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EFFECTS IN ENVIRONMENTAL POLICY

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CONDITIONALITY AND RATCHET
EFFECTS IN ENVIRONMENTAL POLICY

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Abstract: One way to integrate environmental concerns into the European agricultural policy is to let the agricultural income support be contingent on the farmer's environmental performance. With asymmetric information concerning relevant parameters like the individual farmer's cost of supplying environmental quality and in a repeated relationship there will be adverse selection problems in maximizing the environmental return of the income support policy. Adverse selection takes the form of ratchet effects and these are detrimental to environmental quality.

Jel. no. D.82, Q.19, Q.29
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CONDITIONALITY AND RATCHET EFFECTS IN AGRI-ENVIRONMENTAL POLICY

Abstract: An agri-environmental policy can pay farmers to provide environmental quality by making agricultural income support conditional on the farmer's environmental performance. In such a green payment scheme, when the policy objective is to maximize the environmental pay-off, farmers' conditionality terms must reflect the costs of supplying a given environmental quality. In the case of asymmetric information regarding these costs the regulator can up-date the policy terms as he learns about farmer type. This kind of adverse selection problem takes the form of ratchet effects and these are detrimental to environmental quality. Jel.D.82, Q.19,Q.29.

1. Introduction

The integration of social and environmental concern in public economic policies has risen to become an important issue. It is, for example, a prominent topic in the former U.S president Clinton's speech at the Davos World Economic Forum. It is also recommended in several OECD publications that public decision making must integrate environmental matters. On this basis there has, understandingly, been suggestions as to integrate environmental concerns and objectives into the European Union's agricultural income support system moving towards a green payment scheme. The idea is that agricultural income support takes the form of direct payments, and under the envisaged quid-pro-quo policy the individual farmer must meet some environmental success criteria to be eligible for income support. This is the idea of conditionality.

This paper's vision of the relationship between the farmer and his regulator is one of a series of individual short term contracts: within each time period the farmer can, if he meets some criteria, obtain income support. Our notion of conditionality makes the farmer's income support contingent on some measure of environmental performance. We assume that a farmer's cost of supplying environmental quality depends on some personal characteristic, or type,[1] which differs accross the population of farmers. In this case farmers should ideally experience individually different conditionality terms reflecting the cost of complying with the norm. The regulator is initially uninformed about a farmer's cost but he can learn over time and readjust, in order to maximize the environmental yield from the support, the conditions for getting income subsidies

[1] Xepapadeas (1997) suggest that one can think of the type parameter as describing a farmer's ability, soil composition, or proximity to a receiving body. An alternative way to model the problem at hand would be to assume that a given expense (for example a production cut) results in different environmental gains. This is analytically identical to the current approach.

. The contribution of this paper is to address, in relation to the maximization of environmental performance,[2] the adverse selection problems generated by the regulator's readjustment of the conditionality terms. Adverse selection problems has been discussed in Malik (1991) in a model with identical firms with focus on the adjustment of fixed production factors. Karp and Livernois (1994) discuss how a common tax applied to all firms can be updated over time. Niether of these papers deal with the case analysed here.

Two related characteristics are crucial to the problem analyzed here. Firstly, maximization of farmers' environmental contribution through conditionality in the income support programme may call for different individual criteria for being eligible for support and (or) different rewards for meeting the criteria. The basic reason for this is that farm profits may change differently from one farm to another when adjusting to perform to a given environmental standard. It is differences in state variables like outside earning possibilities, reservation wages or disutility of effort or, for example soil and weather conditions that account for this. In our context this calls for a regulatory scheme, i.e., conditionality terms, taking into account these state variables. The second characteristic of the problem is that the regulator can not observe state variables like reservation wages or disutility of working. However, based on current performance he can readjust his beliefs concerning the relevant state variable. This introduces ratchet effects: the notion that if the agent demonstrates that some target is not that costly to achieve then he will be met with demanding incentive schemes in the future.

This problem of adverse selection is addressed in the context of a repeated relationship: the farmer's current performance may allow the regulator to draw inferences concerning the relevant state variable and base the future terms of the income support scheme on this inference. It is well known that extensive long run contracts will outperform the kind of short run contracts analyzed here. In the current context the foundation of the ratchet effect is the absence of the regulator's possibility to commit himself to actions beyond the current period. This seems to be the most reasonable assumption since the conditionality terms are a result of political considerations that are likely to be unstable over time. In relation to earlier literature this paper, thus, contributes by introducing ratcheting problem into the analysis of green payments.

The seminal paper on non-point pollution is Segerson's (1988) analysis of moral hazard problems. Adverse selection problems in relation to environmental regulation is discussed by Laffont (1993) and by Vislie (1995). Environmental stewardship programmes are the focus in Wu and Babcock (1995 and 1996) and

[2]Of course, there does not exist a simple unifying measure of environmental quality. But there are a number of environmental indicators. In the some European Union countries targets on nitrogen losses are applied on a per farm basis.

Moxey et. al. (1999) discusses regulation through contracts when the regulator is unable to observe precisely the producer's abatement costs. Contrary to Malik (1991) and Karp and Livernois (1994) and our approach these papers consider the problem in the context of the static procurement problem under asymmetric information.[3]

2. Environmental Conditionality

We consider a regulator against a group of farmers. Farmers deliver agricultural output, denoted by x per farmer, and environmental quality given on a per farmer basis as $\Psi(x, \epsilon)$ where ϵ is some stochastic parameter relating to weather conditions, like rain and temperature. That is, for a given output there is a range of possible environmental quality levels. We follow the standard idea in the non-point pollution literature and let this range be represented by a probability density function that is conditional upon output. It is assumed here that it is costly, in terms of output, to the farmer to improve his environmental contribution, that is: $\partial\Psi(.)/\partial x < 0$ and $\partial^2\Psi(.)/\partial x^2 < 0$. As the farmer decreases his output he thus increases the chance of high environmental performance but at a decreasing rate. The Ψ-function can be interpreted as summarizing some complex relations between effort, ability, land quality and the like but involving a real cost in terms of lost output when improving environmental performance. These are the basic assumptions of the model.[4]

We make two assumptions regarding environmental performance at the farmer's level. Firstly, individual performance can be monitored.[5] Depending upon the context this can be seen as a strong assumption. Certainly, with respect to some exact environmental measure like the number of species, or the frequency of certain plants such an assumption is unsatisfactory. However, in a policy context part of the design of environmental contingencies in the income support policy would be to decide on some simple and objective environmental indicator applied on a per farm basis. A fertilizer account is one example of such an indicator: Based on factor inputs and the farm's outgoing products one can calculate, by standard methods, the farm's nitrogen loss. Since output is a function of the farmer's effort, his ability and stochastic parameters like rain and temperature the measure is objective with respect to individual environmental performance

[3] The static procurement problem is discussed at length in Laffont and Tirole (1993). In this problem the agent's payoff is zero under symmetric information. In terms of a multi-period model ratcheting will appear as a first period pooling equilibrium.

[4] Clearly, it is restrictive to assume that there is a direct link between production and environmental performance. It can be argued, e.g., with respect to nutrient runoffs, that higher yield results in less nutrient loss given the input of nutrient. Our formulation captures the idea that private profit suffers when the farmer delivers enviromental quality (at the margin). The standard approach to non-point solution is Segerson (1988). In that paper the firm chooses the level of production and abatement effort. Higher abatement effort carries a real cost since it increases the marginal costs of production.

[5] This assumption is also made in Segerson (1988) in her treatment of the single polluter problem.

while, at the same time, it only measures relevant underlying parameters, like effort, without much precision.

Regarding overall environmental performance this obtains by integrating over each farmer's environmental contribution (we assume that farmers are a continuous population). In terms of the principal-agent approach taken here this assumption allows the problem to be decomposed to a number of single agent problems. On this point we have departed from the non-point pollution literature where it is assumed, in the case of multiple polluters, that the total of abatement efforts determine environmental performance according to some possibly non-linear function. Like the assumption of a simple environmental indicator this is certainly a questionable assumption if environmental performance regards very specific themes like species diversity. On the other hand, it is quite common in the political context to specify aggregate objectives as the sum of, for example, individual losses. This is the case with nitrogen losses in several European countries.

Conditionality in the income support scheme obtains when the regulator sets some environmental target, denoted z, serving as a success criteria: it is only if actual performance meets the target that the individual farmer is eligible for income support, denoted by S. Having introduced the Ψ-function the condition for winning the right to support can thus be written as $\Psi(x,\epsilon) \geq z$. We denote by $F(z,x)$ the probability that $\Psi(x,\epsilon) \geq z$. It is assumed that $F_z(.) < 0$, $F_x(.) < 0$, and that $F_{xx}(.) < 0$. The first condition on the derivatives is obvious: as the requirement to environmental performance becomes stricter the farmer is less likely to meet the target. From the remarks above the farmer decreases the probability that actual performance is at or above the target as he increases his output. The final condition on the derivatives makes this effect more pronounced for high output relative to low output. The basic idea behind our formulation is that high output and high environmental performance are competing. This is the case when a farmer must divide a fixed number of hours or a given amount of effort between productive activities and activities minimizing the environmental strain following from production.

Denote by p the price of agricultural output and let the farmer's effort cost function be $\alpha x + \frac{1}{2}x^2$ (which is convex), where α is a type parameter distributed according to $\rho(\alpha) > 0$ with support $\alpha_l \leq \alpha \leq \alpha_u$. Allowing for type specific conditionality terms profits are:

$$(1) \qquad \pi^R = px - \left(\alpha x + \tfrac{1}{2}x^2\right) + F(z(\alpha), x)\, S(\alpha)$$

where $S(\alpha)$ is the support to an α-type farmer and $z(\alpha)$ is his succes criteria. The first and second order conditions for profit maximization are

(2) $p - (\alpha + x) + F_x(z(\alpha), x) S(\alpha) = 0$
(3) $-1 + F_{xx}(z(\alpha), x) S(\alpha) < 0$

We will assume that the farmer's type is known to himself whereas the regulator only knows the distribution of types. Type can be given a number of interpretations. One interpretation is that αx is alternative costs representing the loss of engaging in agricultural activities. The assumption is then that alternative costs differ between farmers. Another interpretation could be differences in farmers' ability. When a farmer's ability increases (low α) his costs go down. This interpretation follow Xepapadeas (1997) where environmental regulation is analysed in a static procurement model. Another possibility is to argue that αx is the farmer's disutility of engaging in production and in this case his objective function would be utility and not profit. This interpretation follow that standard procurement problem discussed in Laffont and Tirole (1993). The basic point is here that a given reduction in output in order to comply with the environmental standard is costly (in terms of reduced earnings or utility) and that costs depend on the unobservable type parameter.[6] We shall refer to α as a parameter describing alternative costs but the other interpretations we have mentioned are equally valid. Unless α is unobservable to the regulator the basis of the ratchet effect disappears. On the other hand, this is a standard assumption in much regulation literature. Being uninformed about the value of α is a problem to the regulator if his aim is to maximize the environmental return of the agricultural support. We can see this by addressing, as a reference, the case of perfect and complete information.

3. Conditionality under Complete Information

Consider the case where the regulator can observe α, that is, information is perfect and symmetric. To address more precisely the question of the terms and conditions of conditionality in income support we have to make some assumptions regarding the policy maker's preferences and regarding his options. We consider here the case where the regulator seeks to maximize farmers' total environmental contribution for a given budget. This, of course, is a somewhat narrow view. In addition to environmental concerns there can be, in the common agricultural policy context for example, social concerns regarding, say, income distribution in agriculture and there may also be concerns regarding the agricultural budget's distribution across member states. Here we neglect such

[6] To expand on the unobservability of α notice that we can define farmers revenue by $p(x - \alpha)$ where $x - \alpha$ is some production function defined over effort (x) and type (α) and $\frac{1}{2}x^2$ is the disutility of effort. In this case the regulator can not reasonably observe α. Alternatively, if the regulator has access to tax accounts and x is output he can observe only $px - \frac{1}{2}x^2$. But this does not reveal to the regulator any information about α. There are, thus, a number of interpretations suggesting that the situation of incomplete information is a relevant one. Of course, if the regulator can somehow, through observable variables, calculate the farmer's type parameter then the basis of the ratchet effect vanish.

matters and focus upon the possibilities of maximizing environmental performance. However, from the efficiency point of view the partial approach taken here commands interest as it addresses the question of cost minimization normally found in policy analysis. And it highlights some important problems regarding the design of environmental conditionality policies. Within this focus it is natural to take the total budget to be fixed. In terms of the agricultural policy this view can also appeal to the fact that budgets in the community are a result of seemingly complex political matters.

Denoting by W the total budget we address the following optimization problem:

(4a) $\quad \text{Max}_{z(\alpha),S(\alpha)} \quad \int_\alpha \Psi\left(x\left(\alpha\right), \epsilon\right) \rho\left(\alpha\right) d\alpha$

where the individual farmer's output is given by (2). The budget constraint is:

(4b) $\quad W = \int_\alpha F\left(z\left(\alpha\right), x\right) S\left(\alpha\right) \rho\left(\alpha\right) d\alpha$

With respect to (4b) notice that by the law of large numbers we have that the expectation regarding the number of farmers actually being eligible for the support is a precise number. Thus, the scheme proposed here is budget balancing in the sense that expected and actual payments to farmers sum to W. The solution to the optimization problem calls for equal output across farmers, that is:

(5a) $\quad x\left(\alpha_i, z\left(\alpha_i\right), S\left(\alpha_i\right)\right) = x\left(\alpha_j, z\left(\alpha_j\right), S\left(\alpha_j\right)\right)$

This is so since farmers' expected marginal contribution to environmental quality must be equal in order to maximize environmental return, that is:

(5b) $\quad \text{E}\left[\frac{\partial \Psi(x(\alpha_i, S(\alpha_i), z(\alpha_i)), \epsilon)}{\partial x}\right] = \text{E}\left[\frac{\partial \Psi(x(\alpha_j, S(\alpha_j), z(\alpha_j)), \epsilon)}{\partial x}\right]$

since otherwise we could change the conditionality policy and increase the conditionality's overall environmental return.[7] Equation (5b) says that the policy must support identical farm production. The point is that if farm output differs between two farmers then the convex combination of their output yields higher environmental quality (this follows from the properties of the Ψ-function.

[7]In relation to agriculture and monetary transfers to farmers it can be argued that the objective function employed here is too simplistic. The reason is that many forms of agricultural support, in the U.S. and within the European Community, are aimed at securing farmers' income. We are focussing on green payments and this may ignore policy concerns that might matter in reality. Clearly, when transfers are tied to output and farmers' only way to increase environmental performance is through reduced output then compliance will lead to less support. This issue is left for future research.

We point to two policy schemes in order to consider the implications of the requirement that each farmer chooses the same output. If the cross compliance policy takes the form of $(z, S(\alpha))$ then $S^{'}(\alpha) < 0$. This follows since the output function is decreasing in α and S: a low α points, other things equal, to high output. When a low α-value is followed by a low subsidy (S) the farmer is, through the policy, given an incentive to decrease his output so that (5b) is satisfied.[8] This demonstrates that maximizing environmental return calls for a policy involving income support's dependency on the state variable.

In the case of $(z(\alpha), S)$ we have that $z'(\alpha) > 0$ for $F_{xz}(.) < 0$ (see the next note). The incentive effects of this scheme is like that of $(z, S(\alpha))$ since the farmer's position improves with a low α: his environmental target is more easely achieved for a low α.

4. Conditionality and Ratchet Effects with Asymmetric Information

Consider now the situation of incomplete information. We focus (first) on individually based income support schemes, that is $S = S(\alpha)$, but with a common success criteria, that is z is identical across farmers. We saw in the previous section that income support should be decreasing in the farmer's type. That argument presupposed that the regulator could observe each farmer's type. Once the regulator is unable to verify the farmer's type matters are different. When the farmer's transfer, in case he actually meets the success criteria, decreases with α the individual farmer naturally seeks to persuade the regulator that α is low. The farmer's type can not be inferred by observation of actual environmental performance since this is a stochastic function. However, the regulator can observe past performance and update the conditionality terms based on these observations. Thus, if the individual farmer signals through his actions that his α is high then he will be met by unfavorable incentives in the future (a lower S-value).

The structure of the signalling game between farmers and the regulator follows the conventional models of ratchet effects: in the first period the regulator decides on conditionality terms for this period and farmers subsequently decide on production. In the first stage of the second period the regulator adjusts the

[8] From (2) and (3) and suppressing α in $z(.)$ and $S(.)$:
$dx/d\alpha = (-1 + F_{xx}(.)S)^{-1} < 0$
$dx/dS = -F_x(.)(-1 + F_{xx}(.)S)^{-1} < 0$
$dx/dz = -SF_{xz}(.)(-1 + F_{xx}(.)S)^{-1} < 0$

The last expression will be negative for $F_{xz}(.) < 0$ and positive for $F_{xz}(.) > 0$. Consider an increase in output combined with an increase in the environmental target. The output increase makes it less likely that the farmer complies with the standard. This is reinforced when environmental requirements are set higher: $F_{xz}(.) < 0$. This is the notion of first order stochastic dominance used also by Segerson (1988).

policy terms given his updated beliefs concerning the state variable (α). Focussing on a signalling equilibrium the beliefs coincide with the state variable's actual value. In the second period's second stage the farmer decides on his output. The appropriate solution is the Perfect Bayesian Equilibrium which requires strategies (here farmers' output and the regulator's decision on conditionality terms) to be optimal given beliefs, and beliefs to be consistent with Bayes' rule given the strategies. In particular, in a signalling equilibrium the regulator correctly infers the farmer's type on the basis of his past actions. At the first stage of the game the farmer will realize that the beliefs of the regulator will be affected by his output decision and will take this signalling effect into account in his output decision. Focussing on first period output's signalling role we restrict attention to continuation equilibria: the model's Perfect Bayesian Equilibrium given the first period conditionality terms.[9]

4.1. Conditionality with Type Dependent Income Support.

As usual the game is solved by a process of backward induction (hence, from now on we index variables by subscripts 1 and 2 to refer to the time period). The first step is to solve the second period where the regulator decides on the conditionality terms for the second period on the basis of his updated beliefs. Farmers decide on output once the conditions of the income support policy are fixed. For given values of z_2, identical between farmers, and $S_2(\alpha)$ output per farmer in the second period is given by :

$$(6) \qquad p - (\alpha + x_2) + F_{x_2}(z_2, x_2) S_2(\alpha) = 0$$

In a signalling equilibrium income support satisfies (also repeated for convenience):

$$(7a) \qquad x_2(\alpha_i^e, z_2, S_2(\alpha_i^e)) = x_2\left(\alpha_j^e, z_2, S_2\left(\alpha_j^e\right)\right)$$

$$(7b) \qquad \alpha_i^e = E[\alpha; x_1(\alpha)]$$

where $E[.]$ is the regulator's expectation of the individual farmer's type parameter conditional upon the farmer's first period action according to Bayes' rule. Equations (7a) and (7b) derive from the properties of a signalling equilibrium: the farmer's first period decision on production is a one-to-one function of type, and the regulator correctly infers the value of α on the basis of his observation of farmers' first period action. The existence and uniqueness of a signalling equilibrium, i.e., the basis of equations (7a) and (7b) is discussed in Mailath (1987).

[9]This type of equilibrium is studied in Freixas, Guesnerie and Tirole (1985). With incomplete information there may be many types of equilibria like pooling, partial-pooling and separating equilibria, cf. Laffont and Tirole (1993). Here the signalling equlibrium is a possibility since next period's pay off is strictly positive.

With a continuum of agents a unique signalling equilibrium requires that the signalling agent's payoff function satisfies some regularity conditions (most importantly: belief monotonicity, type monotonicity and single crossing (or strict incentive compatibility and quasi concavity). Belief monotonicity requires that the farmer's profit is decreasing (or increasing) in the regulator's estimate of his type. This follows immediately from the expression for the farmer's second period real profit:

$$\text{(8)} \qquad \pi_2^R = px_2 - \left(\alpha x_2 + \tfrac{1}{2}x_2^2\right) + F\left(z_2, x_2\right) S_2\left(E\left[\alpha; x_1\left(\alpha\right)\right]\right)$$

where x_2 is an α-farmer's output in the second period, z_2 is the success criteria in this period and second period income support for the α-farmer is determined by the regulator's expectation of α. Belief monotonicity follows immediately since $\partial\left(\pi_1^R + \pi_2^R\right)/\partial E\left[\alpha; x_1\left(\alpha\right)\right] = F\left(.\right)\partial S_2\left(.\right)/\partial E\left[\alpha; x_1\left(\alpha\right)\right] < 0$. Type monotonicity calls for $\partial^2\left(\pi_1^R + \pi_2^R\right)/\partial\alpha\partial x_1$ to be different from zero, that is, for a fixed value of the regulator's belief concerning the farmer's type, the marginal value of output must be either strictly increasing or decreasing in α. The farmer's first period profit is given by:

$$\text{(9)} \qquad \pi_1^R = px_1 - \left(\alpha x_1 + \tfrac{1}{2}x_1^2\right) + F\left(z_1, x_1\right) S_1$$

where S_1 is given once we address the properties of a continuation equilibrium. Using (8) and (9) type monotonicity obtains as $\partial^2\left(\pi_1^R + \pi_2^R\right)/\partial\alpha\partial x_1 = -1 < 0$. The final condition, single crossing, follows if

$$\left(\partial\left(\pi_1^R + \pi_2^R\right)/\partial E\left[\alpha; x_1\right]\right)^{-1}\left(\partial\left(\pi_1^R + \pi_2^R\right)/\partial x_1\right)$$

is either de- or increasing in α. This condition is met in some model specifications, like it is here, while in other contexts it is simply assumed to satisfied.

To derive the signalling equilibrium of the game, let the signalling equilibrium first period output be $x_1 = t\left(\alpha\right)$, where $t\left(.\right)$ is the farmer's (first period) one-to-one and differentiable strategy. The signalling equilibrium first period output function is derived with appeal to incentive compatibility. Incentive compatibility requires that if the farmer's type is α then he maximizes overall real profits, given the regulator's beliefs, by setting first period output by $x_1 = t\left(\alpha\right)$.[10] The beliefs regarding the farmers' type are a function of first period output, and beliefs are obtained by inverting the signalling equilibrium first period output. Thus, in the signalling equilibrium we have: $E\left[\alpha; x_1\right] = t^{-1}\left(x_1\right)$

[10]Strict incentive compatibility requires: $t(\alpha) = Arg\max_{y_1}\pi\left(\alpha, t^{-1}\left(y_1\right), y_1\right)$. This condition together with quasi concavity of the payoff ensures single crossing due to theorem 3 in Mailath (1987). With quasi concavity there is only one maximizer in the above problem.

and $S_2 = S_2\left(t^{-1}(x_1)\right)$, where $S_2(.)$ is defined by (7a) and $x_2(.)$ by (6). Based on this total real profits $\left(\pi = \pi_1^R + \pi_2^R\right)$ are:

$$\text{(10a)} \qquad \pi = px_1 - \left(\alpha x_1 + \tfrac{1}{2}x_1^2\right) + F(z_1, x_1) S_1 + \\ px_2 - \left(\alpha x_2 + \tfrac{1}{2}x_2^2\right) + F(z_2, x_2) S_2\left(t^{-1}(x_1)\right)$$

with

$$\text{(10b)} \qquad p - (\alpha + x_2) + F_x(z_2, x_2) S_2\left(t^{-1}(x_1)\right) = 0$$

The following first order condition identifies the signalling equilibrium output per farmer:

$$\text{(11)} \qquad p - \alpha - x_1^* + F_x(z_1, x_1^*) S_1 = -F(z_2, x_2^*) \frac{\partial S_2}{\partial \alpha}\left(\frac{\partial x_1^*}{\partial \alpha}\right)^{-1}$$

where x_2^* is given by (10b). The term on the left hand side of (11) identifies the ordinary static solution. On the right hand side we find the expression giving the consequences of the ratchet effect: the farmer realizes that he will be met with a less favorable income support scheme if he signals that his α-value is high. For this reason he increases his first period output for strategic reasons. This goes for all farmers except for the α_u-type farmer since α_u is the worst point estimate from the farmers point of view as this gives the lowest possible income support. We summarize this as proposition.[11]

Proposition 1: For any value of $\alpha, \alpha_l \leq \alpha \leq \alpha_u,$ but α_u, first period output increases because of the ratchet effect.

The proposition follows from Mailath (1987) Theorem 2 by noticing that the relevant regularity conditions (belief monotonicity, type monotonicity and single

[11]Proposition 1 establishes formally why there is inefficiencies in farmers first period decision. One can argue that this follows intuitively but without the formal analysis one cannot conclude this, see Mailath (1987).

A referee has poited out that environmental quality should be dependent on the farmer's type. When this is the case the Ψ-function becomes $\Psi(x, \alpha, \epsilon) \geq z$ and the probability function is $F(z,\, x,\, \alpha)$. Like before we have $F_z(.) < 0$, $F_x(.) < 0$, and $F_{xx}(.) < 0$. In this case the relevant derivatives are:

$$dx/d\alpha = (1 - F_{x\alpha})(-1 + F_{xx}(.) S)^{-1}$$
$$dx/dS = -F_x(.)(-1 + F_{xx}(.) S)^{-1} < 0$$
$$dx/dz = -SF_{xz}(.)(-1 + F_{xx}(.) S)^{-1} < 0$$

The signs of dx/dS and dx/dz are unchanged. When $F_{x\alpha} < 1$ the sign of $dx/d\alpha$ is still negative and the analysis go through unchanged. If $dx/d\alpha = 0$ then it would not be possible to rank farmers by observing output and when $dx/d\alpha$ is positive the farmer signals a low value (high subsidy) by lowering his output.

crossing) are satisfied and that the worst point estimate to be held against the farmer is $\alpha = \alpha_u$ since this gives the poorest conditionality terms. Proposition 1 demonstrates that the regulator suffers a loss in the first period due to his (discretionary) change of the income support terms in between the two periods. The individual farmer increases his production strategically and this, of course, results in too low environmental quality in the first period compared to the symmetric information situation. It is relatively straightforward that the first best is supported for $\alpha = \alpha_u$. To see this consider the signalling equilibrium. If a farmer, in the first period, maximizes this period's profit then by the virtue that this is an optimum he could change his production at no cost (he diverges from a top). Since this is a signalling equilibrium he will, by this action, change second period conditions so that they are improved. It is for this reason that the signalling equilibrium involves distorted first period output. But clearly, the farmer of type α_u can safely signal α_u since this gives the poorest second period conditionality terms.

Notice here that unless there is some way to suppress the regulator from taking action in between periods then he will act like described here given his objective. Clearly, one way to suspend the regulator's possibilities of reacting to new information is to engage in long term contracts. In such contractual relationships, however, the parties should know the future production technologies, the farmers' future alternative costs and the like. This is a problem and in addition, in the current context, there is the problem of constraining future actions in a political system where preferences may be subject to changes.

4.2 Conditionality with Type Dependent Success Criteria

Section 4.1 has demonstrated that the discretionary power of the regulator leads to excessive production and environmental degradation in the first period. The basis for this is that each farmer signals that his alternative wage is low in order to win (relatively speaking) more attractive conditionality terms in the second period. In the current setting, however, there is a range of policy options. A policy maximizing total (second period) environmental return calls for $x_2(\alpha_i, z_2(\alpha_i), S_2(\alpha_i)) = x_2(\alpha_j, z_2(\alpha_j), S_2(\alpha_j))$. Let us consider here schemes involving identical payments across farmers but with differences in the success criteria, that is, schemes of the form $x_2(\alpha_i, z_2(\alpha_i), S_2) = x_2(\alpha_j, z_2(\alpha_j), S_2)$.

With $(z_2(\alpha), S_2)$ we have that the symmetric information policy conditions are $z_2'(\alpha) > 0$ for $F_{zx}(.) < 0$. The idea here is that output is decreasing in α. Consider two types $\alpha_i < \alpha_j$ so that for identical conditionality terms $x_2(\alpha_i, z_2, S_2) > x_2(\alpha_j, z_2, S_2)$. Now if output is increasing in z $(F_{zx}(.) < 0)$ we can compensate and let $z_2(\alpha_j) > z_2(\alpha_i)$, that is $z_2'(\alpha) > 0$. This gives the individual farmer an incentive to signal that α is low: he will obtain (relatively speaking) more favorable conditions since the target is more easily achieved. Still focussing on the signalling equilibrium the farmer will increase his output above that obtaining with symmetric information. The workings of the ratchet effect is like before. The requirement on the derivative $F_{zx}(.)$ is saying that with increases in the farmer's output and increases in the required environmental quality it becomes less likely that the farmer meets the success criteria.

If individual conditionality terms regarding the success criteria would somehow involve $dx/dz > 0$, that is $F_{zx}(.) > 0$, the first best involves $z_2'(\alpha) < 0$ and the farmer will, in a signalling equilibrium, produce below the output chosen under symmetric information to strategically (attempt) to signal that his α is high. In this case the ratchet effect improves first period environmental performance. However, we have assumed here that increases in output will shift the distribution of environmental indicators to the left, i.e., it is less likely that environmental performance is at or above the target as output increases. If, in addition, the target moves to the right then the combined effect is to make it less likely that the farmer actually meets the criteria for being eligible for income support. Thus, with the seemingly reasonable assumptions regarding the distribution of environmental quality this case is excluded and we have that the ratchet effect points to low first period environmental performance.

5. Conclusion

Generally, in the context of green payments, individually different conditionality terms are optimal when farmers' costs of meeting some environmental target differ. This paper contributes by showing how ratchet effects are a result of information asymmetries and the regulator's ability to update his policy as he learns about underlying state variable. The ratchet effect makes the environmental contribution of conditionality policies less clear: current environmental quality decreases because of farmers' strategic behaviour.

Interim environmental policy is discussed in Malik (1991) and Karp and Livernois (1994). The analysis in Malik suggests that firms go for a "wait and see" policy whereas we show that first period decisions serve as a signal. This introduces inefficiencies in this period. Karp and Livernois's analysis is based on the idea that all agents meet the same policy, and eventually the economy reaches the first best. This is not possible within our setting. A number of papers focus on asymmetric information in a static context and this approach excludes the kind of inefficiency analysed here which is relevant when the relationship between the farmer and the regulator is of a repeated nature.

One of the paper's conclusions is a warming against very sophisticated and dynamic conditionality terms. A simple approach to conditionality would involve the choice of one common succes crietria and one common income subsidy rate. From the point of view of maximizing the environmental return this is ineffeicient. But, in a dynamic context, the regulator's aim to make the policy precise will result in other inefficiencies due to information failures. Thus it is not obvious that the kind of precise conditionality policies analysed here is a good idea. Clearly, the analysis could be extended and made richer by including, for example, the farmer's allocation of on farm activities between production purposes and environmental purposes, imprecise signal of environmental effort and the like in order to address the nature of the paper's conclusion more broadly. These issues are left to future studies.

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