Monitoring and Enforcement to Remedy Defects in the Pricing and Standards Approach

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Abstract: This paper extends a model of the pricing and standards approach (PSA) to emission control under incomplete tax compliance and examines monitoring and enforcement policy to relax restrictions on the use of PSA. We will show that government's choice of target firms is significant. When additional monitoring and enforcement resources are available, government should utilize them for the least observant firms, as both the efficiency-related and purely quantitative restrictions are relaxed. If additional resources are unavailable, government may face a trade-off between the two restrictions. Although resource reallocation from the most to the least observant firms necessarily relaxes the former, it may also have an adverse effect on the latter.

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1 Introduction

In December 2009, COP15 failed to establish a post-Kyoto framework to control global greenhouse gas (GHG) emissions after 2013. The developed countries, which have been producing GHG's since the Industrial Revolution, demonstrated little, if any, initiative to reach an agreement. Moreover, emerging countries that have recently begun generating more annual GHG's than even their most developed counterparts seemed to lack any sense of responsibility concerning the problem. They are all concerned, however, about the cost of emission reduction, or to put it differently, the possible loss of GDP or profits resulting from any efforts to reduce emissions. Negotiations reached an impasse despite the fact that virtually all of the parties accept the latest scientific assessments of global climate change and recognize the necessity for worldwide emissions reductions.

When it comes to the costs of emission reductions, 'economic' policy instruments such as the pricing and standards approach (PSA)

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or the system of tradable emission permits are said to be the best candidates for environmental policy instruments. The reason is their cost-effectiveness: they are believed to minimize the aggregate cost to realize any exogenously determined total emission reduction. Baumol and Oates (1971) provided a formal proof regarding the cost-efficiency of PSA and Montgomery (1972) did the same for emissions trading. Sandmo (2002) extended a model of PSA to the situation where the regulated firms attempt to evade environmental taxes and argued that PSA minimizes the aggregate cost of emission reduction even though tax compliance is incomplete.

Shiota (2008) pointed out that Sandmo (2002)'s proposition is applicable only to the cases where the target total reductions are small and thus the required environmental tax rates are relatively low. He demonstrated that possible tax evasion by regulated firms reveals a critical deficiency of PSA, i.e., government encounters the three limits when targeting a larger amount of emission reductions via PSA. They are, in order from most to least restrictive: the perfect compliance limit, the cost-efficiency limit, and the unconditional quantity limit. The first is the boundary of total reductions below which government is able to collect all relevant taxes. The second is the boundary below which government is able to ensure an aggregate cost minimizing allocation of emission reductions among firms. The third is the maximum emission reduction which government is able to achieve even if it abandons the idea of cost efficiency. Among the three limits, the second and third are fatal to environmental policy instruments, because the former calls into question the greatest advantage of PSA while the latter directly restricts its ability to control emissions. Therefore, this paper discusses ways in which the government may deal with these two difficulties.

In the following sections, we develop Shiota (2008)'s model and investigate three prototype monitoring and enforcement programs to ease the above-mentioned second and third limits. It seems that any monitoring and enforcement policies which compel regulated firms to reduce their tax evasion would allow government to relax restrictions on the use of PSA. However, our analysis will demonstrate that an increase in the average deterrence of firms as a whole is neither necessary nor sufficient for the relaxation of the cost-efficiency limit. Additionally, it is not necessary for the relaxation of the unconditional quantity limit. We will find that government's choice of which firms to target for monitoring and enforcement is crucial to the results. When additional monitoring and enforcement resources are available, government should use them for the least observant firms because both the limits are relaxed. If additional resources are unavailable, the case may arise where a trade-off between the two limits is inevitable. Resource reallocation from the most to the least observant firms invariably relaxes the second limit less restrictively, but such a policy may reduce the third limit.

2 Behavior of Regulated Firms

We consider a continuum version of Shiota (2008) model. A firm of type j, which is uniformly distributed on $[0, 1]$, generates not only a homogeneous product x_j whose competitive market price is p, but also a homogeneous emission e_j. Technology of the firm is represented by

an identical cost function $C(x_j, e_j)$. We assume that C is strictly increasing and strictly convex in x_j, strictly convex in e_j, and additively separable. Also, we assume

$$\lim_{x_j \downarrow 0} \frac{\partial C}{\partial x_j}(x_j) = 0, \quad \lim_{e_j \downarrow 0} \frac{\partial C}{\partial e_j}(e_j) = -\infty, \tag{1}$$

$$\exists\, e_j^0 \in (0, +\infty) \quad \text{such that} \quad \frac{\partial C}{\partial e_j}(e_j^0) = 0. \tag{2}$$

Firms are required to report their emissions. The proportion of the reported emissions by type j firm is denoted by $b_j \in [0, 1]$. A unit tax $t \geq 0$ is uniformly imposed on the reported emissions $b_j e_j$. The government announces that it will carry out random inspections and impose penalties on convicted firms according to the amount of unreported emissions.

For analytical clarity we assume all firms are risk neutral. Further, allowing for the heterogeneity of the firms in their perception of the probability of conviction and severity of penalties, we specify the expected penalty of firms as follows:

Assumption 1 We assume that the subjective perception of the penalty is quadratic in the level of underreporting:

$$\frac{\gamma}{2}[(1 - b_j)e_j]^2$$

where

$$\gamma = (\bar{a} - \underline{a})j + \underline{a}, \qquad \bar{a} > \underline{a} > 0. \tag{3}$$

Note that γ is the product of the subjective probability of conviction and the coefficient which represents rate of change in the marginal penalty.[*1] Because of the distribution of j, γ is uniformly distributed on the interval $[\underline{a}, \bar{a}]$ with the mean μ,

$$\mu = \frac{\underline{a} + \bar{a}}{2}. \tag{4}$$

Without loss of generality, we postulate that a firm of a larger number type has a higher estimate of the penalty and vice versa.

Since each firm maximizes its expected profit, it chooses (x_j, e_j, b_j) to maximize

$$px_j - C(x_j, e_j) - tb_j e_j - \frac{\gamma}{2}[(1 - b_j)e_j]^2 \tag{5}$$

subject to

$$x_j \geq 0, \ e_j \geq 0, \ 0 \leq b_j \leq 1. \tag{6}$$

Letting λ_j the multiplier on the constraint $b_j \leq 1$, (x_j, e_j, b_j) must satisfy the following first-order conditions at equilibrium:

$$p - \frac{\partial C}{\partial x_j} \leq 0, \ x_j \geq 0, \ x_j\left(p - \frac{\partial C}{\partial x_j}\right) = 0; \tag{7}$$

$$-\frac{\partial C}{\partial e_j} - tb_j - \gamma[(1 - b_j)e_j](1 - b_j) \leq 0, \ e_j \geq 0,$$

$$e_j\left\{-\frac{\partial C}{\partial e_j} - tb_j - \gamma[(1 - b_j)e_j](1 - b_j)\right\} = 0; \tag{8}$$

$$-te_j + \gamma[(1 - b_j)e_j]e_j - \lambda_j \leq 0, \ b_j \geq 0,$$

$$b_j\{-te_j + \gamma[(1 - b_j)e_j]e_j - \lambda_j\} = 0; \tag{9}$$

$$1 - b_j \geq 0, \ \lambda_j \geq 0, \ \lambda_j(1 - b_j) = 0. \tag{10}$$

Referring to Definition 2 in Shiota (2008), the zero-compliance critical tax rate $\tilde{t}_j$ and the zero-compliance critical emission level $\tilde{e}_j$ in our setting are given by

$$\tilde{t}_j = \gamma \tilde{e}_j, \tag{11}$$

$$-\frac{\partial C}{\partial e_j}(\tilde{e}_j) = \gamma \tilde{e}_j. \tag{12}$$

[*1] See Shiota (2008) for more detail.

Hence both $\tilde{e}_j$ and $\tilde{t}_j$ can be represented as implicit functions of γ:

$$\tilde{e}_j = \tilde{e}(\gamma), \quad \tilde{e}'(\cdot) = -\frac{\tilde{e}}{\frac{\partial^2 C}{\partial e_j^2} + \gamma} < 0; \qquad (13)$$

$$\tilde{t}_j = \tilde{t}(\gamma), \quad \tilde{t}'(\cdot) = \frac{\tilde{e}\frac{\partial^2 C}{\partial e_j^2}}{\frac{\partial^2 C}{\partial e_j^2} + \gamma} > 0. \qquad (14)$$

(9) and (10) imply that we have the following nine cases:*2

	$b_j \geq 0$	$\mathcal{L}_{bj} \leq 0$	$\lambda_j \geq 0$	$b_j \leq 1$
(i)	>	=	>	=
(ii)	=	=	>	=
(iii)	=	<	>	=
(iv)	>	=	=	=
(v)	=	=	=	=
(vi)	=	<	=	=
(vii)	>	=	=	<
(viii)	=	=	=	<
(ix)	=	<	=	<

However, it is clear that (ii), (iii), (v) and (vi) are all impossible. Examining (i), (iv), (vii), (viii) and (ix), we find:

$$-\frac{\partial C}{\partial e_j}(e_j) = t, \quad b_j > 0 \quad \text{if} \quad t \leq \tilde{t}_j; \qquad (15)$$

$$-\frac{\partial C}{\partial e_j}(e_j) = \gamma e_j < t, \quad b_j = 0 \quad \text{if} \quad t > \tilde{t}_j. \qquad (16)$$

Finally, we can sum up the properties of the emissions decision $e_j(t)$ as follows:

$$e_j(t) = \begin{cases} e(t) = e^0 & \text{if} \quad t = 0, \\ e(t) & \text{if} \quad 0 < t < \tilde{t}(\gamma), \\ e(t) = \tilde{e}(\gamma) & \text{if} \quad t = \tilde{t}(\gamma), \\ \tilde{e}(\gamma) & \text{if} \quad t > \tilde{t}(\gamma), \end{cases} \qquad (17)$$

where $e(t)$ satisfies

$$-\frac{\partial C}{\partial e_j}(e(t)) = t, \quad e'(\cdot) = -\frac{1}{\frac{\partial^2 C}{\partial e_j^2}} < 0. \qquad (18)$$

3 Monitoring and Enforcement Activities and Aggregate Emission Reduction

In this section, we shall study monitoring and enforcement policies to remedy defects in PSA. Because we are considering a continuum economy with firm $j \in [0, 1]$, the aggregate emission reduction at t, $R(t)$, is given by

$$R(t) = \int_0^1 e_j(0)\, dj - \int_0^1 e_j(t)\, dj = e^0 - \int_0^1 e_j(t)\, dj. \qquad (19)$$

By the analogy of Proposition 4 in Shiota (2008), the cost-efficiency limit $\hat{R}_c$ is given by*3

$$\begin{aligned} \hat{R}_c = R(\hat{t}_c) &= e^0 - \int_0^1 e_j(\hat{t}_c)\, dj \\ &= e^0 - \int_0^1 e_j(\tilde{t}(\underline{a}))\, dj \\ &= e^0 - \int_0^1 e(\tilde{t}(\underline{a}))\, dj \\ &= e^0 - e(\tilde{t}(\underline{a})) \end{aligned} \qquad (20)$$

where the cost-efficiency limit level tax rate $\hat{t}_c$ is given by

$$\hat{t}_c = \min_{j \in [0,1]} \tilde{t}(\gamma) = \tilde{t}(\underline{a}).$$

Similarly, by the analogy of Proposition 5 in Shiota (2008), the unconditional quantity limit $\hat{R}_u$

*2 $\mathcal{L}_{bj} = -te_j + \gamma[(1 - b_j)e_j]e_j - \lambda_j$.

*3 The fourth equality holds from (14) and (17).

is given by[*4]

$$\hat{R}_u = R(\hat{t}_u) = e^0 - \int_0^1 e_j(\hat{t}_u)\, dj$$
$$= e^0 - \int_0^1 e_j(\tilde{t}(\overline{a}))\, dj$$
$$= e^0 - \int_0^1 \tilde{e}(\gamma)\, dj$$
$$= e^0 - \int_{\underline{a}}^{\overline{a}} \tilde{e}(\gamma)\, \frac{1}{\overline{a} - \underline{a}}\, d\gamma \qquad (21)$$

where the unconditional quantity limit level tax rate $\hat{t}_u$ is given by

$$\hat{t}_u = \max_{j \in [0,1]} \tilde{t}(\gamma) = \tilde{t}(\overline{a}).$$

Let us now suppose that government commits itself to implementing a stricter monitoring and enforcement program to ensure higher compliance. Such a commitment will compel regulated firms to revise their subjective estimate of the expected penalty.[*5] We consider such a revision as an upward shift in γ.

It is clear that if the program influences all the firms, (in other words, if the program shifts the whole interval $[\underline{a}, \overline{a}]$ to the right,) it will relax both the cost-efficiency limit and the unconditional quantity limit. Putting such a trivial case aside, we examine the following three prototype programs whose target firms are different.

Definition 1 A monitoring and enforcement program is a *retributive* type, if it raises $\underline{a}$ while leaving $\overline{a}$ constant.

This type of program represents a policy that aims at improving compliance by firms which are most likely to evade taxes, while at the same time maintaining the level of compliance by the most observant firms. As a result, the program improves compliance by regulated firms on average.

Definition 2 A monitoring and enforcement program is a *furtherance* type, if it raises $\overline{a}$ while leaving $\underline{a}$ constant.

This type of program represents a policy that seeks to improve compliance by the best firms, while leaving that of the worst firms unchanged. It also results in increasing the deterrence of regulated firms on average.

Government will require more resources to implement either retributive or furtherance type programs, since both necessitate additional monitoring and enforcement against some parties, while maintaining current monitoring and enforcement levels. However, they are much cheaper than any programs that attempt to improve compliance by all firms.

The following third program would appear to be less costly since government may carry it out by simply reallocating existing monitoring and enforcement resources. Let us first paraphrase that γ is uniformly distributed on $[\underline{a}, 2\mu - \underline{a}]$ from (4) and then define the third program as follows:

Definition 3 A monitoring and enforcement program is a *homogenizing* type, if it raises $\underline{a}$ while leaving μ constant.

[*4] The fourth equality holds from (14) and (17).

[*5] If the government commits itself to increasing its monitoring activities, such as inspections by the government, subjective probability of conviction of each firm will increase. If the government commits itself to strengthening enforcement mechanisms, such as penalty schemes, the evaluation of penalty by each firm will rise. However, we treat monitoring and enforcement as a set here for the sake of simplicity.

This type of program represents a policy that focuses on firms which are most likely to evade taxes, while at the same time allowing the firms which are in the highest degrees of compliance to become less so. It should be noted that this program will not improve compliance by firms on average. Overall, the degree of deterrence is the same as before. In addition, if we consider the opposite effects of this program, we will understand the impact of such a policy that focuses on observant firms, while at the same time allowing bad firms to become worse.

Let us examine the comparative statics effects of $\underline{a}$ and $\overline{a}$ on $\hat{R}_c$ and $\hat{R}_u$ in order to assess the effectiveness of these three programs.

Proposition 1 Suppose that government implements a retributive type monitoring and enforcement program, then:

(i) the cost-efficiency limit becomes less restrictive.
(ii) the unconditional quantity limit also becomes less restrictive.

Proof:

(i) Partially differentiating $\hat{R}_c$ in (20) by $\underline{a}$, and then considering (14) and (18), we have

$$\frac{\partial \hat{R}_c}{\partial \underline{a}} = -e'\tilde{t}' > 0.$$

(ii) Partially differentiating $\hat{R}_u$ in (21) by $\underline{a}$, we have

$$\frac{\partial \hat{R}_u}{\partial \underline{a}} = \frac{1}{(\overline{a}-\underline{a})^2}\int_{\underline{a}}^{\overline{a}} \left[\tilde{e}(\underline{a}) - \tilde{e}(\gamma)\right] d\gamma.$$

Because (13) implies

$$\tilde{e}(\underline{a}) > \tilde{e}(\gamma) \text{ for all } \gamma \in \left(\underline{a}, \overline{a}\right],$$

we conclude

$$\frac{\partial \hat{R}_u}{\partial \underline{a}} > 0. \ \blacksquare$$

The cost-efficiency limit is determined by the firm which has the lowest $\tilde{t}_j$. Because a retributive type program ensures compliance by firms which are least observant, it relaxes the cost-efficiency limit.

The unconditional quantity limit depends on the average deterrence of evasion by firms as a whole. The program targets the worst firms and at the same time effectively deters the others. As a result, it increases the average deterrence of the firms in the economy. Therefore, it also relaxes the unconditional quantity limit.

Consequently, a retributive type program produces qualitatively the same result as a program that targets all firms and shifts the whole interval $\left[\underline{a}, \overline{a}\right]$ to the right.

Proposition 2 Suppose that government implements a furtherance type monitoring and enforcement program, then:

(i) the cost-efficiency limit remains unchanged.
(ii) the unconditional quantity limit becomes less restrictive.

Proof:

(i) Partially differentiating $\hat{R}_c$ in (20) by $\overline{a}$, we have

$$\frac{\partial \hat{R}_c}{\partial \overline{a}} = 0.$$

(ii) Partially differentiating $\hat{R}_u$ in (21) by $\overline{a}$, we have

$$\frac{\partial \hat{R}_u}{\partial \overline{a}} = \frac{1}{(\overline{a}-\underline{a})^2}\int_{\underline{a}}^{\overline{a}} \left[\tilde{e}(\gamma) - \tilde{e}(\overline{a})\right] d\gamma.$$

Because (13) implies

$$\tilde{e}(\gamma) > \tilde{e}(\overline{a}) \text{ for all } \gamma \in \left[\underline{a}, \overline{a}\right),$$

we conclude

$$\frac{\partial \hat{R}_u}{\partial \bar{a}} > 0. \ \blacksquare$$

Since a furtherance type program targets good firms only and does not deter firms which are least observant, it does not relax the cost-efficiency limit.

The average deterrence of the firms in the economy rises regardless of which ones become more observant so long as the deterrence of the others remains the same as before. Thus a furtherance type program improves the compliance of firms on average. As a result, it relaxes the unconditional quantity limit.

It should be noted that an increase in the average deterrence of firms as a whole is not sufficient to relax the cost-efficiency limit.

Proposition 1 and 2 provide a guiding principle for a policy maker when additional monitoring and enforcement resources are available. In such a situation, the government should use the resources for the least observant firms, since both the cost-efficiency limit and the unconditional quantity limit will be relaxed by doing so. If the government uses them for the most observant firms, the cost-efficiency limit will remain unchanged, although the unconditional quantity limit will be relaxed. We could add that if the government targets the vast majority of firms which fall somewhere in between, the result will be the same as the case targeting the most observant firms, because the cost-efficiency limit is determined only by the least observant firms and the unconditional quantity limit is determined by all the firms.

Proposition 3 Suppose that government implements a homogenizing type monitoring and enforcement program, then:

(i) the cost-efficiency limit becomes less restrictive.

(ii) the impact on the unconditional quantity limit depends on the mid-range and mean of the zero-compliance critical emission levels of the firms;

(a) If the mid-range is smaller than the mean, then the limit becomes restrictive.

(b) If the mid-range is equal to the mean, then the limit remains unchanged.

(c) If the mid-range is larger than the mean, then the limit becomes less restrictive.

Proof:

(i) Partially differentiating $\hat{R}_c$ in (20) by $\underline{a}$, and then considering (14) and (18), we have

$$\frac{\partial \hat{R}_c}{\partial \underline{a}} = -e'\tilde{\imath}' > 0.$$

(ii) By (4), we can rewrite $\hat{R}_u$ as follows:

$$\hat{R}_u = e^0 - \int_{\underline{a}}^{2\mu-\underline{a}} \tilde{e}(\gamma) \frac{1}{2(\mu-\underline{a})} d\gamma.$$

Partially differentiating this expression by $\underline{a}$, we have

$$\begin{aligned}
&\frac{\partial}{\partial \underline{a}} \left[e^0 - \int_{\underline{a}}^{2\mu-\underline{a}} \tilde{e}(\gamma) \frac{1}{2(\mu-\underline{a})} d\gamma \right] \\
&= \frac{1}{\mu-\underline{a}} \left[\frac{\tilde{e}(2\mu-\underline{a}) + \tilde{e}(\underline{a})}{2} \right. \\
&\qquad \left. - \int_{\underline{a}}^{2\mu-\underline{a}} \tilde{e}(\gamma) \frac{1}{2(\mu-\underline{a})} d\gamma \right] \\
&= \frac{2}{\bar{a}-\underline{a}} \left[\frac{\tilde{e}(\underline{a}) + \tilde{e}(\bar{a})}{2} \right. \\
&\qquad \left. - \int_{\underline{a}}^{\bar{a}} \tilde{e}(\gamma) \frac{1}{\bar{a}-\underline{a}} d\gamma \right]. \quad (22)
\end{aligned}$$

Thus its sign depends on the sign of

$$\frac{\tilde{e}(\underline{a})+\tilde{e}(\overline{a})}{2}-\int_{\underline{a}}^{\overline{a}}\tilde{e}(\gamma)\frac{1}{\overline{a}-\underline{a}}d\gamma. \quad \blacksquare$$

By implementing a homogenizing type program, government compels the least observant firms to revise their estimates of penalties upward and ensures their compliance. Hence, it will be able to relax the cost-efficiency limit. A slight degradation of compliance by the firms which are most observant will not affect the limit. We must take note of the fact that government is able to improve abatement cost-efficiency even if the average of the perceived penalties remains unchanged. Thus, an increase in the average deterrence of firms as a whole is not necessary to relax the cost-efficiency limit.

The impact on the unconditional quantity limit is ambiguous. It depends on the distribution of the zero-compliance critical emission levels among the firms, or more exactly the positions of the mid-range and mean of the critical levels. If the mid-range is smaller than the mean, the distribution of the critical emission levels is skewed to the left. There exist a few observant firms whose critical levels are saliently low and thus raise the limit largely. The homogenizing program makes the limit restrictive, because the negative effect of the most observant firms becoming more tax-evasive exceeds the positive effect of the outlaw firms becoming less so. If the mid-range is larger than the mean, the distribution of the critical emission levels is skewed to the right. A fraction of the firms are extreme outlaws, have extraordinary high critical levels and thus lower the limit drastically. The homogenizing program makes the limit less restrictive because the positive effect exceeds the negative effect in this case. If the mid-range agrees to the mean, the distribution of the critical emission levels is symmetric. The homogenizing program has no influence on the limit because the positive effect is offset precisely by the negative one.

When additional monitoring and enforcement resources are unavailable, Proposition 3 gives a clue to effective monitoring and enforcement policies, although a panacea probably may not exist. Resource reallocation from good firms to bad ones will always relax the cost-efficiency limit. However, such a reallocation may have the reverse effect on the unconditional quantity limit, if the distribution of the zero-compliance critical emission levels is skewed to the left, in which case government must accept a trade-off between cost-efficiency and unconditional quantity limits. If the goal is a simple relaxation of the purely quantitative restriction on the use of PSA, government should reallocate the resources from the bad firms to the good ones.

4 Concluding Remarks

We have studied how monitoring and enforcement programs ease the cost-efficiency limit and the unconditional quantity limit of PSA revealed by Shiota (2008). Three prototype programs, which differ in additional resource availability and/or targeting firms, were examined.

Both the retributive type program and the furtherance type programs assume that additional monitoring and enforcement resources are available. The former tightens monitoring and enforcement programs for the least observant firms, while leaving those of the remaining firms unchanged. The latter tightens monitoring and enforcement programs for the most observant

firms, while leaving those of the rest unchanged. We found that the retributive type program relaxes the cost-efficiency limit as well as the unconditional quantity limit, and that the furtherance type program relaxes the unconditional quantity limit but has no influence on the cost-efficiency limit.

The homogenizing type monitoring and enforcement program assumes that additional monitoring and enforcement resources are unavailable. The program reallocates a part of the existing resources from the most observant firms to the least observant ones. As a result, it tightens monitoring and enforcement programs of the least observant firms instead of loosening those of the rest. We found that the homogenizing type monitoring and enforcement program relaxes the cost-efficiency limit, however, its effect on the unconditional quantity limit depends on the distribution of the critical emission levels, where regulated firms commit 100% tax evasion and become irresponsive to any rise in the tax rate. If the distribution is symmetric, the program has no influence on the unconditional quantity limit. If it is skewed to the right, the program relaxes the limit. And if skewed to the left, the program reduces the limit. Thus, we proved that there exists a trade-off between relaxation of the cost-efficiency limit and that of the unconditional quantity limit, when additional resources are unavailable and the distribution of the critical emission levels is skewed to the left.

We can conclude that although stricter monitoring of and enforcement against regulated firms is relevant to remedying defects in PSA, government needs to be careful about choosing which firms to target. Whenever additional resources are available, government should utilize them to improve compliance by the firms which are most likely to commit total tax evasion, since government is able to relax both limits at the same time by doing so. When additional resources are unavailable, government must be conscious of the fact that there is a case where relaxation of the cost-efficiency limit is incompatible with that of the unconditional quantity limit. By reallocating monitoring and enforcement resources from the most to the least observant firms, government is always able to make the cost-efficiency limit less restrictive. However, such a policy may have an adverse effect on the unconditional quantity limit.

Finally, we would like to suggest a subject for future research. In examining programs to improve compliance, we treated their effects as exogenous influences on subjective evaluation of penalties. Our results show which firms the government should target in order to relax the limits. If we require the minimization of more realistic social costs to attain a specified level of total reduction, however, it would be necessary to consider not only the cost of misallocation of emission reductions but also the cost to ensure tax compliance.

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ボーモル/オーツ税を補完するための監視と強制

塩田　尚樹

本論では，被規制主体が脱税する可能性を考慮した環境規制の経済モデルを拡張し，ボーモル/オーツ税の実用性を向上させるための監視・強制対策について検討した。その結果，政府が監視・強制活動の強化対象としてどのような被規制主体を選択するかが重要であることが判明した。監視・強制活動に新たな資源を投入することができる場合は，それを遵守率の低い被規制主体の監視・強制に向けることが望ましい。そうすれば，ボーモル/オーツ税の費用効率性に関する制約と総削減量に関する制約を同時に緩和することができる。監視・強制活動に新たな資源を投入することができない場合，政府は費用効率性に関する制約と総削減量に関する制約のトレードオフに直面する可能性がある。遵守率の高い被規制主体から遵守率の低い主体へと監視・強制活動の資源を再配分すると，ボーモル/オーツ税の費用効率性に関する制約は必ず緩和されるが，総削減量に関する制約は被規制主体のタイプの分布によっては逆に厳しくなることがある。