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POLISH ACADEMY OF SCIENCES, SZCZECIN DEPARTMENT
AGRICULTURAL UNIVERSITY OF SZCZECIN
FACULTY OF ECONOMICS AND ORGANIZATION OF FOOD ECONOMY

MODELLING OF ECONOMY IN SPECIALLY PROTECTED REGIONS

Proceedings of the international conference

held on 9-11 june 1994 in Drawno, Poland

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ENFORCEMENT OF WATER PROTECTION REGULATIONS

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Introduction

For more than a decade, environmental economists have argued that any policy measures to protect the environment should make use of the market mechanism as much as possible. With private goods and competition, market transactions allocate resources efficiently. However, despite environmental economists' complaints, policy makers still prefer orders and prohibitions as instruments for environmental protection.

So far in Germany measures for water protection are almost exclusively based on orders and prohibitions. Government may declare an area a water protection area (WPA). This means that in the declared area the use of pesticides is forbidden and the use of fertilizer is strictly limited. Farmers who operate in a WPA suffer losses due to lower yields or higher operating costs. In order to avoid these losses they may consider not to comply to the standards set by the government. It is for this reason that the criminal law is of increasing importance to make sure that environmental standards are met.

But the criminal law is not only instrument for the government to set incentives to obey the law. It should be considered to pay compensation to the farmers.

In the following sections I present a model and subsequently report some results suggesting that a mix of compensation and punishment is optimal to implement environmental standards. To achieve any effect at all it is necessary to monitor farmers' use of pesticides and fertilizer.

The institutional framework

Three instruments can be employed to enforce water protection regulations: compensation, punishment, and monitoring and control.

If farmers have the water rights they will be entitled to a compensation for any regulation which causes private losses. The compensation may be considered as a price for the water right. However, the decision to participate in the market is not free. Those, whose lands are part of the WPA, must accept the proposed compensation. But still, there is a minimum compensation to be paid.

Any control measures are considered to be costly. These costs as well as the compensation are paid for out of the government's environmental budget.

The punishment used will usually be a fine. For reasons of justice the fine may not exceed a certain amount. The fine should fit the crime.

The problem to be solved is to find an optimal mix of instruments that achieves best the social goals of welfare and justice.

The model[1]

It is assumed that N farmers suffer a loss from water protection regulations. Let each farmer's loss be k_j. Government is not informed about every farmer's loss, but knows the distribution of losses. In the model it is assumed that k_j is evenly distributed in $[0, \bar{k}]$. Accordingly, the density function is given by $g = 1/\bar{k}$.

Rational farmers comply to the regulations if their payoff is at least as much as their payoff in the case of non-compliance. This can be stated as follows:

$$C - k_j \geq (1 - p)C - pF \Leftrightarrow k_j \leq p(C + F), \qquad (0.1)$$

where C is the compensation payment, F is the fine, and p is the probability of control. If a farmer is caught using pesticides in the WPA the compensation is withdrawn and, in addition, a fine must be paid (0.1) holds for risk neutral farmers.

I call condition (0.1) the compliance condition. Farmer j complies with the rules if his or her cost of compliance are smaller than the expected punishment.

[1] Models of this type have been developed by Becker (1968) and Polinsky/Shavell (1984) and (1992).

Let the number of farmers controlled be i. The individual farmer's probability to be monitored is given by

$$p = i/N. \tag{0.2}$$

The enforcement measures p, C, F adopted by the government determine the expected punishment $p(C+F)$. For the assumed distribution of private cost the rate of compliance is given by:

$$\frac{n}{m} = \int_0^{p(C+F)} g\ dk = \frac{p(C+F)}{\bar{k}}. \tag{0.3}$$

It follows that the total private cost is

$$K = N \int_0^{p(C+F)} kg\ dk = \frac{\bar{k}n^2}{2N}. \tag{0.4}$$

Water protection enhances water quality and environmental quality in general. Assuming a positive environmental effect by $U(n)$ the welfare W is given by

$$W = U(n) - K(n) - ci, \tag{0.5}$$

where c is the cost to control one farmer. Furthermore, it is assumed that environmental quality is increasing in the number of farmers who comply, and that the marginal gains from improved environmental quality exceed the marginal private cost of compliance. In other words, the WPA is not too big. Full compliance would be the most favoured outcome. However, as already stated, farmers do not comply unless they are given sufficient incentives.

To create these incentives is costly and, moreover, the government faces a budget constraint. In terms of the model the government's problem is to maximize the welfare function given in (0.5) subject to the following constraints:

$$F \leq \overline{F}, \tag{0.6}$$

where $\overline{F}$ is the upper limit to the fine.

$$C \geq \underline{C}, \tag{0.7}$$

where $\underline{C}$ is a lower limit to the compensation payment required by law.

$$B \geq NC + ci, \tag{0.8}$$

where B is the budget available for improving water quality.

and, as a technical constraint

$$i \leq N. \tag{0.9}$$

Due to restrictions of space, any technical details of the solution of this constrained maximization problem are skipped. Instead, the main results are described.

Results

The first result is that fines are used to the greatest possible extent, whenever $c > 0$.

$$F = \overline{F}. \tag{0.10}$$

The intuition behind this is as follows. Note that fines are transfers. For some given level of deterrence $p(C + F)$, if fines can be raised it is possible to lower p and thus to lower the number of costly controls. Fines and controls are substitutes. From a welfare perspective fines which are transfers are preferred to controls.

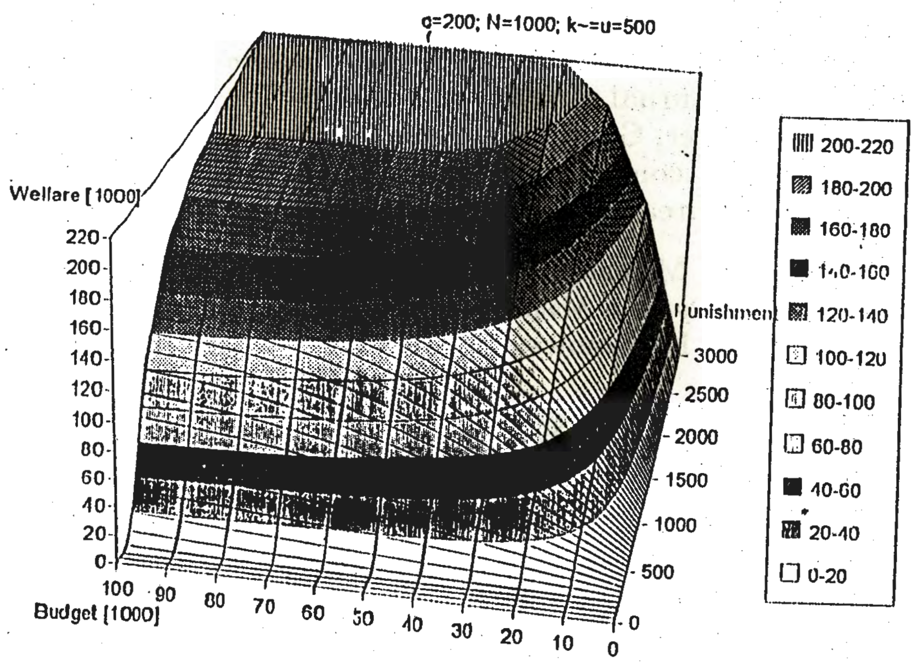
Secondly, the budget will be fully used.

$$i = \frac{B - CN}{c} \Leftrightarrow C = \frac{B - ci}{N} \tag{0.11}$$

Compensations are transfers, too. If it does not pay to have more controls, any increase in the budget will be used to increase further the compensation. This also raises the level of deterrence. If the budget allocated to water protection is greater, a particular level of protection can be achieved cheaper. Increased compensation allows the reduction of costly controls.

In figure 1 it is shown how the restriction on fines and the budget constraint affect welfare. It is clear from figure 1 that budget and fines are substitutes as instruments for water protection.

Figure 1



Conclusions

There are two conclusions that can be drawn from the model. The first concerns the informational requirements. To determine an optimal mix of instruments it is necessary to build into the model the relevant legal constraints and, in addition, a value function for environmental quality. Secondly, as has been made clear in the discussion of results, with a tight budget constraints it seems necessary to make use of substantial fines. When looking for the equilibrium of using stick or carrot to create incentives, the economies in transition may, unfortunately, be forced to give priority to the stick.

References

1. Becker, Gary S., 1968, *Crime and Punishment: An Economic Approach*. Journal of Political Economy 76, 169-217. Reprinted in: Becker, Gary S./ Landes Wiliam M. (eds., 1974) Essays in the Economics of Crime and Punishment. New York: National Bureau of Economic Research. 1-54.

2. Polinsky M. Mitchell/ Shavell, Steven, 1992: *Enforcement Costs and the Optimal Magnitude and Probability of Fines*. Journal of Law and Economics 35, 133-148.

3. Polinsky A. Mitchell/ Shavell, Steven, 1984: *The Optimal Use of Fines and Imprisonment*. Journal of Public Economics 24, 89-99.

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