, they may result in a greater amount of pollution emission than the NRR policies, and thus give rise to a lower level of social welfare. (JEL: D 72, Q 52, Q 58)

1 Introduction

The superiority of the revenue-raising (RR) policy instruments in terms of efficiency has been suggested by several studies (see, e.g., GOULDER, PARRY, AND BURTRAW [1997], PARRY [1997], PARRY, WILLIAMS III, AND GOULDER [1999], FULLERTON AND METCALF [2001]). The RR instruments, including emission taxes or auctioned emission permits, can generate proceeds, which can be used to decrease other distortionary taxes. This has been referred to as the revenue-recycling effect. Thus, the RR instruments give rise to two dividends: one is the benefit from environmental protection (the green dividend), and the other is the nonenvironmental benefit associated with recycling tax revenues (the nonenvironmental dividend). On the other hand, the non-revenue-raising (NRR) instruments, such as emission quotas or grandfathered tradable permits, produce only the green dividend. Therefore, the previous papers argue that the NRR instruments are less efficient than the RR instruments.

The above argument is based on the condition that the two types of policies achieve the same degree of environmental protection; in other words, they have the same magnitude as the green dividend. The additional benefit arising from exploiting the revenue-recycling effect leads to the superiority of the RR instruments. However,

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in practice the different types of policy instruments may not achieve the same goal as the environmental regulation, especially when the stringency of environmental regulation is subject to the influence of interest groups.[1]

The influence of interest groups on the formation of environmental policy has been widely recognized.[2] In the presence of lobbying, the magnitude of the green dividend becomes an endogenous variable, and depends on the types of policy instruments. We will show that the NRR policy may result in a smaller amount of pollution emission than the RR policy. If the green dividend of the NRR policy is sufficiently large, then the NRR policy will give rise to a higher level of social welfare than the RR policy, even though the latter can generate two dividends. The purpose of this paper is to demonstrate that, in the presence of political distortion, there may arise a trade-off between the environmental benefit and the nonenvironmental benefit from exploiting the revenue-recycling effect as an RR policy is introduced. With such a trade-off, the superiority of the RR policies becomes disputed.

A number of papers develop the positive theory of government regulation when the policymakers are subject to the influence of interest groups. STIGLER [1971] emphasizes the ability of the regulated groups to use the regulatory process to transfer income from other groups to themselves. PELTZMAN [1976] generalizes the model of STIGLER [1971], and stresses the trade-off between the social welfare and the regulated group's political support faced by the regulator in the final vote-maximizing equilibrium. A shortcoming of these two papers is the failure to portray the competition among interest groups. BECKER [1983] fills this gap, but he ignores the interaction between the regulator and the regulated parties. Here we construct a common-agency lobbying model, in which the policymaking is subject to the influence of polluting industries. The common-agency model adopted here is able to overcome the shortcomings of the previous papers.[3] By offering political contributions to the government, the interest groups attempt to affect the rate of an emission tax, which in turn determines the stringency of the environmental regulation. The emission tax revenues can be rebated to the polluting industries or distributed to the general public. We will show that the magnitude of the environmental dividend is closely related to the way the proceeds are distributed. This issue has been overlooked by most of the previous papers.

The revenue-recycling effect plays an important role in our analysis. In order to capture the essence of this effect, we assume that the tax revenues distributed to the general public will generate a higher level of social welfare than those rebated to the polluting industries. Although we consider an emission tax, this tax can be an RR instrument, an NRR instrument, or a hybrid instrument, depending on the fraction of tax revenues rebated to the industries. If this fraction equals zero, then the emission tax is a typical RR instrument, which will fully exploit the revenue-

[1] See the examples proposed by STAVINS [1998].

[2] See, e.g., ACKERMAN AND HASSLER [1981] and CROPPER et al. [1992].

[3] Another difference between this present paper and the literature mentioned above is that we deal with a normative issue, whereas the major concern of those papers is a positive issue.

recycling effect. If this fraction equals one, then the emission tax along with the full refund is equivalent to an NRR instrument, and the welfare gain from recycling tax revenues cannot be reaped. We should note that, as emphasized by GOULDER, PARRY, AND BURTRAW [1997] , the distinguishing criterion between the RR policy and the NRR policy is whether the revenue-recycling effect is exploited, and not simply whether revenues are raised. The tax will be a hybrid instrument, provided that the fraction is between zero and one.[4] This setting allows us to compare all policies in a single model.

We show that lobbying will deviate the actual emission tax away from the optimal level that would maximize the social welfare. We address the following question: On taking the policy distortion arising from the interest groups into consideration, what type of policy instrument will give rise to the highest level of social welfare? It should be noted that we are not going to address the question of how the type of policy instrument is actually selected, which is a positive issue. Instead, we are dealing with the type of policy instrument that will maximize the social welfare, which is a normative issue. More precisely, this paper is a second-best analysis, just like GOULDER, PARRY, AND BURTRAW [1997], PARRY [1997], and FULLERTON AND METCALF [2001]. However, the distortion in those papers arises from preexisting distorting taxes, whereas the distortion in our model comes from political influence.

Within the setting mentioned above, we find that the RR instruments are not necessarily more efficient than the NRR instruments. The reason for this is that the industrial groups may lobby for a larger amount of pollution emission under the RR instruments than under the NRR instruments; i.e., the NRR instruments may give rise to a larger environmental dividend. Thus, given the political distortion, the policy instrument that maximizes the social welfare has to balance the nonenvironmental dividend from exploiting the revenue-recycling effect and the environmental dividend. Although the RR instruments can generate both the green dividend and the nonenvironmental dividend, there may arise a conflict between these two dividends. If the extra environmental benefit from adopting the NRR instruments is sufficiently large, then the RR instruments will be inferior to the NRR instruments in efficiency, even if the latter generate only the green dividend.

The findings are related to the double-dividend hypothesis. GOULDER [1995] distinguishes between the strong and the weak form of the double dividend. The results of BOVENBERG AND DE MOOIJ [1994] and other studies tend to reject the strong double dividend.[5] The weak double-dividend hypothesis has been viewed as relatively uncontroversial. The weak double dividend argues that it is always preferable to return environmental tax revenues by reducing a distortionary tax rather

[4] The fraction of tax revenues rebated to industries is also related to the distribution of the scarcity rents due to the environmental regulation. Under the RR instruments, the general public possesses the rents, and under the NRR instruments, the industries possess them.

[5] The concept of the strong double dividend implies that the gross efficiency costs are negative when environmental taxes are substituted for distortionary taxes.

than by returning them in a lump-sum fashion. According to BOVENBERG [1999, p. 421], a corollary of the weak form is that "environmental taxes are more efficient instruments for environmental protection than environmental policy instruments that do not yield any revenues." However, we find that the RR instruments are not always more efficient than the NRR instruments. As a result, if the political distortion is taken into consideration, then the weak double-dividend hypothesis may fail.[6]

A number of papers have discussed the problem of instrument selection from the perspective of political economy, including BUCHANAN AND TULLOCK [1975], MALONEY AND MCCORMICK [1982], DEWEES [1983], HAHN [1990], DIJKSTRA [1998], DAMANIA [1999], and AIDT AND DUTTA [2004]. Those papers belong to the realm of positive analysis; the effect of the selection of instruments on the social welfare is not their major concern. Instead, as noted above, the present paper investigates a normative issue: What is the second-best policy instrument that will maximize the social welfare in the presence of political distortion?

This paper is related to FREDRIKSSON AND STERNER [2005], who explore the properties of an emission tax under a refunded emissions program. They examine the effect of the fraction of rebated tax revenues on the emission tax and the total pollution. They find that firms with relatively low pollution intensity may lobby for a higher emission tax rate, and that an increase in the share of tax revenues returned to the polluting firms will raise the emission tax rate and reduce the pollution emissions. The present paper departs from FREDRIKSSON AND STERNER [2005] in that they do not consider the impact of changing the share of rebated tax revenues on the social welfare, which is the focus of the present paper. They assume that the share of tax revenues returned to the polluting firms is an exogenous parameter, whereas this present paper allows for an endogenous refunding share, and thus represents an extension of their model.

Another related paper is LAI [2007a], who finds that in the presence of the influence of interest groups, grandfathered tradable permits may be more efficient than auctioned permits. LAI [2007a] confines his analysis to the tradable emission permit program, and ignores the issues of the double dividend. In addition to extending our analysis to a more general setting, we also place emphasis on the weak double-dividend hypothesis.

The remainder of this paper proceeds as follows. In section 2, we introduce the model underlying our analysis. In section 3, we present the objective functions of the government and the interest groups. The determination of the equilibrium emission tax is also discussed. In section 4, we examine the second-best policy instrument in the presence of political distortion. Section 5 consists of discussions on the weak double dividend and on the situation where green lobbying is introduced. In section 6, we present our concluding remarks.

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6 PROOST AND VAN REGEMORTER [1995] show that when the equity dimension is involved, the weak double-dividend hypothesis can fail. However, interest groups do not play any role in their model.

2 The Model

Consider a small open economy, which contains I polluting industries.[7] We assume that the firms in a polluting industry are homogeneous, so that the number of the firms in the industry can be normalized as one.[8]

The markets of the products are perfectly competitive, and the products can be freely imported from other jurisdictions. The reason why we make this assumption is to rule out the market power of industries. It is well known that the presence of the market power of industries leads to a second-best emission tax that is below the Pigouvian tax (BAUMOL AND OATES [1988, ch. 6]). Assuming away the industries' market power helps us to concentrate on the scarcity rents due to environmental regulations. For simplicity, the prices of the products are normalized as one. In order to produce outputs, all of the industries employ a variable input, x, and a sector-specific input. The use of x will generate pollutants. By appropriately choosing the unit of pollutant, each unit of x used gives rise to one unit of pollutant.

A representative firm in industry i solves the following problem:

$$\max_{x_i, a_i} \Pi_i = f_i(x_i) - w x_i - A_i(a_i) - t(x_i - a_i) + r_i \,, \tag{1}$$

where $f_i(x_i)$ is the production function, with the properties $\partial f_i/\partial x_i > 0$ and $\partial^2 f_i/\partial x_i^2 < 0$, and w is the price of purchasing x, which is exogenously given. The abatement technology is feasible, and the abatement amount is denoted by a_i. The net pollutant emitted is denoted by e_i, which equals $x_i - a_i$. The abatement cost function, $A_i(a_i)$, is a strictly convex function of a_i, with the properties $\partial A_i/\partial a_i > 0$ and $\partial^2 A_i/\partial a_i^2 > 0$. The variable r_i stands for the rebated emission taxes. When making production decisions, firms regard r as given.

To control pollution damage, the government will impose a regulation on the emissions. Although (1) shows the case where the government adopts an emission tax at rate t, it can be interpreted more broadly than it would at first appear. As indicated by PEZZEY [1992], there is a full symmetry between the price-control instruments and the quantity-control instruments with respect to efficiency and political acceptability, provided that both instruments embody the same property-right sharing regarding the scarcity rents due to the regulation between the polluting firms and the general public.[9] Thus, given the same property-right sharing, a price-control instrument can represent a quantity-control instrument because of the symmetry.[10]

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[7] Alternatively, we can consider that in this small open economy there is one industry, which contains I firms.

[8] Assuming that all firms are identical will rule out the distributional effect within an industry, which has been studied by FREDRIKSSON AND STERNER [2005].

[9] PEZZEY [1992] points out that the symmetry may be ruined by some factors, including uncertainty and monitoring and enforcement costs. In what follows, we will assume away these factors.

[10] Also see GOULDER, PARRY, AND BURTRAW [1997]. They represent a nonauctioned quota by a virtual tax, which produces scarcity rents retained by the polluting firms.

In this paper, the property-right sharing regarding the scarcity rents is represented by the fraction of tax revenues rebated to the polluting industries. We will return to this issue in more depth in section 3.

Given the emission tax rate and the refunded tax revenues, the firm will choose x and a to satisfy the following conditions:

$$\partial f_i(x_i)/\partial x_i - w - t = 0\,, \tag{2}$$

$$\partial A_i(a_i)/\partial a_i - t = 0\,. \tag{3}$$

Equation (2) states that the equilibrium level of the dirty input will equate the value of its marginal product with the gross marginal cost. From (3), at the equilibrium level of abatement, the marginal abatement cost should be equal to the emission tax rate. From these two equations we can derive the effects of changing t on x_i and a_i as follows:

$$\frac{\partial x_i}{\partial t} = \frac{1}{\partial^2 f_i/\partial x_i^2} < 0\,, \tag{4}$$

$$\frac{\partial a_i}{\partial t} = \frac{1}{\partial^2 A_i/\partial a_i^2} > 0\,. \tag{5}$$

As expected, an increase in t will reduce the firm's demand for x and increase its pollution abatement. Since the firm's net emissions, e_i, equal $x_i - a_i$, by combining (4) with (5) we obtain $\partial e_i/\partial t = \partial x_i/\partial t - \partial a_i/\partial t < 0$; or, in words, the net pollution emissions decrease as t increases.

In addition to the owners of firms or industrialists, the economy under consideration also contains another two types of residents: environmentalists and consumers. We assume that the same types of residents are identical. There are n_g environmentalists, where the subscript refers to "greens." The utility function of a representative environmentalist is given by

$$u_g = y_g + \gamma s - d(E)\,, \tag{6}$$

where y stands for the income of the environmentalist, which is assumed to be exogenously given.[11] The variable s stands for the transfer or tax relief from the government, which is financed by the emission tax revenues.

The marginal utility from a dollar of transfer payments is denoted by γ, and is greater than one.[12] Since the specification of the industrialists' utility function implicitly assumes that their marginal utility from the rebated tax revenues equals one, this specification characterizes the situation in which the emission tax revenues distributed to the general public are more desirable than those rebated to the polluting industries. That the marginal utility γ is greater than one can be attributed to the transfer payments received by the environmentalists being used to cut preexisting distortionary taxes, which we do not explicitly specify in this model, and to the fact

[11] Environmentalists can work in competitive industries that do not emit pollution, or they can receive income from capital or other wealth, so that their income is independent of the environmental regulation.

[12] Similar specifications can be found in GRUENSPECHT [1988] and NEARY [1994].

that the gross welfare cost arising from the distortionary taxes is greater than one.[13] According to this interpretation, γ represents the marginal cost of public funds, and $\gamma - 1$ reflects the marginal excess burden of the distortionary taxes. Alternatively, we can attribute $\gamma > 1$ to the environmentalists having lower income, so that they derive a higher marginal utility from the transfer payment. For the purpose of exposition, we will adopt the former interpretation in what follows. Although this specification is simple, we believe that it can capture the essence of the revenue-recycling effect.

Much of the literature related to the double-dividend hypothesis focuses on the strong form. These papers demonstrate that the strong form fails due to the tax-interaction effect, which states that existing distortionary taxes may interact with the environmental regulation and thereby enlarge the welfare costs. Our focus is different; we place a special emphasis on the weak double-dividend hypothesis, which is closely related to the presence or the absence of the revenue-recycling effect. Since the tax-interaction effect is not the key element in the weak double-dividend hypothesis, we do not consider this effect here.

The disutility arising from pollution is denoted by $d(E)$, with the properties $d' > 0$ and $d'' > 0$. The variable E denotes the total emissions, which equal $\sum_{i=1}^{I} e_i$. Although industries are heterogeneous, we assume that their pollution emissions are homogeneous (e.g., CO_2), so the aggregate emissions equal the sum total of all industries' emissions.

There are n_c consumers. The utility function of a representative consumer is given by[14]

$$u_c = y_c + \gamma s \,, \tag{7}$$

where y_c stands for the income of the consumer, which is exogenously given. The rest of the notation is the same as in the case of the environmentalists.

3 *The Equilibrium Emission Tax*

The previous section reveals that the profit of the polluting industries is closely related to the environmental regulation, and thus these industries have incentives to affect the formation of environmental regulation. The owners of the firms (industrialists) are assumed to organize themselves into separate groups that coordinate offers of political contributions to the government. We assume for the time being that the environmentalists do not engage in lobbying. Green lobbying will be introduced in section 5. We assume that the consumers constitute a large part of the total population and are thus too numerous to overcome the free-rider problem and organize themselves into a lobbying group.

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13 BALLARD, SHOVEN, AND WHALLEY [1985] suggest a gross welfare cost in the range of 1.17 to 1.56 per dollar of tax revenue raised.

14 Note that the consumers do not suffer from pollution. This assumption is mainly for simplicity. Relaxing this assumption to allow them to suffer from pollution will not change the results that follow, provided that the consumers remain inactive in the lobbying game.

Before discussing the determination of the equilibrium policy, it will prove convenient in what follows to define the industrial groups' payoff functions. The gross-of-contributions payoff function of industry i takes the form

$$W_i = \Pi_i = f_i(x_i) - wx_i - A_i(a_i) - t(x_i - a_i) + \alpha_i \lambda t E\,, \tag{8}$$

where α_i denotes industry i's share of rebated tax revenues, and the summation of α_i is equal to one. The share α_i is assumed exogenously fixed; that may be done according to historical emissions or other rules.

Note that in this stage the interest groups recognize their influence on the refunded tax revenues, and so we replace r with $\alpha_i \lambda t E$, where $\lambda \in [0, 1]$ is the fraction of the emission tax revenues that are rebated to the polluting industries. All lobbying groups regard λ as given. The aim of each lobbying group is to maximize its net payoff, which is equal to the gross payoff minus the political contributions.

In our setting, λ represents the polluting industries' property rights regarding the tax revenues or the scarcity rents due to the environmental regulation. According to PEZZEY [1992], the same distribution of the property rights over the scarcity rents will result in full symmetry between the price-control instruments and the quantity-control instruments with respect to efficiency and political acceptability. Since λ depicts the distribution of property rights regarding the scarcity rents, different values of λ represent different types of policy instruments.[15] When $\lambda = 1$, the scarcity rents due to the emission restriction accrue to the firms, so $\lambda = 1$ represents the NRR policies. For example, an emission tax accompanied by fully rebated tax revenues is equivalent to grandfathered tradable permits, which are an NRR policy. On the other hand, $\lambda = 0$, which means that all of the scarcity rents accrue to the general public, can represent the RR policies (e.g., pure emission taxes and auctioned tradable permits). A λ that is between zero and one represents a hybrid instrument, such as an emission tax accompanied by partially rebated revenues, or tradable emission permits in which part of the initial permits are allocated through auctions and the proceeds are distributed to the general public. Although an emission tax accompanied by partially rebated revenues gives rise to *some* scarcity rents for the general public, we will refer to it as a hybrid instrument for the purpose of classification. In this paper, we define an RR instrument as one under which the general public possesses *all* of the scarcity rents.

Then we move on to the aggregate welfare of the environmentalists, which is given by

$$W_g = n_g u_g = n_g y_g + \gamma\beta(1 - \lambda)tE - D(E)\,, \tag{9}$$

where $\beta \in (0, 1)$ denotes the fraction of $(1 - \lambda)tE$ received by the environmentalists. The variable D represents the aggregate disutility from pollution, which equals

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[15] We note that the policy instrument is a continuous variable in this present paper. As indicated by PEZZEY AND PARK [1998, p. 542], "the choice of instrument is not always discrete, since there are many hybrid instruments along the dimensions [...] between revenue-raising and non-revenue-raising instruments."

$n_g d(E)$, with the properties $D' > 0$ and $D'' > 0$. Finally, the aggregate welfare of the consumers is equal to

$$W_c = n_c u_c = n_c y_c + \gamma(1-\beta)(1-\lambda)tE\,. \tag{10}$$

Industry i offers political contributions, m_i, to the government in order to affect the environmental policy. The goal of the incumbent government is to remain in office. To this end, the government chooses the emission tax rate to maximize a weighted average of the social welfare and the collected political contributions. Following GROSSMAN AND HELPMAN [1994], the government's political support function is given by

$$G = \theta \sum_{i=1}^{I} m_i + W\,, \tag{11}$$

where the parameter $\theta \geq 0$ denotes the weight that the government attaches to the political contributions.

The social welfare function, W, is defined as the summation of the welfare of all industries, environmentalists, and consumers, which equals

$$\begin{aligned} W &= \sum_{i=1}^{I} W_i + W_g + W_c \\ &= \sum_{i=1}^{I} W_i + \gamma(1-\lambda)tE + n_g y_g + n_c y_c - D(E)\,. \end{aligned} \tag{12}$$

In deriving the social welfare function above, we apply the relationship $(n_g + n_c)s = (1-\lambda)tE$.

For ease of exposition, we assume that all the industrial groups' contribution schedules are globally truthful; that is, the contribution schedule of a lobbying group everywhere reflects its true welfare.[16] Therefore, $\partial m_i/\partial t$ will be equal to $\partial W_i/\partial t$. As we will see, this relationship is important in determining the equilibrium emission tax rate.

The first-order condition of the government's maximizing the political support can be obtained by differentiating (11) with respect to t:

$$\frac{\partial G}{\partial t} = \theta \sum_{i=1}^{I} \frac{\partial m_i}{\partial t} + \frac{\partial W}{\partial t} = \theta \sum_{i=1}^{I} \frac{\partial W_i}{\partial t} + \frac{\partial W}{\partial t} = 0\,, \tag{13}$$

where we apply the relationship $\partial m_i/\partial t = \partial W_i/\partial t$.

Equation (13) characterizes the equilibrium emission tax, which is denoted by t°. We can see that the equilibrium tax is closely related to the industrial groups' lobbying. Industry i's attitude toward lobbying the emission tax is reflected by

[16] BERNHEIM AND WHINSTON [1986] show that a truthful schedule is a best response to any strategy of the opponent, even if it is not the only best response. Therefore, they argue that truthful Nash equilibria may be focal among the set of Nash equilibria. This justifies the assumption of global truthfulness. Actually, however, the global-truthfulness assumption is not essential to our analysis. All the following results remain the same without this assumption. It is adopted for ease of exposition.

$\partial m_i/\partial t$, which is defined as industry i's marginal willingness to contribute (MWTC) toward lobbying t. A positive MWTC_i toward lobbying t means that industry i will lobby for a higher emission tax; a negative MWTC_i means that industry i will lobby to lower the emission tax.

Let us examine the industrial groups' lobbying attitude in more detail. Industry i's MWTC toward lobbying t equals

$$\frac{\partial m_i}{\partial t} = \frac{\partial W_i}{\partial t} = -e_i + \alpha_i \lambda (1-\eta) E\,, \tag{14}$$

where $\eta = -(\partial E/\partial t) \cdot (t/E) > 0$ denotes the demand elasticity of the emissions with respect to t.

Industry i's MWTC consists of two parts. The first part, $-e_i$, measures the effect of t on industry i's profits associated with production activities. We call this the *regulation effect*. An increase in t is harmful to industry i's profits, so that the regulation effect is negative. The negative regulation effect leads industry i to lobby for a lower emission tax.

The second part, $\alpha_i \lambda (1-\eta) E$, reflects the effect of the emission tax on the rebated tax revenues received by industry i. This effect is referred to as the *tax-refunding* effect. The sign of the tax-refunding effect is ambiguous, and depends on the demand elasticity for emissions. If the demand for pollution emissions is inelastic, implying $\eta < 1$, then the emission tax revenues will increase with the tax rate, so the tax-refunding effect will be positive. A positive tax-refunding effect leads the industry to lobby for a higher tax rate. On the other hand, if the demand for pollution emissions is elastic, then the tax-refunding effect will be negative, and industry i will endorse a lower emission tax.

One implication of the above result is that if industry i's tax-refunding effect is positive and outweighs the regulation effect, then industry i will lobby for a higher tax rate. This result is similar to Result 1 of FREDRIKSSON AND STERNER [2005], which states that the firms with relatively low pollution intensity may lobby for a higher pollution tax rate. FREDRIKSSON AND STERNER [2005] focus on refunded-emissions-payment programs, in which the pollution tax revenues are refunded to the polluters in proportion to their output shares. Since the firms that are cleaner than average receive refunds larger than their tax payments (i.e., using the terms of this present paper, the clean firms have a strong tax-refunding effect), they have the incentive to raise the tax rate.

Although an individual industry may have a positive MWTC toward lobbying t, the summation of all industries' MWTCs, which equals $(\lambda - 1 - \lambda\eta)E$, is negative. This means that the aggregate political contributions provided by the industries as a whole will increase when the government lowers the tax rate. As a result, the aggregate industrial lobby will wish to lower the emission tax rate.

We also need to know the effect of t on the social welfare, which can be obtained by partially differentiating (12) with respect to t:

$$\frac{\partial W}{\partial t} = t\frac{\partial E}{\partial t} + (\gamma - 1)(1-\lambda)(1-\eta)E - D'\frac{\partial E}{\partial t}\,. \tag{15}$$

In the following we will focus on the interior solution. By setting $\partial W/\partial t$ equal to zero, we can obtain the emission tax that maximizes the social welfare, which is denoted by t^*, as follows:

$$t^* = \frac{\eta D'}{\eta - (\gamma - 1)(1-\lambda)(1-\eta)} . \tag{16}$$

As expected, when γ equals one, (16) shows that the emission tax maximizing the social welfare will equal the marginal pollution damage. However, when γ is greater than one, and λ is positive, we can verify that t^* will be greater than the marginal pollution damage, provided that $\eta < 1$. This result is consistent with the notion of the double dividend from adopting emission taxes.[17]

Let us now turn to the equilibrium emission tax. By substituting (14) and (15) into (13), we can rewrite the first-order condition of the government's maximizing the objective function as follows:

$$\begin{aligned} \frac{\partial G}{\partial t} &= \theta[-1+\lambda(1-\eta)]E + t\frac{\partial E}{\partial t} + (\gamma-1)(1-\lambda)(1-\eta)E - D'\frac{\partial E}{\partial t} \\ &= \{\theta[-1+\lambda(1-\eta)] - \eta + (\gamma-1)(1-\lambda)(1-\eta) + D'\eta/t\}E = 0 . \end{aligned} \tag{17}$$

From (17) we can solve for the equilibrium emission tax, which is denoted by t°, as follows:

$$t^\circ = \frac{\eta D'}{\theta[1-\lambda(1-\eta)] + \eta - (\gamma-1)(1-\lambda)(1-\eta)} . \tag{18}$$

Comparing (18) with (16) reveals that the presence of industrial lobbying results in the equilibrium emission tax being lower than the welfare-maximizing tax. This result arises because the aggregate industrial lobby wishes to lower the emission tax rate. If there is no lobbying, which is represented by setting $\theta = 0$, then t° will be the same as t^*.

In addition, we note that the equilibrium emission tax decreases with increasing θ.[18] Given the amount of political contributions, the larger that θ is, the more incentive the government will have to lower the emission tax. We also note that t^* is independent of θ. As a result, a larger θ will enlarge the gap between t^* and t°, thereby causing environmental deterioration to a greater extent.

4 *The Second-Best Instrument*

In this section we turn to address our major question: given the policy distortion due to lobbying, what type of policy instruments (or what kind of distribution of property rights) will maximize the social welfare? According to Coase [1960], the initial assignment of a property right will not affect the efficiency with which resources

[17] A similar result can be found in Lee and Misiolek [1986].

[18] This can be seen from the comparative-static result of (17), which shows that $\partial t^\circ/\partial\theta = (-\partial^2 G/\partial\theta\partial t)/(\partial^2 G/\partial t^2)$. The denominator is negative, as required by the second-order condition of maximizing G, and the numerator equals $-[-1+\lambda(1-\eta)] > 0$. Thus t° decreases with increasing θ.

are allocated, provided that the transaction cost is trivial. However, as demonstrated in the previous section, such an invariance property does not necessarily hold once lobbying is present.

As indicated previously, the type of policy instrument can be represented by λ. In the following we obtain the second-best λ, which will maximize the social welfare given the emission tax rate distorted by the interest groups.[19] Taking the equilibrium emission tax into consideration, the effect of λ on the social welfare is given by

$$\frac{dW}{d\lambda}\bigg|_{t=t^\circ} = \frac{\partial W}{\partial \lambda} + \frac{\partial W}{\partial t}\frac{\partial t^\circ}{\partial \lambda}\,. \tag{19}$$

The first term on the right-hand side of (19) represents the direct effect of λ on the social welfare. This direct effect equals

$$\frac{\partial W}{\partial \lambda} = (1-\gamma)t^\circ E^\circ < 0\,, \tag{20}$$

where E° is the resultant total emissions when the emission tax equals t°. The direct effect is negative. The reason for this is that a decrease in λ will enlarge the transfers received by the environmentalists and the consumers,[20] and will enhance the social welfare through the revenue-recycling effect.

A change in λ will also indirectly affect the social welfare by changing the stringency of environmental regulation, which is reflected by the second expression on the right-hand side of (19). The sign of the indirect effect is ambiguous. If the indirect effect is negative, then $dW/d\lambda$ will be unambiguously negative, for all $\lambda \in [0, 1]$. This indicates that choosing $\lambda = 0$ will maximize the social welfare, and thus the second-best policy will be the RR instruments. On the other hand, if the indirect effect is positive, then the sign of $dW/d\lambda$ will be ambiguous. A hybrid instrument or even an NRR instrument may be the most efficient policy in this situation.

The sign of the indirect effect depends on two factors. The sign of $\partial W(t^\circ)/\partial t$ can be obtained from the first-order condition of the government's maximizing the political support. From (13), we obtain that $\partial W(t^\circ)/\partial t$ is positive,[21] so that the social welfare increases with t. This follows from the industrial lobbying resulting in a suboptimally low emission tax rate, and thus an increase in t will enhance the social welfare.

The sign of the indirect effect also depends on that of $\partial t^\circ/\partial\lambda$. Although $\partial t^\circ/\partial\lambda$ can be obtained by differentiating (18) with respect to λ, we adopt the comparative-static approach for ease of calculation. This approach shows that $\partial t^\circ/\partial\lambda$ equals

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[19] In this paper the first-best situation refers to the situation in which the interest groups cannot influence the policymaking, i.e., to the one in which $\theta = 0$. The second-best situation here means the situation where the interest groups can influence the emission tax rate. The comparison of the first-best policy instrument with the second-best one is provided at the end of this section.

[20] The proof of the effect of λ on the transfers received by the environmentalists and the consumers is provided in the Appendix.

[21] As indicated in (13), the first-order condition $\partial G(t^\circ)/\partial t = 0$ implies that $\partial W(t^\circ)/\partial t$ equals $-\theta\sum_{i=1}^{I}\partial W_i(t^\circ)/\partial t$, which can be rewritten as $\theta[1-\lambda(1-\eta)]E^\circ > 0$.

$-(\partial^2 G/\partial t \partial \lambda)/(\partial^2 G/\partial t^2)$. Since the second-order condition of the government's maximizing G requires the denominator to be negative, the sign of $\partial t^\circ/\partial \lambda$ is the same as that of $\partial^2 G/\partial t \partial \lambda$. Partially differentiating (17) with respect to λ yields

$$\frac{\partial^2 G}{\partial t \partial \lambda} = (1-\eta)[\theta - (\gamma - 1)]E^\circ \,. \tag{21}$$

Equation (21) shows that the effect of λ on t° is ambiguous, and depends on several parameters, including θ, γ, and η. Since the demand for pollution emissions is generally inelastic, we will focus on the case where η is less than one hereafter.

According to (21), we obtain the following proposition:

PROPOSITION 1 *In the case where η is less than one, if θ is less than $\gamma - 1$, then a reduction in λ will raise the emission tax rate and reduce the quantity of emissions. By contrast, if θ is greater than $\gamma - 1$, then a reduction in λ will lower the emission tax rate and enlarge the quantity of emissions. The results will be reversed when η is greater than one.*

This ambiguity in the effect of λ on the equilibrium emission tax reflects two offsetting effects in the model. On the one hand, a reduction in λ affects the aggregate MWTC of the industrial groups, which is represented by the first term on the right-hand side of (17), through the tax-refunding effect. A reduction in λ will weaken the tax-refunding effect and intensify the downward political pressure on the emission tax rate. The extent of the reduction in the emission tax rate due to a lower λ is positively related to θ.

On the other hand, a reduction in λ will enlarge the amount of transfers received by the environmentalists and the consumers, and thus strengthen the revenue-recycling effect, which is measured by the third term on the right-hand side of (17). A larger revenue-recycling effect, which is reflected by a larger $\gamma - 1$, will generate a stronger incentive for the government to raise the emission tax, thereby resulting in a higher emission tax rate.

In the case where $\eta < 1$, when θ is greater than $\gamma - 1$, the first effect outweighs the second one, so a reduction in λ will lower t° and thus enlarge the quantity of emissions. If θ is less than $\gamma - 1$, the results will be reversed.

By combining both the direct and indirect effects, we obtain the effect of λ on the social welfare as follows:

$$\left.\frac{dW}{d\lambda}\right|_{t=t^\circ} = \underbrace{(1-\gamma)t^\circ E^\circ}_{(-)} + \underbrace{\theta[1-\lambda(1-\eta)]E^\circ}_{(+)} \underbrace{\frac{\partial t^\circ}{\partial \lambda}}_{(?)} \,. \tag{22}$$

Equation (22) characterizes the second-best λ, which is denoted by λ^*. Setting $\lambda = \lambda^*$ will maximize the social welfare. According to Proposition 1, when θ is so small that $\partial t^\circ/\partial \lambda < 0$, a decrease in λ will enhance the social welfare through the direct effect by strengthening the revenue-recycling effect, and through the indirect effect by raising the emission tax rate and improving the environmental quality. In this situation, there is no conflict between the nonenvironmental dividend and the environmental dividend arising from a reduction in λ. As a result, setting $\lambda = 0$ will maximize the social welfare, and thus the RR instruments will be the second-best policy.

By contrast, if θ is so large that $\partial t^\circ/\partial\lambda > 0$, then there will arise a conflict between the green dividend and the nonenvironmental dividend when λ is reduced. In this case, a reduction in λ will enhance the social welfare through the revenue-recycling effect, whereas it will also worsen the environmental quality due to a decline in the emission tax. The effect of a reduction in λ on the social welfare is thus ambiguous. If the resultant deterioration in the environmental quality outweighs the welfare enhancement associated with the revenue-recycling effect, then the RR instruments are no longer the second-best policy. Instead, a hybrid instrument ($\lambda \in (0, 1)$) may be the second-best policy. If the pollution damage is sufficiently large, then $dW(t^\circ)/d\lambda$ will be positive for all $\lambda \in [0, 1]$. This indicates that setting $\lambda = 1$ will maximize the social welfare, and thus the NRR instruments will be the second-best policy.

In order to explain the above results in more depth, and to highlight the trade-off between the nonenvironmental dividend and the green dividend, we suppose that the economy initially adopted an NRR instrument, and only the green dividend emerged. Then we consider what will occur when the economy introduces a (partial) green tax reform, i.e., it switches from the NRR instrument to a hybrid instrument, so that a certain amount of tax revenue is raised. This green tax reform will generate a nonenvironmental dividend through exploiting the revenue-recycling effect, and it will also reduce the magnitude of the green dividend, provided that the government attaches a large weight to the political contributions. The welfare effect of introducing the hybrid instrument depends on the trade-off between the two dividends. If the reduction in the green dividend outweighs the nonenvironmental dividend, then introducing any instrument that can exploit the revenue-recycling effect will lower the social welfare.

The following proposition summarizes what we have found:

PROPOSITION 2 *In the case where $\eta < 1$, if θ is less than $\gamma - 1$, then the RR instruments ($\lambda = 0$) will be the second-best policy. When θ is greater than $\gamma - 1$, the result will be ambiguous; the hybrid instruments ($\lambda \in (0, 1)$) or the NRR instruments ($\lambda = 1$) may be the second-best policy. The results will be reversed when $\eta > 1$.*

We can observe that many policies in practice are of the hybrid type, e.g., a system of tradable permits in which a certain fraction of permits is auctioned, or an emission tax with an exemption for some inframarginal emissions. Thus, the hybrid policies deserve more discussion. In this paper, a hybrid policy can by represented by an interior λ^*, which satisfies the condition $(dW/d\lambda)|_{t=t^\circ} = 0$. From this condition, we can derive the interior second-best λ, which is equal to

$$\lambda^* = \frac{\theta\varepsilon}{\gamma - 1 + \theta\varepsilon(1 - \eta)}, \tag{23}$$

where $\varepsilon = (\partial t^\circ/\partial\lambda) \cdot (\lambda/t^\circ)$ denotes the elasticity of t° with respect to λ. Since $\partial t^\circ/\partial\lambda > 0$ is the necessary condition for an interior λ^*, the elasticity ε must be positive. Equation (23) shows that an interior λ^* increases with θ.[22] The relationship between λ^* and θ stems, as indicated at the end of section 3, from an increase in θ enlarging the gap between t^* and t°, thereby worsening the environmental quality to a greater extent. The second-best λ should offset the deterioration in the environment due to an increase in θ. For an initial λ^* that is between zero and one, an increase in λ will raise t°, whereas it will lower t^*.[23] As a result, an increase in λ will narrow the gap between t^* and t°, and thus offset the distortion due to an increase in θ. This suggests that an efficient hybrid policy should have a smaller fraction of auctioned permits or have a larger exemption for inframarginal emissions, when the government attaches a larger weight to the political contributions.

Finally, we finish this section by relating the results obtained above to the existing papers. As mentioned previously, a number of papers have argued that the RR instruments are more efficient than the NRR instruments. This argument is based on the assumption that the government seeks to maximize the social welfare, i.e., the authors are considering a first-best situation. This situation can be represented by setting $\theta = 0$ in the present paper. By so doing, the government's objective function is reduced to the social welfare function, and thus the equilibrium emission tax is equal to the welfare-maximizing emission tax t^*, which satisfies $\partial W(t^*)/\partial t = 0$. The effect of λ on the social welfare becomes

$$(24)\qquad \left.\frac{dW}{d\lambda}\right|_{t=t^*} = \frac{\partial W(t^*)}{\partial \lambda} + \frac{\partial W(t^*)}{\partial t}\frac{\partial t^*}{\partial \lambda} = \frac{\partial W(t^*)}{\partial \lambda} = (1-\gamma)t^* E^* < 0\,,$$

where E^* is the corresponding emissions when $t = t^*$. The indirect effect of λ will vanish because $\partial W(t^*)/\partial t = 0$. Since $dW/d\lambda$ is less than zero for all $\lambda \in [0, 1]$, the RR instruments ($\lambda = 0$) are the most efficient policy, as argued by those previous papers. The reason for this result is that once the emission tax rate has been optimally set, a decline in λ only strengthens the revenue-recycling effect, and has nothing to do with the green dividend.

Alternatively, many related papers assume that the stringency of the environmental protection is fixed when different types of instruments are adopted. Under this assumption, the indirect effect of λ will also vanish, and thus the RR instruments will be more efficient than the NRR instruments.

However, introducing the industrial lobbying (i.e., $\theta > 0$) distorts the decision-making on the emission tax, resulting in $\partial W(t^\circ)/\partial t$ being positive. With a positive $\partial W(t^\circ)/\partial t$, a decline in λ strengthens the nonenvironmental dividend on the one hand, whereas it reduces the green dividend on the other hand, as long as $\partial t^\circ/\partial \lambda > 0$. Such a conflict between the two dividends may give rise to superiority of the NRR instruments in efficiency, which is contrary to the results obtained in the previous papers.

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22 This can be seen by partially differentiating (23) with respect to θ, which yields that $\partial \lambda^*/\partial \theta = (\gamma - 1)\varepsilon/[\gamma - 1 + \theta\varepsilon(1-\eta)]^2 > 0$.

23 The comparative-static result shows that the sign of $\partial t^*/\partial \lambda$ is the same as that of $\partial^2 W(t^*)/\partial t \partial \lambda$. By partially differentiating (15), we obtain $\partial^2 W(t^*)/\partial t \partial \lambda = -(\gamma - 1) \cdot (1-\eta)E^* < 0$, where E^* is the corresponding emissions when $t = t^*$.

5 Discussion

5.1 Related Literature

The results in Propositions 1 and 2 are also related to the weak double-dividend hypothesis. As indicated by BOVENBERG [1999], the idea behind this is to compare policy changes with different ways of recycling tax revenues. A weak double dividend occurs when the welfare gain achieved by the policy that exploits the revenue-recycling effect is greater than the gain achieved by the policy that does not.

However, the notion of the weak double dividend is generally examined on the assumption that different policies give rise to the same magnitude of the green dividend. We have shown that the magnitude of the green dividend depends on the way the proceeds are used, when the political influence of interest groups is involved. Although an NRR instrument cannot exploit the revenue-recycling effect, it may be more efficient than an RR instrument because of a greater green dividend being produced. This indicates that the weak double-dividend hypothesis does not necessarily hold.

While the weak double dividend will hold true in a world with only one nonenvironmental distorting tax, BABIKER, METCALF, AND REILLY [2003] and METCALF, BABIKER, AND REILLY [2004] show that it will not necessarily be true in a world with multiple distortions. Their results stem from the interactions between various distorting taxes due to the introduction of an environmental tax. In contrast to their papers, we do not rely on the tax-interaction effect; instead we focus on the trade-off between the green dividend and the nonenvironmental dividend arising from lobbying, which distinguishes this paper from theirs.[24]

Another related paper is BOVENBERG, GOULDER, AND GURNEY [2005], who point out that the RR policies impose a larger burden on the regulated industries than the NRR policies, because firms not only incur abatement costs but must also pay for inframarginal pollution. In order to avoid serious adverse effects on regulated industries and thus enhance political feasibility, the regulator can allow firms to retain a portion of the potential revenues through the grandfathering of permits or exemptions from pollution taxes. As indicated previously, such policies carry an efficiency cost because of the failure to explore the revenue-recycling effect. BOVENBERG, GOULDER, AND GURNEY [2005] examine the efficiency costs of avoiding adverse industry-distributional effects under environmental policies. Although both BOVENBERG, GOULDER, AND GURNEY [2005] and the present paper recognize the political opposition from the adoption of the RR policies, BOVENBERG, GOULDER, AND GURNEY [2005] assume that all the different policy instruments achieve the same extent of environmental protection. That setting ignores the possible trade-off between the proportion of potential revenues retained by the firms (i.e., λ in this paper) and the extent of environmental protection, which is the major issue in this paper.

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24 Neither BABIKER, METCALF, AND REILLY [2003] nor METCALF, BABIKER, AND REILLY [2004] consider the political economy aspect.

The present paper is also related to BRENNAN AND BUCHANAN [1980]. They discuss how the constitution should be framed to restrain a Leviathan government that would exploit taxpayers in the postconstitution stage. Similarly, the present paper investigates which type of policy instrument can remedy the policy distortion resulting from a corruptible government. To this end, we follow a sequential setting such as that of BRENNAN AND BUCHANAN [1980], rather than a simultaneous setting in which both the type of policy instrument and the degree of environmental protection are simultaneously determined. Since we want to emphasize the effect of policy instrument selection on the degree of environmental regulation, a sequential setting seems more appropriate for our analysis.

5.2 The Introduction of Green Lobbying

So far, we have assumed that the environmentalists do not engage in lobbying. In the following, we relax this assumption and see what will change when the environmentalists are able to affect the formation of the emission tax.

The MWTC of the environmental group can be derived by partially differentiating its payoff function (9), which equals

$$\frac{\partial W_g}{\partial t} = \gamma\beta(1-\lambda)(1-\eta)E - D'\frac{\partial E}{\partial t} > 0\,. \tag{25}$$

Here we still focus on the case where $\eta < 1$. The MWTC of the environmental group is positive, which indicates that the environmental group wishes to raise the emission tax. This result is consistent with intuition. An increase in t not only improves the environmental quality, but also increases the transfers received by the environmentalists (provided that λ is positive). Both effects are beneficial to the environmentalists' welfare.

In this case, the government's political support function becomes

$$G = \theta\left(\sum_{i=1}^{I} m_i + m_g\right) + W\,, \tag{26}$$

where m_g denotes the environmental group's political contributions. The social welfare function remains the same as (12). The first-order condition for the government's maximizing political support is

$$\begin{aligned}\frac{\partial G}{\partial t} &= \theta\left\{[-1+\lambda(1-\eta)]E + \gamma\beta(1-\lambda)(1-\eta)E - D'\frac{\partial E}{\partial t}\right\}\\ &\quad + t\frac{\partial E}{\partial t} + (\gamma-1)(1-\lambda)(1-\eta)E - D'\frac{\partial E}{\partial t} = 0\,.\end{aligned} \tag{27}$$

Equation (27) shows that, unlike in the case discussed previously, the equilibrium emission tax may exceed the socially optimal tax. As indicated above, the environmental group wishes to raise the emission tax. Introducing the green lobbying will offset the lobbying of the industrial groups. If the influence of the environmental group, which is represented by the last two terms in the curly braces in (27), outweighs that of the industrial groups, which is represented by the first term in the curly braces, then t° will exceed t^*.

Again, we are interested in knowing the effect of λ on t°. The sign of $\partial t^\circ/\partial\lambda$ is the same as that of $\partial^2 G/\partial t\partial\lambda$, which equals

$$\frac{\partial^2 G}{\partial t\partial\lambda} = (1-\eta)[\theta(1-\gamma\beta)-(\gamma-1)]E^\circ\,. \tag{28}$$

Comparing (28) with (21), we find that a negative $\partial t^\circ/\partial\lambda$ is more likely to occur when the green lobby appears. When $\theta > \gamma - 1$, an increase in λ may lower t° in (28), whereas it unambiguously raises t° in (21). This follows from the environmentalists' lobbying offsetting (at least partially) the industrial groups' lobbying.

The presence of the green lobbying gives rise to different results. In the case where the green lobby is absent, if there is no conflict between the green dividend and the nonenvironmental dividend (i.e., $\partial t^\circ/\partial\lambda$ is negative), then the RR instruments ($\lambda = 0$) must be the second-best policy. However, this result is no longer sustained once the lobbying of the environmentalists is introduced. The effect of λ on the social welfare in this case equals

$$\left.\frac{dW}{d\lambda}\right|_{t=t^\circ} = \underbrace{\frac{\partial W}{\partial\lambda}}_{(-)} + \underbrace{\frac{\partial W}{\partial t}}_{(?)}\underbrace{\frac{\partial t^\circ}{\partial\lambda}}_{(?)}\,. \tag{29}$$

Let us consider a situation in which $\partial t^\circ/\partial\lambda < 0$ and $\partial W(t^\circ)/\partial t < 0$, which implies that t° exceeds t^*. In this situation, even if no conflict between the green dividend and the nonenvironmental dividend exists, which means $\partial t^\circ/\partial\lambda < 0$, the RR instruments ($\lambda = 0$) are not necessarily the second-best policy. This result stems from t° exceeding t^*. The equilibrium tax, which is set at a suboptimally high level, gives rise to a suboptimally low level of emissions. Although a decline in λ will strengthen the revenue-recycling effect, it will also raise the emission tax and lower the level of emissions further, which will reduce the social welfare. If the reduction in the social welfare arising from the pollution control is significant, then a decrease in λ is inefficient, and thus $\lambda^* = 0$ is not the second-best policy. Instead, the hybrid instruments or the NRR instruments constitute the most efficient policy in this case.

6 *Concluding Remarks*

In this paper, we argue that non-revenue-raising policies may give rise to a higher level of social welfare than revenue-raising policies, when the goal of environmental protection is subject to political influence. In this situation, although the RR policies can reap the advantage of the revenue-recycling effect, they may result in less stringent environmental regulation than the NRR policies, especially when the weight that the government attaches to political contributions is large. If the pollution damage is significantly large, then the NRR policies will be more efficient than the RR policies.

In this paper, we place the emphasis on the revenue-recycling effect, and do not explicitly consider the tax-interaction effect. The tax-interaction effect, when present, generally outweighs the revenue-recycling effect (see, e.g., GOULDER, PARRY, AND BURTRAW [1997]). When the tax-interaction effect is introduced, the welfare-maximizing emission tax in (16) will be lower than the marginal pollution damage, as shown by BOVENBERG AND DE MOOIJ [1994]. Similarly, introducing the tax-interaction effect into the model will enlarge the welfare cost, and thus result in a lower equilibrium tax rate. Although the tax-interaction effect is important in determining the relationship between the welfare-maximizing tax rate and the marginal pollution damage, excluding this effect in the model does not significantly affect the validity of our findings, because the crucial difference between the RR policies and the NRR policies is the presence or absence of the revenue-recycling effect, and not the tax-interaction effect. In addition to helping us to focus on the different political-economy consequences due to different ways of recycling the proceeds, the other advantage of this setting is that it contrasts with the findings of BABIKER, METCALF, AND REILLY [2003] and METCALF, BABIKER, AND REILLY [2004]. Their findings rely on the tax-interaction effect, whereas we show that the weak double dividend may fail to hold in the absence of the tax-interaction effect.

As indicated by SCHULZE AND URSPRUNG [2001], the interaction between interest groups and the government portrayed by the common-agency lobbying model will meet the circumstances of corruption. Thus, the weight that the government attaches to the political contributions is related to the level of corruption in the country; a large weight attached to the political contributions means that there is severe corruption. Accordingly, we expect that the NRR policies are more likely to give rise to a higher level of social welfare than the RR policies when the government is sufficiently corruptible. This implies that we should be cautious when evaluating the introduction of RR policies or green tax reforms in developing countries, because they are usually plagued with quite significant corruption problems.

The two CO_2 tax bills introduced into the 110th U.S. Congress (H.R. 2069 and H.R. 3416) impose prices that are roughly comparable to the ten or so cap-and-trade bills, which would appear to contradict the main prediction of the analysis. One possible reason for this is that the CO_2 tax bills should be discounted because their chances of ever becoming law look remote.[25] Another possible answer is that the tax instrument and the permit instrument aim at different economic activities. Most of the cap-and-trade programs are associated with *production* activities, whereas the two CO_2 tax bills mentioned above impose taxes on *consumption* activities.[26]

This distinction is important. If the target of the policy instrument is the production activity, then the polluters will have an incentive to lobby for less stringent

[25] The author would like to thank a referee for providing this explanation.

[26] This can be seen from the "Save our Climate Act of 2007"(H.R. 2069), which requires a tax to be imposed on the imported manufactures that contain carbon content. In contrast, the manufactures that are exported are free of tax. As a result, the CO_2 tax bills aim at the consumption rather than the production activity.

regulation, as we usually expect. However, if the policy instrument aims at the consumption activity, and the imported manufactures are also subject to the tax, then the domestic producers may have an incentive to lobby for more stringent environmental regulation to serve as a barrier to entry.[27] This issue is especially important when the tariff barriers have been lowered; domestic producers may then resort to the environmental tax as a nontariff barrier. Such an incentive does not exist in a policy aiming at production activity, because the imported manufactures are not subject to the same regulation. According to the prediction of the present paper, the tax rate will be lower than the permit price when the tax revenues are not returned to the polluters. If we incorporate the incentive of creating barriers to entry, which may raise the tax rate, then we may explain why the two CO_2 tax bills impose prices that are roughly comparable to those in the cap-and-trade bills.

Appendix: The Effect of λ on the Transfers Received by the Environmentalists and the Consumers

Let S be the total transfers received by the environmentalists and the consumers in equilibrium, so that S equals $(1-\lambda)t^\circ E^\circ$. The effect of λ on the transfers received by the environmentalists and the consumers can be obtained by totally differentiating S with respect to λ to obtain

$$\text{(A1)} \qquad \frac{dS}{d\lambda} = \frac{\partial S}{\partial \lambda} + \frac{\partial S}{\partial t}\frac{\partial t^\circ}{\partial \lambda} = -t^\circ E^\circ + (1-\lambda)(1-\eta)E^\circ \frac{\partial t^\circ}{\partial \lambda}\,.$$

If $\partial t^\circ/\partial\lambda$ is negative, then $dS/d\lambda$ is also negative.

On the other hand, when $\partial t^\circ/\partial\lambda$ is positive, the two terms on the right-hand side of (A1) have opposite signs. To sign $dS/d\lambda$, we need to know the magnitude of $\partial t^\circ/\partial\lambda$, which can be obtained by partially differentiating (18) with respect to λ:

$$\text{(A2)} \qquad \frac{\partial t^\circ}{\partial \lambda} = \frac{\eta D'}{\Delta^2}[(1-\eta)(\theta-\gamma+1)]\,,$$

where Δ denotes the denominator of t°. Then substituting (A2) into (A1) yields

(A3)
$$\frac{dS}{d\lambda} = \frac{\eta D'}{\Delta^2}[\theta\{-1+(1-\eta)[1-(1-\lambda)\eta]\} - \eta + (\gamma-1)(1-\lambda)(1-\eta)\eta]E^\circ\,.$$

Since $\partial t^\circ/\partial\lambda > 0$ ensures that $\theta > \gamma - 1$, we have the following inequality:

(A4)
$$\frac{dS}{d\lambda} < \frac{\eta D'}{\Delta^2}[(\gamma-1)\{-1+(1-\eta)[1-(1-\lambda)\eta]\} - \eta + (\gamma-1)(1-\lambda)(1-\eta)\eta]E^\circ\,.$$

After some algebra, the right-hand side of the above inequality can be expressed as $-(\eta^2\gamma E^\circ D')/\Delta^2$, which is less than zero. As a result, we prove that $dS/d\lambda$ is negative.

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[27] See MICHAELIS [1994] and LAI [2007b] for more details on this issue, and EDERINGTON AND MINIER [2003] for the empirical evidence.

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