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Endogenous Monitoring: A New Challenge for the Regulation of Energy Externalities*

By Katrin Millock**

Summary

The design of policy to regulate environmental externalities depends on the regulator's information base. It has typically been considered as given and static. However, by incorporating incentives for monitoring into pricing, information and policy targeting can be improved. The article models such a policy, illustrated with an application to energy end-use. Such endogenous monitoring policies can help to regulate externalities that are not directly linked to fuel use, but also depend upon the efficiency parameters of pollution sources. It provides incentives for metering of energy end-use, and thereby contributes to reducing carbon dioxide emissions. Furthermore, efficient monitoring is a pre-requisite for the success of the flexible incentives incorporated into the Kyoto Protocol. The article argues that endogenous monitoring policies could facilitate the implementation of the Clean Development Mechanism through the use of a two-part crediting system combining an ex ante standardised credit with additional credit after verification of actual reductions.

1. Introduction

The environmental externalities associated with energy use are multi-faceted. Energy use creates both local externalities such as emissions of particulates from combustion in transportation or in household stoves, as well as regional externalities linked to the acidification derived from sulphur and nitrogen emissions. For international policy, the abatement of global externalities such as greenhouse gases has become a priority. The Kyoto Protocol, signed in December 1997, sets out objectives for the abatement of anthropogenic greenhouse gases. The present article studies the problem of regulating externalities from energy use, with particular emphasis on the problem of information. A standard economics perspective examines the regulator's choice of policy instrument as dependent on a set of criteria: environmental effectiveness, cost efficiency, administration, monitoring and sanctioning costs. The feasibility of using economic instruments such as emission taxes or tradable quotas, or regulation such as performance or technology standards, thus is intrinsically dependent on the amount and type of information that the regulatory agency possesses. The problem is that the information base most often is considered fixed and static, although information can be improved by investments in monitoring. The implications of this possibility have not been studied in-depth.

The article shows how the optimal choice of instruments used to regulate the externalities from energy use will change with the more widespread adoption of modern monitoring technologies. The acquisition of information on individual pollution sources will enable the implementation of policy instruments that are better targeted, that is, adapted according to the individual pollution source. Recognition of this fact opens up a range of new opportunities for policy. There could be important implications in at least three fields. First, it can improve the regulation of sulphur emissions and other emissions depending on the efficiency characteristics of technology. Second, by providing better incentives for metering, it can also narrow the efficiency gap related to energy end-use. Third, on an international level, the use of project-based approaches such as the Clean Development Mechanism, envisaged in the Kyoto Protocol, will depend crucially upon proper verification and enforcement proce-

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dures.[1] We will illustrate how the application of incentive policies conditioned on monitoring can contribute to the implementation of flexible mechanisms for greenhouse gas abatement.

Section 2 briefly summarises the economic framework for the regulation of externalities resulting from energy use. In Section 3, an illustrative model is presented in which the introduction of monitoring of emissions is endogenous and conditions the best type of instrument used by the regulator to internalise the externalities from energy use. Section 4 then examines the implications of this framework for the application of the flexible incentives introduced in the Kyoto Protocol. It shows how the success of project-based approaches, such as Joint Implementation and the Clean Development Mechanism, depends upon the implementation of appropriate incentives for monitoring. Section 5 concludes.

2. Instrument choice for environmental policy

The instruments that normally are considered as regulatory tools can be categorised under three main headings: economic instruments (emission charges or tradable quotas), regulation based on command-and-control, and finally, voluntary approaches.[2] The use of economic instruments has increased considerably in the past years in OECD countries.[3]

Economic instruments for environmental regulation are commonly compared to what has been labelled command-and-control regulation. The term has to a certain extent obscured the fact that such regulation can take many forms, including both the prescription of a certain technology (such as norms of adopting the best available control technology[4]) or the stipulation of an allowed quantity of emissions (performance standards). Helfand (1991) shows how the economic efficiency of command-and-control regulation varies with the specific type of standard.

Voluntary approaches, or environmental agreements, have been prominent in recent environmental legislation, e.g. the Fifth European Programme for Environmental Action. A standard typology[5] separates unilateral commitments by firms (self-regulation such as the Responsible Care initiative by the Chemical Producers' Association in Canada), public voluntary schemes (which may entail subsidies for the adoption of some technology or a publicly sponsored label), and finally, negotiated agreements between the regulator and an individual firm or a collective of firms. A negotiated agreement specifies an aggregate target of pollution reduction to be reached within a given timeframe. The likelihood of reaching a negotiated agreement, and its properties, will depend upon the regulatory threat of mandatory regulation, the cost of public tranfers, and the bargaining power between the regulator and the firms.[6]

Since the externalities from energy use are complex, it is likely that a combination of different instruments will be necessary to solve the problem. Different criteria have been put forward to facilitate the choice of policy instrument:[7] environmental effectiveness[8], static and dynamic efficiency, information intensity, ease of monitoring and enforcement, flexibility to confront technological change, equity, market structure, legal structure, and political feasibility.

The criterion we will analyse in-depth in this article is the information base. Typically, it has been treated as given and static. Instead, possibilities exist to improve the information base, which will in turn change the set of instruments that ought to be applied to regulate externalities. The next section will show how the information base is intrinsically linked to the monitoring and enforcement possibilities of the regulatory agency, and thus, ultimately to the environmental effectiveness of the policy instrument. This link has received relatively little attention in previous analyses of how to apply economic incentives for the regulation of environmental externalities. Mandatory monitoring of all sources or spot controls of some sources is frequently used to enforce pollution laws. If incentives for monitoring are incorporated into pricing policies, the decision to install monitoring will be an endogenous choice by polluters. We label this endogenous monitoring. We will show that the advantages of endogenous monitoring are important both for national policies that aim at regulating the externalities from energy use as well as for the international flexible incentives introduced in the Kyoto Protocol to control greenhouse gas emissions.

The general problem of information and uncertainty can be treated from several angles.[9] Here, we will treat in detail the aspect of asymmetry of information between the

[1] Another crucial issue, the definition of the baseline, will not be discussed here.

[2] Legal approaches such as liability could be added to the list. In certain ways, it resembles some of the other instruments. For instance, a collective negotiated agreement resembles the principle of joint and collective liability.

[3] OECD (1995). We will not enter into the details of the theory of emission charges and tradable quotas here, since it will be familiar to most readers, but simply refer to the excellent survey by Cropper and Oates (1992) or the classical text by Baumol and Oates (1988). Tietenberg (1992, 1995) explores the functioning and characteristics of a market of tradable emission quotas in great depth.

[4] See Pearce and Turner (1990) for a presentation of technology-based pollution control in the EU and in the US.

[5] Carraro and Lévêque (1999).

[6] Segerson and Miceli (1998).

[7] Bohm and Russell (1985); Hanley et al. (1997).

[8] Defined by how closely the policy reaches the abatement objective.

[9] In a classical examination of uncertainty about marginal abatement costs, Weitzman (1974) showed that the advantage of quantity-based versus price-based rules depends upon the difference in

regulatory agency and polluters. The relevant information problem is the following: the individual emissions by each firm are private knowledge[10], and the regulator cannot know the benefit of reducing emissions at an individual unit. This problem is more or less severe according to the sector of energy use. In the case of regulated public utilities, partially owned by government, the problem may be less prevalent, but it will be particularly important for transport or household energy use, where many small pollution sources contribute to pollution that in aggregate terms create an environmental problem. In theory, the difficulty of regulating several small pollution sources when individual emissions are not observable can be solved by applying collective charges whenever pollution exceeds a certain threshold value.[11] The political feasibility of implementing such a solution seems small, however.

Research based on the theory of asymmetric information is useful in several manners.[12] Related to energy, it has for example been used to examine whether environmental policy will be efficient when there is a separate regulator encharged with the energy industry (the public utilities commission) and another one (the environmental agency) separately in charge of regulating environmental externalities.[13] One of the most relevant lessons is that the externalities from energy use may be easier to regulate than other environmental externalities. This counter-intuitive statement derives from the special structure of the energy industry and its history of close direct regulation.[14] Even after privatisation and deregulation, most countries have appointed utilities commissioners to oversee either the rate setting in itself, and/or market conditions in general. Hence, the regulator has means to affect both the pricing of energy as well as the pricing of the externality in itself. Mechanism design shows that the regulator can control externalities arising from many small sources by relying upon observations of output or input use.[15] Statistics on energy use for individual units can be quite detailed, and at least for some emissions (carbon dioxide emissions notably) there exists a direct proportional link between input use and resulting emissions which allows for efficient regulation even when individual emissions are not observable. The idea of endogenous monitoring will therefore not be applicable to the energy system at large; nevertheless, it has a potential role in three specific areas.

For certain emissions from energy use, e.g. sulphur emissions or particulates, the type of fuel, the vintage of technology, its maintenance and the efficiency with which it is used will significantly affect the quantity of emissions. Here, it is not efficient to base regulation only upon observation of input use, and incentives that improve the information on individual pollution sources will be important. The second area of application relates to the regulation of energy end-use. When energy demand elasticities are low, or the price signal is diluted, a price increase may not be sufficient to induce a reduction in energy use. Pricing policies for which different tariffs are levied according to the existence of a meter or not may provide stronger signals for consumers to invest in energy-saving technologies and reduce energy consumption. Third, for project-based flexible mechanisms such as the Clean Development Mechanism, transaction costs can be very high and endogenous monitoring can offer opportunities for cost savings.[16] There are thus potential applications of endogenous monitoring in at least three large areas of energy policy. For illustrative purposes of the more general framework, the next section develops a model that allows for non-observability of individual emissions in combination with heterogeneity in energy use.

3. Endogenous monitoring of externalities: an illustration applied to energy end-use

In this section, we present a basic model illustrated with an application to energy end-use. The limitations of the model are the following. It only treats energy as an input and does not study the issue of regulating the energy-producing industry itself. In fact, the lower number of actors in the production stage as well as some embodied technical change may facilitate the regulation of that sector. On the other hand, regulating energy end-use is maybe more challenging because there is a multiple number of small heterogeneous energy users and because of the fact that behavioural factors may nullify the impact of technical change.

We assume there is a continuum of different units of emission sources, each characterised by a parameter θ, representing the efficiency of energy-using technology. For example, θ, can be interpreted as the efficiency of the motor of a vehicle, or the vintage of capital. The regulator does not know individual values of the heterogeneity

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absolute value of the marginal damage and abatement cost functions. One important part of uncertainty regards the possible irreversibility of damages and the existence of an option value for investment in emissions abatement (Arrow and Fisher 1974; Henry 1974). Ha-Duong (1998) evaluates the relative magnitude of these effects for the problem of climate change.

[10] Uncertainty about abatement costs or quantity of emissions cause quite different problems. Only the second aspect will be treated here.

[11] Segerson (1988).

[12] Lewis (1996) provides an excellent survey of different applications of contract theory and mechanism design to environmental regulation.

[13] Baron (1985).

[14] Here, on the other hand, a risk of regulatory capture exists.

[15] Laffont and Tirole (1993); Laffont (1994).

[16] Based on Coase (1937), transaction costs are normally defined as costs of information search, negotiation and monitoring. For an application to the energy sector, see e. g. Ostertag (1999). Endogenous monitoring can lower transaction costs by saving monitoring costs.

parameter θ, only its distribution. The simplifying assumption is made that the technology is homogeneous within each production unit.[17] θ is distributed on a support $[\underline{\theta}, \overline{\theta}]$ with a known, continuous, strictly positive density function $f(\theta)$ and a distribution function $F(\theta)$. Each unit's energy use, e, is dependent on the location of the unit on the space of θ, $e=e(\theta)$. For example, in the case that θ represents the efficiency of the motor of a vehicle, e would represent the amount of petrol. In the case that e represents the energy input of a manufacturing industry, θ would represent the vintage of capital. It could be the type of industrial boiler, and e, its fuel use.

The net profits of each unit are defined as $\pi(e(\theta),\theta)$, shorthand for the full specification of the value of output net of input costs: $\pi(e(\theta),\theta)=p_y g(e(\theta),\theta)-p_e e(\theta)$. Output price, p_y, and input price, p_e, are assumed fixed. The production function, g, is assumed to be concave in input use e. Furthermore, production is assumed to increase with θ, and the cross derivative between θ and energy use is assumed to be negative:

$$\frac{\partial g}{\partial e}>0;\quad \frac{\partial^2 g}{\partial e^2}<0;\quad \frac{\partial g}{\partial \theta}>0;\quad \frac{\partial^2 g}{\partial e\partial \theta}<0. \tag{1}$$

The first two derivatives are standard characteristics of decreasing marginal productivity. Taken together, the third and fourth condition on the production function imply that units with a high θ are more productive and use less input for a given level of output than units with a low θ. In the absence of any policy on externalities, producers will use energy input at a level where the value of its marginal productivity equals its private input cost:

$$p_y \frac{\partial g(e(\theta),\theta)}{\partial e}=p_e \tag{2}$$

Energy use causes externalities, however, denoted $z=z(e(\theta),\theta)$. Externalities are a function both of the quantity of energy input that is used, and the heterogeneity parameter of the unit. A more fuel-efficient appliance, for instance, would cause less energy waste, thus reducing energy externalities.[18] Externalities are assumed to increase with energy use, but decrease with the efficiency of technology:

$$\frac{\partial z}{\partial \theta}<\theta;\quad \frac{\partial z}{\partial e}>0;\quad \frac{\partial^2 z}{\partial e^2}\geq 0.^{19} \tag{3}$$

Aggregate pollution is defined as

$$Z=\int_{\underline{\theta}}^{\overline{\theta}} z(e(\theta),\theta)f(\theta)d\theta. \tag{4}$$

The social cost of pollution is assumed to be a convex function of aggregate pollution, C(Z):

$$\frac{\partial C}{\partial Z}>0;\quad \frac{\partial^2 C}{\partial Z^2}>0.^{20} \tag{5}$$

Without the possibility of measuring emissions, and without observing input or output use, the regulator can at most only check whether a certain unit is operating or not. Based on this information, the only economic instrument that can be applied to control pollution is a uniform licence fee T on operating units. Since the licence fee cannot be varied according to the amount of pollution of each production unit, each unit will use energy at a level disregarding external costs, defined by e_0^*:

$$e_0^*=\arg\max \pi(e(\theta),\theta)-T. \tag{6}$$

The net profits of operating units can then be defined as $\pi(e_0^*(\theta),\theta)-T$.

There will be a marginal operating unit, θ_m, defined as the unit just able to carry the cost of the licence fee:

$$\pi(e_0^*(\theta_m),\theta_m)=T. \tag{7}$$

In order to set the level of the licence fee to maximise social welfare, the regulator has to solve the following problem[21]:

$$\underset{T}{Max} \int_{\theta_m(T)}^{\overline{\theta}} \pi(e_0^*(\theta),\theta)f(\theta)d\theta - C\left(\int_{\theta_m(T)}^{\overline{\theta}} z(e_0^*(\theta),\theta)f(\theta)d\theta\right) \tag{8}$$

The objective is to maximise the social surplus from energy use less its environmental costs. The necessary first order condition for setting the optimal level of the licence fee implies that:

$$C'\left(Z_0(T^*)\right) z\left(e(\theta_m^*(T^*)),\theta_m^*(T^*)\right) = \pi\left(e_0^*(\theta_m^*(T^*)),\theta_m^*(T^*)\right)=T^* \tag{9}$$

where

$$Z_0(T^*)=\int_{\theta_m^*}^{\overline{\theta}} z(e_0^*(\theta),\theta)\, f(\theta)d\theta$$

The optimal licence fee on each operating unit, T^*, is equal to the marginal cost of pollution, evaluated at the optimal aggregate level, times the pollution of the mar-

17 Note that θ is treated as a given parameter in this static model, e. g. in the short run, the polluter cannot change θ by investments.

18 It is assumed the rebound effect is not large enough to outweigh the initial savings. In fact, the conditions imposed on the production and pollution functions ensure this is the case.

19 The second derivative is necessary for the second-order condition of a maximum.

20 In order to focus on the problem of observability of emissions, it is assumed that the damages can be measured in monetary terms.

21 Under the assumptions specified in equations (1) and (3), profits increase with θ and the units that will close down are in the interval between $\underline{\theta}$ and θ_m. Proofs are in Millock, Sunding and Zilberman (1999), or available upon request.

ginal unit θ_m. (All proofs are in Millock, Sunding and Zilberman, 1999.) In the absence of information, regulation thus takes a precautionary stance and accesses a tax level corresponding to the worst case scenario (since pollution decreases with θ, θ_m has the highest level of pollution.) Note that this policy is very costly in that a large number of units could be forced to close down in order to reduce pollution[22] – this is a direct effect of the lack of targeting the most polluting units in the absence of information on each individual unit.

Now, suppose there is a monitoring technology available that would cost v to install per unit. If such a monitoring technology could be installed to measure the pollution by each individual unit, policy could be targeted so that each unit carries the true social cost of its energy use through the payment of an emission fee t. Individual energy use would be adjusted to a level denoted e_1^*, where

$$e_1^* = \arg\max \pi(e(\theta),\theta) - tz(e(\theta),\theta) - v. \qquad (10)$$

The net profits of each monitored unit can then be defined as

$$\pi(e_1^*(\theta),\theta) - tz(e_1^*(\theta),\theta) - v. \qquad (11)$$

Consider the extreme case, where monitoring is mandatory for all units that wish to operate. In order to define the socially optimal level of production and pollution, the following problem has to be solved:

$$\underset{\delta(\theta),e(\theta)}{Max} \int_{\underline{\theta}}^{\bar{\theta}} \big(\delta(\theta)\, \pi(e(\theta),\theta)\big) f(\theta) d\theta - C\left[\int_{\underline{\theta}}^{\bar{\theta}} \big(\delta(\theta) z(e(\theta),\theta)\big) f(\theta) d\theta\right] \qquad (12)$$

subject to

$$0 \le \delta(\theta) \le 1$$
$$0 \le e(\theta)$$
$$\underline{\theta} < \theta < \bar{\theta}$$

where $\delta(\theta)$ indicates the fraction of quality θ that is in operation. The necessary conditions for an optimal solution $e_1^*(\theta)$ and $\delta^*(\theta)$ are:

$$\frac{\partial \pi(e_1^*(\theta),\theta)}{\partial e_1} = C'(Z^*)\frac{\partial z(e_1^*(\theta),\theta)}{\partial e_1} \quad \forall \quad \theta \qquad (13)$$

$$\delta^*(\theta) = 1 \quad if \quad \pi(e_1^*(\theta),\theta) - C'(Z^*)\frac{\partial z(e_1^*(\theta),\theta)}{\partial e_1} - v \ge 0$$

$$\delta^*(\theta) = 0 \quad if \quad \pi(e_1^*(\theta),\theta) - C'(Z^*)\frac{\partial z(e_1^*(\theta),\theta)}{\partial e_1} - v < 0 \quad \forall \quad \theta \qquad (14)$$

Equation (13) simply states that energy should be used at a level where its marginal social benefit equals its marginal social cost. Equations (14) state that those units for which net profits less monitoring and externality costs are negative should not operate.

Millock, Sunding and Zilberman (1999) show that the optimal level of external effects defined in equations (13) and (14) can be implemented through a Pigovian tax on emissions, $t = C'(Z^*)$, and a requirement that the polluter pays the monitoring costs. Subsidising units to install monitoring equipment would induce too much monitoring technology and is not preferable. Note that the more costly is the monitoring technology, the lower will be the charge on emissions. High monitoring costs force more units to close down, thereby lowering the aggregate level of pollution.[23]

A special case of the policy is when v=0. This is the traditional full information case of a Pigovian tax. The model presented here thus extends the use of an emission tax to include the cost of monitoring individual emissions.

Given the cost of imposing mandatory monitoring of all pollution sources, an intermediate solution can be envisaged. It entails a delegation of the choice of monitoring to individual units through the use of a policy that provides incentives for the investment in monitoring. A simple linear policy to yield incentives for monitoring is the following. Any non-monitored unit will pay a fixed fee T_0 since the regulator cannot distinguish the individual contribution to aggregate pollution of each unit. Units that adopt monitoring will pay an emission tax t per unit of pollution and a fixed tax T_1, which amounts to a subsidy when $T_1<0$. Under certain conditions, there will exist a unit θ_c that will be indifferent between adopting monitoring equipment or not. Millock, Sunding and Zilberman (1999) show that the optimal linear incentive scheme consists of taxes

$$T_0 = C'(Z^*)z(e_0^*(\theta_m),\theta_m), \qquad (15)$$

$$T_1 = C'(Z^*)\big[z(e_0^*(\theta_m),\theta_m) - z(e_0^*(\theta_c),\theta_c)\big], \qquad (16)$$

$$\text{and } t = C'(Z^*). \qquad (17)$$

The fixed fee T_0 is equal to the undifferentiated licence fee described above. It equals the marginal social cost of pollution times the pollution of a non-monitored unit of type θ_m (equation 15). Monitored units pay an emission fee $t = C'(Z^*)$ on their observed individual pollution (equation 17). In addition, the policy entails a subsidy to monitored units corresponding to the social value of the difference between imputed pollution and actual pollution

22 Polluters could try to avoid the payment of the licence fee by merging several units in order to minimize tax payments. The analysis excludes this possibility.

23 Under the assumptions of the model ($\frac{\partial \pi}{\partial \theta} > 0$ and $\frac{\partial z}{\partial \theta} < 0$), the units that close down are at the lower end of θ.

by a monitored unit with $\theta = \theta_c$ (equation 16). This is the incentive to invest in monitoring of individual emissions. The fact that a fixed tax is levied on non-monitored units makes the policy self-enforcing. It is in the interest of the individual agent to try and reclaim the difference between the fixed fee and actual pollution costs.[24] The policy makes the decision to install monitoring endogenous and saves resources compared to compulsory monitoring of all units. The optimal level of monitoring will depend upon the cost of monitoring, the benefits from emission reductions as well as the distribution of the units according to the heterogeneity parameter. In comparison with a policy of mandatory monitoring, the welfare gains from the proposed policy will be the largest in the case when the cost of monitoring is high, when the environmental benefits from constraining pollution are small, and when constraining energy use to control externalities causes a large loss in the surplus from production.

The model can be extended to include several parameters of observation. For example, concerning transport externalities, the regulatory agency may be able to observe vintage of the car or the maintenance level at low cost and implement a policy combining undifferentiated fuel taxation with differentiated taxes depending on car vintage or the state of maintenance of the car. The basic point remains the same - there is a marginal benefit from investing in monitoring since it allows a more direct "targeting" of policy.[25]

This is not the place to derive direct policy implications from the basic model used to illustrate the idea, but we will outline the implications for the three areas where endogenous monitoring may have potentially large effects. First, it is clear that the incentive scheme can be applied both to problems of measuring the *quantity* of energy use, as well as the quantity of pollution arising from energy use (the *quality* aspect). For externalities resulting from transport, the measurement of different forms of emissions from an individual car could be envisaged at a certain cost. Taxation based upon the measurement of actual emissions would aim at changing behaviour regarding engine maintenance, fuel choice, and driving patterns. Sometimes, substitution possibilities for the individual household are limited, however. Emissions per volume unit of fuel are mainly determined at the refinery level. At the household level, possibilities for reducing emissions then include the change to a more environmentally efficient vehicle or the better maintenance of the vehicle. The proposed policy makes it in the driver's interest to try and regain part of the fixed payment if it can be proven that his vehicle is less polluting than the standard one. Experience shows that spot controls do not give the same incentives for continuous maintenance, and that there is scope to improve the compliance rate.[26] Administration of the policy can easily be incorporated into existing systems that require annual controls of the car.

Concerning the regulation of quantity, the most intuitive example relates to the measurement of energy consumption in residential multi-family housing. When there are few substitution possibilities for the fuel choice of the individual household, the control of the quantity of energy consumed by households constitutes a means of controlling the externalities from their energy use. There is thus a direct link between metering energy end-use and the externalities resulting from energy use. Implementing a two-part tariff conditioned on the existence of a meter will give incentives to some households to invest in such meters, and consequently contain incentives for wasteful use of energy. It could thus be helpful in overcoming the so-called efficiency gap, relating to the difference between current energy use and optimal energy use.[27] Several market failures may explain the efficiency gap, but also the possibility that consumers in fact make rational investment decisions taking into account the uncertainty about future energy prices and the irreversibility of investments.[28] In addition, there exists the possibility of inertia among consumers.[29] A two-part tariff such as suggested here may give a stronger signal to consumers than simply raising input price.

Finally, it is important to note that in some cases the mis-use of monitoring policies has led to a certain reluctance to implement policies that will have beneficial incentive effects, if correctly used. A case in point is the deregulation of the Swedish electricity market, in which the installation of a meter was made a condition for switching supplier. The requirement acted as a barrier to free competition in the market, and was subsequently abolished for small users. The inherent economic logic of metering energy use and its externalities should not be confused with its misuse as a market barrier.[30]

4. Endogenous monitoring: a pre-requisite for the success of the Clean Development Mechanism

In this section, we will show how endogenous monitoring might be helpful in the implementation of the project-

24 This resembles the idea proposed by Swierzbinski (1994) of a deposit-refund system for pollution charges.

25 See Verhoef and Nijkamp (1999) for a detailed comparison of second-best policies for heterogeneous firms and targeted first-best policy.

26 Harrington et al. (1996).

27 Hourcade et al. (1995).

28 Hassett and Metcalf (1993).

29 Jaffe and Stavins (1994).

30 In addition, the political feasibility of actually implementing the monitoring policy will depend upon its distributional consequences (compared to the initial rate setting rule).

based flexible mechanisms specified in the Kyoto Protocol, in particular the Clean Development Mechanism.

The Kyoto Protocol specifies binding targets for greenhouse gas emission reductions for the countries listed in Annex I. Article 3 of the Protocol details the specific conditions of the commitment, which is to limit overall emissions of greenhouse gases by at least 5 per cent below 1990 levels in the commitment period 2008-2012. The Protocol includes three different forms of flexible incentives: emissions trading (Article 17), Joint Implementation (Article 6), and the Clean Development Mechanism (Article 12). Article 17 states that

"The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article."[31]

The concept of emissions trading is thus limited by the phrase "supplemental to domestic actions", and the rules for such trading have not yet been worked out. Joint Implementation (JI) is the one flexible mechanism for which there is some previous experience on the international level. Since it is project-based, it does not necessarily have the same efficiency properties as an emissions market.[32]

For emissions trading, the problem of monitoring individual emissions may be considered resolved within the workings of the trading mechanism itself. On a macro level, the regulator can control the aggregate quantity of emissions, at least to a first approximation. On a micro level, the trading partners have incentives to control the quantity in order to realise the gains of trade. The detailed implementation of monitoring procedures for emissions trading are certainly important to investigate, but the use of endogenous monitoring may here be of secondary importance. In contrast, since both JI and the Clean Development Mechanism (CDM) operate on a project basis, no aggregate accounts exist by which to verify emission credits. The discussion hence focuses on the implementation of JI and the CDM.

Whereas emissions trading and JI can be used only among Annex I countries (that is, countries with a binding emission reduction target), the CDM was conceived as a means of allowing flexibility in abatement between a Party listed in Annex I and a non-Annex I country. Article 12(2) states that

"The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3."

Furthermore, Article 12(5) states that emission reductions resulting from the project shall be certified by the Conference of the Parties on the basis of:

"(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity."

One special provision concerning the CDM is that part of the proceeds from certified projects should be allocated towards financing adaptation by Parties that are especially vulnerable to global climate change. (Article 12(8)). This represents a bias against the CDM in favour of the other two flexible mechanisms. On the other hand, emission reductions under the CDM can be used already from the year 2000, which is not the case of credits from the two other flexible mechanisms.

One of the central questions concerning JI and the CDM is the fear of fictitious abatement. Furthermore, the possibility of using reductions compared to baseline in Eastern European economies in transition led to a denunciation by environmental groups of the sale of credits for "hot air". The problem derives from the specification of a baseline under which emission targets already are above the emissions under business-as-usual. In order to ensure the participation of developing countries with many other priority problems, specific conditions were added to the CDM: additionality to existing bilateral aid, and requirements to ensure sustainable development. Forestry projects are not eligible for the CDM, for instance.[33] Participation in the CDM is voluntary, which means that policies have to be self-enforcing. The fact that two parties might benefit from concluding a contract under the CDM without necessarily contributing to the overall goals of emissions abatement set out in the Kyoto Protocol has led to serious questioning of the possibility of implementing the CDM. How can transparency, efficiency and accountability be achieved?

There is a problem of hidden information in both mechanisms, since the actual amount of emissions reduction is private information of the two parties to an agreement. This creates a moral hazard problem. In terms of contract

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31 UNFCCC (1998).

32 Bohm (1997).

33 According to a strict interpretation of Article 12, land use change or forestry activities should not be included since the article does not mention such activities explicitly. The issue is at the moment undecided and subject to negotiations by the Conference of the Parties.

theory, the CDM has to fulfil both participation and incentive compatibility constraints. Participation constraints guarantee the participation of the non-Annex I countries by allowing them at least their status quo payoff. Transfer payments to ensure the participation of agents is a common feature of contracts entered into voluntarily by agents. The specification of baselines that created "hot air" can in this perspective be interpreted as necessary compensation to fulfil the participation constraints of poor countries. Incentive compatibility constraints ensure that the stipulated abatement actually takes place, and that no party has incentives to cheat about the amount of credits obtained. The incentive compatibility constraints can severely decrease the cost savings resulting from the flexible mechanism.[34]

The main problems with the CDM are the difficulties of an unobservable baseline for the host country and the uncertainty in verifying the actual emission reductions. In contrast to emissions trading, the parties have a common interest in colluding by overestimating the emission reductions generated by the project. Since the transparency and accountability of the mechanism depends upon verifiable measures of actual achievements, there exists a trade-off between the number of projects that enter into the mechanism and its environmental integrity; the stricter requirements on verifiability are imposed, the fewer projects are eligible.[35] On the other hand, if there is a true problem of cheating, the actual aggregate emission reduction obtained under a stricter policy of verification may exceed that of a policy maximising the number of projects. This is part of the trade-off that future research needs to investigate.

The cause of the enforcement problem that riddles both JI and the CDM resides in the technical and legal problems in setting up a credible sanctioning system. For the CDM, an executive board is designated to supervise the mechanism. The costs of certifying emission reductions for every project, however small, may be prohibitive. In addition, the problem of allocating liability between buyer and seller remains unresolved. Article 18 states that the Parties to the Protocol shall determine and address cases of non-compliance, including "the development of an indicative list of consequences". Whether a credible enforcement system at all can be worked out on an international level remains at the heart of the problem of implementing the flexible mechanisms. The basic credibility of the system worked out in the Kyoto Protocol depends on whether solutions can be found to this problem.

Contract theory can in this case be helpful in order to put in place self-enforcing mechanisms. Explorations of the functioning of JI have led to proposals that baselines should be specified independently of each party's characteristics.[36] The investing party would be credited any reduction below this exogenous baseline, and would thus have an incentive to verify actual emission reduction. Since the baseline in the Kyoto Protocol is set to 1990 emission levels, it should be exogenous as to future decisions, but it will by its nature depend upon the characteristics of each party. For the CDM, the problem is more difficult to solve since the host country by definition lacks a baseline emissions reduction target. A second proposal to solve the incentive compatibility problem is to have a third-party act on behalf of the host country, i. e. strategic delegation.[37] The difficulty with this option lies in the necessity to ensure that the pay-off to the agent does not vary with the payoff to the host country.

An application of the analysis in Section 3 may help to elaborate possible solutions to the problem. Currently, no standardised emission accounting exists on a project level. This is where a policy giving incentives for monitoring and self-enforcement becomes relevant. Conditioning the allocation of credits according to whether actual and verifiable measurement of emission reduction is done or not will give incentives for proper monitoring. The alternative for the parties to the CDM would be a standardised credit of emissions reduction attributed to a certain type of project (different energy efficiency investments, the development of renewable energy sources etc.). Since there is a risk of crediting in excess of the actual reduction, only part of the estimated value will be credited ex ante. Parties that invest in providing verifiable evidence of emission reductions above the standard credit can then obtain the corresponding difference in credits after verification. The advantage of such a policy lies in the fact that it provides incentives for the parties to actively engage in monitoring. If monitoring of emission reductions remains the sole preoccupation of the Conference of Parties, or rather, the executive board that shall supervise the implementation of the CDM, parties to the transaction will still have incentives to cheat in their stated reductions. By transferring the burden of proof onto the parties in the transaction, part of the moral hazard problem may be avoided. The alternative of introducing mandatory monitoring of every single project would lead to extremely high monitoring costs, and is not likely to be cost-efficient. Some figures from JI-type projects may indicate the range and relative size of monitoring costs.[38] For instance, a project on reduced impact logging in Malaysia budgeted USD 150 000 for monitoring and research costs in addition to total direct costs of USD 450 000. Another project involving fuel switch and improvement of the energy efficiency of a heating plant in the Czech Republic estimated monitoring costs of

34 Hagem (1996).

35 Dutschke and Michaelowa (1998).

36 Wirl, Huber and Walker (1998).

37 Janssen (1999).

38 Dudek and Wiener (1996).

USD 20000 to 25000 for a total capital investment of USD 1500000. Dudek and Wiener (1996) provide yet further quantifications of monitoring and other transaction costs related to similar projects.

There are two dimensions to which the proposed policy might be applied: the problem of uncertainty concerning the actual emission reductions, and the determination of credit life.

Uncertainty about the actual emissions reduction

There can be a large difference between emission reductions projected ex ante and measured ex post, at the end of the project life. Data from Begg, Parkinson and Jackson (1999) on a sample of nine pilot JI projects show a range of under-performance from 0 to 70 per cent of ex ante predictions. The risk of allocating credits for fictitious abatement thus favours allocation ex post. For the investing party, however, the period may be too long and some credits are necessary at the beginning of the project in order to gain the participation of investors. There is a clear trade-off between ex ante and ex post credit allocation.[39] One option would be to allocate credits at yearly monitoring and inspection. The costs of such yearly verification may be very high, however, especially for small projects or for large infrastructural projects. This would add to the transaction costs of the mechanism and deter its use. The illustrative model presented in Section 3 suggests that a two-part crediting system maybe could be used instead.

Practically, the mechanism could work in the following manner. A standardised emission credit would be allocated to the CDM project according to some specified project types. Based upon experience from JI and pilot scale CDM projects, statistical averages of energy and implied carbon emission savings from certain types of investments can be calculated according to project type. If actual measures can verify emission reductions in excess of the standard credit, the parties will present this evidence to the secretariat responsible for the CDM, and upon verification additional credits can then be transferred to the investing party at the end of the project life. Similar to the analysis outlined in Section 3, there would be a subsidy for parties that invest in monitoring emissions and can provide the necessary evidence of actual emission reductions. The investing party will thus have incentives to ensure that proper monitoring mechanisms are included in the CDM contract. The exact size of the ex ante credit would have to be determined by weighting the risk of fictitious abatement against the costs of verifying the actual reduction. This investigation will be a topic for future research – here we simply outline possible designs for the implementation of the CDM.

Determination of the life of credits

Endogenous monitoring may also contribute to solving a second problem concerning emission reduction credits: the length of the credit. The initial credit could be certified for a specified number of years, after which the parties may demand an extension based upon verifiable proof of the persistence of actual reductions. This limitation of the life of a credit would provide incentives for continuous project maintenance rather than just initial compliance for spot checks at the start of a project. Also here there exists a trade-off between the provision of correct incentives for the parties involved in the project and the uncertainty to investors from any price volatility during the credit life.

These two applications of policies based upon endogenous monitoring may assist in solving the inevitable trade-off between environmental integrity, on the one hand, and prohibitive transaction costs on the other hand. The proposed monitoring policy is so far a suggestion for a future research agenda. Finding workable mechanisms for monitoring and enforcement of the CDM is quite urgent since any failure in implementing the CDM may have resounding effects on the use of the other flexible mechanisms in the Kyoto Protocol and may seriously damage the credibility of the Protocol.

5. Conclusions

The paper has shown that the standard policy of internalising the externalities from energy use by the means of economic instruments is heavily dependent upon the cost of monitoring and verification of actual emissions. The problem of regulating externalities from energy use was extended to a cost-benefit analysis that explicitly accounts for the monitoring costs. A policy was proposed under which part of the burden of proof of verifying actual emissions is transferred to pollution sources. The policy involves an up-front payment that is undifferentiated according to the pollution source, in combination with a subsidy related to the installation of emissions monitoring that is verifiable to an outside party. An advantage of this scheme compared to traditional environmental taxes is that price signals to consumers may be weak either because of dilution throughout several levels of the distribution chain, or because of low price elasticities of demand. A policy with built-in incentives for monitoring can provide stronger incentives for the consumer to start investigating the costs of actual energy use, and reclaim any payment that does not correspond to actual energy costs.

The article concluded by an investigation of the implications of endogenous monitoring for international policy

[39] Grubb (1999).

related to global climate change. The development of transparent and verifiable monitoring and enforcement procedures is an absolute pre-requisite for the success of the flexible mechanisms introduced into the Kyoto Protocol on greenhouse gas emission reductions. In particular, the implementation of the CDM is troubled by problems of measurement of the baseline and of actual emission reductions. The introduction of a two-part emission crediting system conditioned on the provision of verifiable measures was proposed. Credits would be allocated ex ante according to standardised estimates depending on project type. Then, at the end of the life of the project, investing parties could apply for ex post credits following the provision of verifiable measures of actual reductions.

The two-part crediting system could also apply to the determination of the life of a credit. A standard life of the credit could be determined initially. Then, upon provision of proof of durable emission reductions, it could be extended for an additional period. The mechanism aims at balancing the trade-off between ex ante credits, that distort incentives for continuous maintenance of the project, and ex post credit allocation after actual emission reductions, a policy that could lead to large uncertainties for the investing party and high transaction costs. The use of endogenous monitoring for the CDM may go some way towards alleviating the problems of implementing the flexible mechanisms of the Kyoto Protocol, a cornerstone for the successful implementation of future energy policy.

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Zusammenfassung

Endogenes Monitoring: eine neue Herausforderung für die Regulierung energiebedingter externer Effekte

Die Ausgestaltung von Maßnahmen zur Regulierung von externen Effekten auf die Umwelt hängt von den verfügbaren Informationen ab. Diese werden meist als gegeben und unveränderlich angesehen. Durch entsprechende Anreize können jedoch der Informationsstand und damit die Zielgenauigkeit von Maßnahmen verbessert werden. Der Artikel modelliert ein solches Vorgehen und illustriert es am Beispiel der Endverbrauchs von Energie. Der Ansatz bietet Anreize, den Endenergieverbrauch zu messen und trägt so zu einer Verminderung von CO_2-Emissionen bei. Er kann aber auch bei Externalitäten verfolgt werden, die nicht direkt mit dem Energieverbrauch in Verbindung stehen, aber von der Effizienz der Verschmutzungsquellen abhängen. Effizientes Monitoring ist ferner eine Voraussetzung für den erfolgreichen Einsatz der flexiblen Anreizsysteme des Kyoto-Protokolls. Der Artikel zeigt, wie endogenes Monitoring die Umsetzung des „Clean Development Mechanism" erleichtern kann, indem ein zweistufiges Verfahren verwendet wird, bei dem ex ante eine standardisierte Gutschrift für vorgesehene Emissionsminderungen gewährt wird, die durch eine zusätzliche Gutschrift nach Verifikation der tatsächlichen Emissionsminderung ergänzt werden kann.