Set-Aside versus Quotas in Contracts for Agro-Environmental Regulation

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Abstract

In this paper, we analyze the simultaneous regulation of several goods produced on agricultural land such as environmental amenities and crops. This analysis is conducted using a general two goods model where all agricultural land is used for production. The regulation authority can regulate these goods either through set aside requirements or production quotas. The paper focuses on information asymmetry about some farm performance index creating adverse selection. When public funds are non costly we show that the net social welfare induced by the two types of contracts are equal. In general we also show that if the goal of the regulation is to decrease the production of the quota good it is better to use a quota contract. On contrary if the regulation aims at increasing the production of the quota good, it is better to use a set aside contract.

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1 Introduction

Set aside programs have been mainly implemented in the framework of agricultural market regulation. Such policy has been an important regulation tool in USA with the Farm Bill Act and more recently in Europe with the set-aside programs proposed in 1988 and 1992. The aim of the regulation authority was to limit the excess of product supply and to limit the increasing public expenditure for agriculture support, even though the agricultural income support is socially accepted. It has been shown in previous papers (Bourgeon et al., 1995, Jayet, 1998) that simultaneous set-aside and high price policies could be efficiently consistent with a high weight of farmers in the welfare function (see also Gisser, 1993 for a first approach of the problem).

Another benefit from set-aside, which has been focused on recently, is the environmental impact of such a policy. In many European countries, set aside is used to produce environmental amenities. Many environmental benefits such as nutrients cleaning, can be created on set-aside land through its transformation, for example, into wetlands. When we take into account the double production aspect - the production of crops and of environmental amenities - we have now to consider that the "quality" of the land is not only due to the yields from traditional agricultural production. All the plots are characterized both by their potential yield for crop production and their potential environmental yield. In other words the land is now characterized not only by a potential private benefit but also by its potential public amenity. The regulator has to take both into account, whereas rational individual producers may focus only on the private yields.

In this paper, we propose the analysis of the simultaneous regulation of several goods produced on agricultural land such as environmental amenities and crops. This analysis is conducted using a general model of agricultural production where all agricultural land is used to produce two different goods. The principal may regulate these productions either through set aside requirements for production of an amenity or through production quotas for the marketed goods. In other words the principal may regulate the input or the output.

Plots are characterized by their private benefit capacities and production costs. Those are function of a characteristics of the farm, unknown to the regulator, who only knows its distribution. The paper focuses on this information asymmetry creating adverse selection. We keep out the public choice of the agricultural price so that the consumer is not integrated in this analysis, in which only taxpayers face producers. We show how the theory of contract is able to help us to solve our problem.

The question whether one should regulate through input or output in an asymmetric information setting has been considered earlier in several papers. Maskin and Riley, 1985 use a two goods model in which one of the good is used as input in the production of the other good. They show in the case of general nonlinear incentive schemes that monitoring output is superior under certain assumptions. Roughly these require that more productive agents supply larger input and produce larger output when only lump sum taxes are used. Maskin and Riley use a setting in which they maximize the transfer of the regulation subject to a welfare constraint.

Kahlil and Lawarrée, 1995 show that the choice between input and output monitoring will be determined by the identity of the residual claimant in the principal-agent relationship. We believe that this result, which is obtained in the framework of the labor market is less relevant for agricultural regulations. Indeed in the case of agricultural policy, residual claimancy seems to be more the result of a political process than a choice variable of the regulator. Moreover it is not necessarily clear who the residual claimant is since the agent's action may benefit both the principal and the agent, which was not the case for Kahlil and Lawarrée. Indeed in our setting the principal wants to maximize the social welfare, which also includes the profit made by the agent.

Bontems and Bourgeon, 2000 analyze the relative efficiency of input and output incentive schemes in an agency model under adverse selection. They find that two cases may appear. In the first one, both incentive schemes imply the same ranking of agents regarding the productivity parameter. In that case one instrument always dominates the other, whatever the agent's type. This is the case studied by Maskin and Riley. In the second case, the two schemes produce reverse ranking and the principal is always better off using a type-dependent mixed strategy over the two incentive schemes. If there is no restriction on mixed strategies the principal is able to implement the first best. We believe that the possibility of having mixed strategies in the framework of agricultural regulations is unrealistic because of the high transaction costs that would follow.

Our original contribution is to present an analysis of the regulation of two different agricultural goods by the means of input or output. We characterize two contracts oriented towards the double regulation policy. The first contract focuses on set aside for the production of an amenity, whereas the second focuses on the quantity of the marketed good to produce. Our settings are also a bit different compared to the articles above indeed we generally have a positive reservation profit. Further the principal takes the agents profit into account in the welfare function which is his objective function. These differences imply that the results provided by Maskin and Riley and Bontems and Bourgeon need not necessarily hold.

The remainder of the paper is organized as follows. Section 2 presents the model, section 3 derives the farmer's program, section 4 presents the regulator's programs and derives conditions for one contract to be superior to the other. Finally section 5 summarizes the results and concludes.

2 The model

We consider a set of farmers each of them owning a surface normalised to one unit. A parameter θ called performance index, characterizes the farm, and represents also the private information possibly unknown by the regulator when asymmetric information arises. The set of farmers is defined by a continuum of mass 1 on the support $\Theta = [\underline{\theta}, \overline{\theta}]$. Let $F(\theta)$ and $f(\theta)$ be respectively the cumulative distribution of θ and the corresponding density, which is assumed to be positive on Θ. A plot can be used for the production of two types of goods denoted good 1 for the amenity and good 2 for the marketed good. Let x be a plot productivity indicator[1], which follows a distribution defined by the density $h(x,\theta)$ and the cumulative function $H(x,\theta)$ common to all farms and parametrized by θ. The farmer receives either a net yield $a(\theta)$ from production of good 1 or a yield $b(\theta)x$ from production of good 2, which costs $c(\theta)$ to produce. This cost is assumed to be independent of the plot. Typically good 1 will be produced on low producing plots and good 2 on high producing plots. The support on which the distribution h is assumed to be positive and independent on θ is denoted by $X = [\underline{x}, \overline{x}]$.

The individual farmer's profit, denoted by $\pi(\theta)$, depends on the yields of both goods produced and on the production cost for good 2. Let a partition of X be defined by some threshold plot characterized by the performance index $\kappa(\theta)$. The partition is such that with no regulation, good 1 is produced on the plots with performance index below κ and good 2 is produced on the plots with performance index above κ. When no regulation process is implemented, the marginal net yields for the two different types of production are identical on the threshold plot. Given the settings of the problem we will therefore have $\kappa(\theta) = \frac{a(\theta)+c(\theta)}{b(\theta)}$. The unregulated farmer's profit is:

$$\pi(\theta) = \int_{\underline{x}}^{\kappa(\theta)} a(\theta)h(x,\theta)dx + \int_{\kappa(\theta)}^{\overline{x}} (b(\theta)x - c(\theta))\, h(x,\theta)dx \tag{1}$$

We consider now two types of contracts proposed by the principal to regulate the production of the two goods. The first one is a set aside contract by which the farmer is provided a transfer t when he agrees to set aside a part s of his land for the production of the good 1. The second one is a contract on a quantity ψ that the farmers accepts as a production limit for the good 2. This limit could be defined as a minimum or a maximum production, depending on the objective of the regulation. The transfer τ is then given as counterpart. Note that in our setting all the land is used for production of either good 1 or good 2.[2] This means that we only need to regulate one good, and the production of the other good will automatically take place on the remaining land. Without loss of generality we therefore choose to study the regulation of good 2. We assume that the principal wants a different amount of good 2 being produced than would be without any regulation. To simplify the problem further we only study two ways of regulating that good: imposing restrictions on the land available for production of good 1 or a production quota on good 2. This arbitrary choice is convenient for the special cases we want to study and the results obtained could easily be generalized to the other possible combinations. The program of the regulator is to define the optimal mechanism design related to the two

[1] It could be for example an indicator of the soil productivity for traditional agricultural production, alternatively for production of environmental amenities.

[2] We can still study the case when the farmer or the regulator decides not to produce at all on some plots. Indeed we just need to consider one of the two goods, preferabily good 1 as being nothing and giving yield $a(\theta) = 0$.

types of contracts, respectively $(s(\theta), t(\theta))$ and $(\psi(\theta), \tau(\theta))$, when it faces informational deficit.

The regulator's objective W is determined by the total farmers' income Π, the expected benefit of the amenity B, and the public budget of the regulation J. This budget includes the direct net transfers from taxpayers to producers T and the cost of the public intervention on the market of the good 2 . We take account of the shadow cost of public funds λ:

$$W = \Pi + B - (1 + \lambda)J \tag{2}$$

The total farmers' income is given by $\Pi = \int_{\Theta} \pi(\theta) dF(\theta)$. The expected benefit of the regulation is a linear function of the quantity of the good 1 produced: $B = mQ_1$. The public budget is assumed to be linear in Q_2: $J = T + nQ_2 - p$. Q_1 and Q_2 are respectively the total amount of the production of goods 1 and 2 on all the farms and m, n and p are parameters.

In this paper we consider two applications of this model to agro-environmental policies. The first application is traditional set-aside and production quotas to limit agricultural production. The second application is wetland creation on agricultural land to increase environmental amenities. Comparison of traditional land set-aside and production quotas to limit agricultural production is easily represented in the model developed. Indeed we just need to define good 1 as land set-aside and good 2 as traditional agricultural production supported by guaranteed price and refunds to export as usually implemented by the Common Agricultural Policy. We have to adapt the parameter values and put $a(\theta) = 0$, $b(\theta) = 1$, assuming that x is the yield of the plot. Further we let m, n and p be positive in the benefit function since that we aim at more amenities and less domestic supply excess of the traditional agricultural good.

Comparison of set aside and production quotas to increase the environmental amenities on agricultural land through wetland creation is a little bit more tricky. In the model this would correspond to good 1 being the production of environmental amenities through wetland creation and good 2 being the traditional agricultural production. Ideally we would like to compare a land set aside program to create good 1 with a production quota on good 2. Recall that we have assumed that all the agricultural land must be used for production of good 1 or good 2. This means that a lower limit for set aside of land for production of good 1 is the same as a corresponding upper limit for set aside of land for production of good 2, which is the case studied in the model.

It will be clearer and useful in interpreting of the results to deliver now two assumptions characterising the technology and the distribution of θ. Let us denote by $l(\theta, x)$ the difference of profitabilty related to the plot x when good 2 is produced instead of good 1, $l(x, \theta) = bx - (a + c)$, consistently with the definition of the threshold plot $\kappa(\theta)$. The first assumption $(H1)$ means that θ inclines toward a perdormance index related to the traditional good. The second assumption is the usual stochastic dominance condition

$(H2)$. We set for any θ and for any x :

$$\frac{\partial l(x,\theta)}{\partial \theta} \geqslant 0 \tag{H1}$$

$$\frac{\partial H(x,\theta)}{\partial \theta} < 0 \tag{H2}$$

3 The farmer's programs

3.1 The farmer's program with the set aside contract

The regulator might want to put a restriction on the surface used for the production of good 1. In application of the usual revelation principle[3], we consider that the optimal mechanism cannot be better than the mechanism leading the producer to reveal his own characteristic. Formally the announce $\widetilde{\theta}$ of the producer θ accepting the contract $(s(\widetilde{\theta}), t(\widetilde{\theta}))$ depends on a threshold productivity $v(\widetilde{\theta}, \theta)$ defined by the required land set aside. In accordance with the land which has to be set aside for production of good 1: $s(\widetilde{\theta}) = \int_{\underline{x}}^{v(\theta,\widetilde{\theta})} h(x,\theta)dx$, the profit is now:

$$\pi_s(\theta,\widetilde{\theta}) = \int_{\underline{x}}^{v(\theta,\widetilde{\theta})} a(\theta)h(x,\theta)dx + \int_{v(\theta,\widetilde{\theta})}^{\overline{x}} \left(b\left(\theta\right)x - c(\theta)\right)h(x,\theta)dx + t\left(\widetilde{\theta}\right)$$

Hence the farmer's program is

$$\max_{\widetilde{\theta}} \pi_s(\theta,\widetilde{\theta})$$

of which the solution leads to the first and second order incentive conditions. These conditions have to be taken into account by the regulator to be sure that the farmer announces the truth (i.e. the optimal announce is θ). The optimal set aside productivity threshold is denoted $\overline{v}(\theta)$. The incentive constraints yield:

$$\dot{t}\left(\theta\right) = \left(b\left(\theta\right)\overline{v}(\theta) - c(\theta) - a(\theta)\right)\dot{s}\left(\theta\right) \tag{3}$$

$$\left(\dot{a}(\theta) + \dot{c}(\theta) - \dot{b}\left(\theta\right)\overline{v}(\theta) + b(\theta)\frac{\partial H(\overline{v}(\theta),\theta)/\partial\theta}{h(\overline{v}(\theta),\theta)}\right)\dot{s}(\theta) > 0 \tag{4}$$

The informational rent R_s is the additional gain of the producers when he accepts to tell the truth, in other word this rent is the difference of profits between the situations with and without regulation. The informational rent is given by:

$$R_s(\theta) = t(\theta) + \int_{\kappa(\theta)}^{\overline{v}(\theta)} \left(a(\theta) - b\left(\theta\right)x + c(\theta)\right)h(x,\theta)dx \tag{5}$$

[3] See for example Green and Laffont,1979, Dasgupta, Hammond and Maskin 1979 and Baron and Myerson, 1982 .

The total differential of the rent is given by following expression derived in appendix A.1:

$$\dot{R}_s(\theta) = \int_{\kappa(\theta)}^{\overline{v}(\theta)} \left(b(\theta) \frac{\partial H(x,\theta)}{\partial \theta} + \left(\dot{a}(\theta) - \dot{b}(\theta)\, x + \dot{c}(\theta) \right) h(x,\theta) \right) dx$$

A sufficient condition for the rent to be monotonic is that the sign of the expression $b(\theta) \frac{\partial H(x,\theta)}{\partial \theta} + \left(\dot{a}(\theta) - \dot{b}(\theta)\, x + \dot{c}(\theta) \right) h(x,\theta)$ is constant. We consider the usual case for this kind of problems and assume the sign of $b(\theta) \frac{\partial H(x,\theta)}{\partial \theta} + \left(\dot{a}(\theta) - \dot{b}(\theta)\, x + \dot{c}(\theta) \right) h(x,\theta)$ is negative. This is summarized by the condition $(H3)$:

$$b(\theta) \frac{\partial H(x,\theta)}{\partial \theta} - \frac{\partial l(x,\theta)}{\partial \theta} h(x,\theta) < 0 \tag{H3}$$

Satisfaction of this condition is provided by the assumptions $(H1)$ and $(H2)$.

Let us consider that the regulator wants to increase set aside for increasing the production of amenities or for decreasing the production of the traditional agricultural good. The contract makes sense when there are incentives to set-aside, that implies $\overline{v}(\theta) \geqslant \kappa(\theta)$. Then let us note that the incentive condition (4) and the hypothesis $(H3)$ imply a necessarily decreasing set-aside requirement by the contract. That means that the lowest the farm productivity is, the larger the set aside allocation for production of good 1 required by the contract will be. Note that if the yield parameters $a(\theta)$ and $b(\theta)$ and the cost $c(\theta)$ do not depend on the general farm performance index θ,

The decreasing rent implies that the regulator proposes the contract to the θ subset $[\underline{\theta}, \eta_s]$ if he wants to decrease the production of good 2 or to increase the production of good 1. In terms of the program to reduce agricultural production or to increase environmental amenities this result means that the contract will require larger set aside on the least performing farms.

3.2 The farmer's program with the quota contract

As previously, the announce $\widetilde{\theta}$ of the producer θ accepting the contract $(\psi(\widetilde{\theta}), \tau(\widetilde{\theta}))$ depends on a threshold productivity $u(\widetilde{\theta}, \theta)$ defined by the regulated production. In accordance with the quota $\psi(\widetilde{\theta}) = \int_{u(\widetilde{\theta},\theta)}^{\overline{x}} x h(x,\theta) dx$, the profit is now:

$$\pi_q(\theta, \widetilde{\theta}) = \int_{\underline{x}}^{u(\widetilde{\theta},\theta)} a(\theta) h(x,\theta) dx + \int_{u(\widetilde{\theta},\theta)}^{\overline{x}} \left(b(\theta)\, x - c(\theta) \right) h(x,\theta) dx + \tau\left(\widetilde{\theta}\right)$$

Hence the farmer's program is

$$\max_{\widetilde{\theta}} \pi_q(\theta, \widetilde{\theta})$$

The optimal threshold yield is denoted by $\overline{u}(\theta)$. The incentives conditions can be defined by:

$$\dot{\tau}(\theta) = (a(\theta) + c(\theta) - b(\theta)\,\overline{u}(\theta))\,\dot{\psi}(\theta) \tag{6}$$

$$\left(\dot{a}(\theta) + \dot{c}(\theta) - \dot{b}(\theta)\,\overline{u}(\theta) - \frac{a(\theta) + c(\theta)}{h(\overline{u}(\theta),\theta)\overline{u}(\theta)^2}\int_{\overline{u}(\theta)}^{\overline{x}} x\frac{\partial h(x,\theta)}{\partial \theta}dx\right)\dot{\psi}(\theta) < 0 \tag{7}$$

The informational rent R_q is now:

$$R_q(\theta) = \tau(\theta) + \int_{\kappa(\theta)}^{\overline{u}(\theta)} (a(\theta) + c(\theta) - b(\theta)\,x)\,h(x,\theta)dx \tag{8}$$

The differential of the rent is

$$\begin{aligned}\dot{R}_q(\theta) &= \left(b(\theta) - \frac{a(\theta)+c(\theta)}{\overline{u}(\theta)}\right)\left(\int_{\overline{u}}^{\overline{x}} \frac{\partial H(x,\theta)}{\partial \theta}dx\right) + \\ &\int_{\kappa(\theta)}^{\overline{u}(\theta)}\left[b(\theta)\,\frac{\partial H(x,\theta)}{\partial \theta} + \left(\dot{a}(\theta) + \dot{c}(\theta) - \dot{b}(\theta)\,x\right)h(x,\theta)\right]dx\end{aligned}$$

The expression of the differential of the rent leads us to directly take account of the two hypotheses $(H1)$ and $(H2)$ to make sure that the rent is monotonic. Let us note that the general condition implying the monotonicity of the rent does not guarantee that the contract will be regular ($\dot{\psi}(\theta) > 0$ for any θ). For any θ, this general condition can written as:

$$\frac{\partial l(\overline{u},\theta)}{\partial \theta} - \frac{b\kappa}{h(\overline{u},\theta)\overline{u}^2}\left(\overline{u}\frac{\partial H(\overline{u},\theta)}{\partial \theta} + \int_{\overline{u}}^{\overline{x}} \frac{\partial H(x,\theta)}{\partial \theta}dx\right) > 0 \tag{H4}$$

The assumptions $(H1)$ and $(H2)$ allow us to be sure that the incentive condition 7 will be satisfied[4].

As for the set aside contract, let us consider that the regulator wants to increase the production of amenities or to decrease the production of the traditional agricultural good, so that $\overline{u}(\theta) \geqslant \kappa(\theta)$. The incentive condition 7 and the hypotheses $(H1)$ and $(H2)$ lead to a necessarily increasing quota requirement for the production of good 2. This means that the lowest the farm performance index is, the smallest the quota for production of good 2 will be. The decreasing rent implies that the regulator proposes the contract to the θ subset $[\underline{\theta}, \eta_q]$.

[4]That can be verified by the relations : $\frac{\partial l(\theta,x)}{\partial \theta} = \dot{b}x - \dot{a} - \dot{c}$ and $\int_{\overline{u}}^{\overline{x}} x\frac{\partial h(x,\theta)}{\partial \theta}dx = -\overline{u}\frac{\partial H(\overline{u},\theta)}{\partial \theta} - \int_{\overline{u}}^{\overline{x}} \frac{\partial H(x,\theta)}{\partial \theta}dx$.

3.3 Comparison between the incentive conditions

We define the production of the two goods given the production threshold w.

$$\begin{aligned} q_1(w,\theta) &= \int_{\underline{x}}^{w} h(x,\theta)dx = H(w,\theta) \\ q_2(w,\theta) &= \int_{w}^{\overline{x}} xh(x,\theta)dx \end{aligned}$$

The previous results can be summarized in this table when the expected rent is monotonically decreasing and when the functions defining the contract are regular.

	set-aside	quota
amenities (q_1)	$q_1(\overline{v}(\theta),\theta)$	$q_1(\overline{u}(\theta),\theta)$
product (q_2)	$q_2(\overline{v}(\theta),\theta)$	$q_2(\overline{u}(\theta),\theta)$
1st order IC	$\dot{t} = b(\overline{v}-\kappa)\dot{s}$	$\dot{\tau} = b\left(\frac{\kappa}{\overline{u}}-1\right)\dot{\psi}$
2nd order IC	$b\frac{\partial H(\overline{v},\theta)}{\partial\theta} - \frac{\partial l(\overline{v},\theta)}{\partial\theta}h(\overline{v},\theta) < 0$ implying $\dot{s} > 0$	$\frac{b\kappa}{h(\overline{u},\theta)\overline{u}^2}\left(\overline{u}\frac{\partial H(\overline{u},\theta)}{\partial\theta} + \int_{\overline{u}}^{\overline{x}}\frac{\partial H(x,\theta)}{\partial\theta}dx\right) - \frac{\partial l(\overline{u},\theta)}{\partial\theta} < 0$ implying $\dot{\psi} > 0$
subset of firms eligible to contract	$[\underline{\theta},\eta_s]$	$[\underline{\theta},\eta_q]$

The set-aside contract requires a weaker general condition related to the second order condition. Nevertheless the usual and realistic assumptions $(H1)$ and $(H2)$ are sufficient to make simplier the second order condition of the two contracts. The set-aside contract will be regular when the set-aside requirement s is a decreasing function of θ. The quota contract will be regular when the quota function ψ is an increasing function of θ.

4 The regulator's programs

4.1 Complete charcaterization of the contracts

Consider now the regulator' programs in the two cases related to the two contracts. Recall that the part of the objective function depending of the regulation is $\Pi + mQ_1 - (1+\lambda)[T + nQ_2]$, where Q_1 and Q_2 are respectively the total production of good 1 and 2 in all the farms, T is the total net transfer due to contracts from taxpayers to all the farms, m and n are positive parameters, and λ is related to the opportunity cost of public funds. Consistently with application to agricultural policies, we introduce the assumption $(H5)$ meaning that the private benefit $b(\theta)$ of the production $q_2(\theta)$ is greater than the public cost n^5.

$$b(\theta) > n \tag{H5}$$

By extension, the non contracting agents are provided profits equivalent to $\pi(\theta)$, null transfers and threshold yield equal to $\kappa(\theta)$. The public programs are :

$$\begin{aligned} W_s &= \max_{\overline{v}(\cdot)} \int_\Theta [\pi_s(\theta,\theta) + mq_1(\overline{v}(\theta),\theta) - (1+\lambda)(t(\theta) + nq_2(\overline{v}(\theta),\theta))] f(\theta)d\theta \\ W_q &= \max_{\overline{u}(\cdot)} \int_\Theta [\pi_q(\theta,\theta) + mq_1(\overline{u}(\theta),\theta) - (1+\lambda)(\tau(\theta) + nq_2(\overline{v}(\theta),\theta))] f(\theta)d\theta \end{aligned}$$

with

$$\begin{aligned} \pi_s(\theta,\theta) &= a(\theta)q_1(\overline{v}(\theta),\theta) + b(\theta)\, q_2(\overline{v}(\theta),\theta) - c(\theta)(1 - q_1(\overline{v}(\theta),\theta)) + t(\theta) \\ \pi_q(\theta,\theta) &= a(\theta)q_1(\overline{u}(\theta),\theta) + b(\theta)\, q_2(\overline{u}(\theta),\theta) - c(\theta)(1 - q_1(\overline{u}(\theta),\theta)) + \tau(\theta) \end{aligned}$$

Recall that the set-aside contract involves $s(\theta) = q_1(\overline{v}(\theta),\theta)$, instead the quota contract involves $\psi(\theta) = q_2(\overline{u}(\theta),\theta)$. We show in appendix A.3 that the social net benefits can be rewritten so that the Euler equation can be applied. Let us define the function:

$$k(x,\theta) = m + (1+\lambda)[b(\theta)\kappa(\theta) - (b(\theta) - n)x] \tag{9}$$

This gives us the following result which characterizes the threshold productivity related to each of the two contracts.

$$\forall\theta \in [\underline{\theta},\eta_s] \quad : \quad k(\overline{v},\theta) = \lambda\frac{F}{f}\left(\frac{\partial l(\overline{v},\theta)}{\partial\theta} - b\frac{\frac{\partial H(\overline{v},\theta)}{\partial\theta}}{h(\overline{v},\theta)}\right) \tag{10}$$

$$\forall\theta \in [\underline{\theta},\eta_s] \quad : \quad k(\overline{u},\theta) = \lambda\frac{F}{f}\left(\frac{\partial l(\overline{u},\theta)}{\partial\theta} + \frac{b\kappa}{\overline{u}^2}\frac{\int_{\overline{u}}^{\overline{x}} x\frac{\partial h(x,\theta)}{\partial\theta}dx}{h(\overline{u},\theta)}\right) \tag{11}$$

Finally, when we recall that the pivot farmer η has a rent equal to zero, and after deriving the optimal pivot performance index, the two contracts are characterized by the following proposition.

Proposition 1 *The mechanism design is completely defined for the two contracts first by the implicit equation leading to the threshold productivity and to the computation of the*

[5] The Common Agricultura Policy leads us to set $b(\theta) = p$ as the domestice price, and $n = p - e$ as the difference between the domestic price and the world price e.

two basic terms of each of the contracts, second by the relation defining the pivot farm.

$$\text{set-aside contract}\left|\begin{array}{l}\overline{v}(\theta)\ \textit{given by (10)}\\ s(\theta)=H(\overline{v}(\theta),\theta)\\ t(\theta)=t(\eta_s)+\int_{\eta_s}^{\theta}l(\overline{v}(y),y)\dot{s}(y)dy\\ t(\eta_s)=\int_{\kappa(\eta_s)}^{\overline{v}(\eta_s)}l(x,\eta_s)h(x,\eta_s)dx\\ \eta_s=\arg\max\limits_{\eta}W_s\end{array}\right.$$

$$\text{quota contract}\left|\begin{array}{l}\overline{u}(\theta)\ \textit{given by (11)}\\ \psi(\theta)=\int_{\overline{u}}^{\overline{x}}xh(x,\theta)dx\\ \tau(\theta)=\tau(\eta_q)-\int_{\eta_q}^{\theta}\frac{l(\overline{u}(y),y)}{\overline{u}(y)}\dot{\psi}(y)dy\\ \tau(\eta_q)=\int_{\kappa(\eta_q)}^{\overline{u}(\eta_q)}l(x,\eta_q)h(x,\eta_q)dx\\ \eta_q=\arg\max\limits_{\eta}W_q\end{array}\right.$$

After the regulator is able to characterize the two contracts suggested for the regulation, the question of comparison arises. First we will try to compare the threshold productivity defined by the two contracts.

4.2 Comparing the threshold productivities and comparing the pivot farms

Let us denote by $w(\theta)$ the productivity equal to $\frac{m+(1+\lambda)b\kappa}{(1+\lambda)(b-n)}$ which is the solution of the equation $k(x,\theta)=0$ taking x as the unkown variable. Two results come easily with this last relation. First the two threshold yields are such as $\overline{v}(\underline{\theta})=\overline{u}(\underline{\theta})=w(\underline{\theta})$. Second the two threshold yields are *always* equal to w when $\lambda=0$, that means $\overline{v}=\overline{u}=w$ for any θ.

Note that with $(H1)$, $(H2)$ and 10, $k(\overline{v},\theta)\geq 0$. After noting that $\int_{\overline{u}}^{\overline{x}}x\frac{\partial h}{\partial\theta}(x,\theta)dx=-\overline{u}\frac{\partial H}{\partial\theta}(\overline{u},\theta)-\int_{\overline{u}}^{\overline{x}}\frac{\partial H}{\partial\theta}(x,\theta)dx$, we obtain an equivalent result with the threshold $\overline{u}$, that means $k(\overline{u},\theta)\geq 0$. It is easily shown that $\frac{\partial k}{\partial x}<0$, that leads any contracting θ is provided by a threshold productivity lower than w.

The equations 10 and 11 allow us to compute the difference between the thresholds $\overline{v}(\theta)$ or $\overline{u}(\theta)$ as given by the following relation of which the left term has the sign of $\overline{u}(\theta)-\overline{v}(\theta)$:

$$\left(b-n+\frac{\lambda}{1+\lambda}\frac{F}{f}\dot{b}\right)(\overline{v}-\overline{u})=\frac{\lambda}{1+\lambda}b\frac{F}{f}\left(\frac{\frac{\partial H(\overline{v},\theta)}{\partial\theta}}{h(\overline{v},\theta)}-\frac{\kappa}{\overline{u}}\frac{\frac{\partial H(\overline{u},\theta)}{\partial\theta}}{h(\overline{u},\theta)}-\frac{\kappa}{\overline{u}^2}\frac{\int_{\overline{u}}^{\overline{x}}\frac{\partial H(x,\theta)}{\partial\theta}dx}{h(\overline{u},\theta)}\right)\quad(12)$$

Let us assume that the function $\frac{\partial H(x,\theta)}{\partial\theta}$ is continuous (as implicitly admitted up to now to assure regularity of integrals) and $\lambda>0$. It is impossible to have the two thresholds $\overline{v}(\theta)$ and $\overline{u}(\theta)$ equal when θ is strictly greater than $\underline{\theta}$ because $\int_{\overline{u}}^{\overline{x}}\frac{\partial H(x,\theta)}{\partial\theta}$ is strictly negative with $(H2)$. Continuity leads us to expect that $\overline{v}>\overline{u}$ for any θ strictly greater than $\underline{\theta}$

Note that the welfare functions can be rewritten in terms of $k(x,\theta)$ given that we have $\overline{v}$ and $\overline{u}$ solving 10 and 11 respectively:

$$
\begin{aligned}
C &= \int_{\Theta} \left[\pi(\theta) + mq_1(\kappa(\theta),\theta) + nq_2(\kappa(\theta),\theta)\right] f(\theta)d\theta \\
W_s &= C + \int_{\underline{\theta}}^{\eta_s} \left(\int_{\kappa(\theta)}^{\overline{v}(\theta)} k(x,\theta)h\left(x,\theta\right)dx - \lambda R_s\left(\theta\right) \right) f(\theta)d\theta \\
W_q &= C + \int_{\underline{\theta}}^{\eta_q} \left(\int_{\kappa(\theta)}^{\overline{u}(\theta)} k(x,\theta)h\left(x,\theta\right)dx - \lambda R_q\left(\theta\right) \right) f(\theta)d\theta
\end{aligned}
$$

We can show that:

$$
\begin{aligned}
\frac{\partial W_s}{\partial \eta_s} &= f(\eta_s)\int_{\kappa(\eta_s)}^{\overline{v}(\eta_s)} k(x,\eta_s)h(x,\eta_s)dx \\
\frac{\partial W_q}{\partial \eta_q} &= f(\eta_q)\int_{\kappa(\eta_q)}^{\overline{u}(\eta_q)} k(x,\eta_q)h(x,\eta_q)dx
\end{aligned}
$$

Let us recall that the function h is positive and that the threshold productivity $\overline{v}(\theta)$ or $\overline{u}(\theta)$ is greater or equal to $\kappa(\theta)$. Let us take account of the positivity of functions $k(x,\eta_s)$ on $[\kappa(\eta_s),\overline{u}(\eta_s)]$ and $k(x,\eta_q)$ on $\left[\kappa(\eta_q),\overline{u}(\eta_q)\right]$ (because $k(\kappa,\theta) = m + (1+\lambda)n\kappa > 0$ and $\frac{\partial k}{\partial x} < 0$). The only possibility to have the pivot of a contract strictly included in the interval $[\underline{\theta},\overline{\theta}[$ is got when the threshold productivity is equal to κ (whis is strictly lower than w).

At last, recall that $\overline{v} > \overline{u}$ for any θ greater than $\underline{\theta}$. That means the quota pivot is never greater than the set-aside pivot. The figures 1 and 2 (assuming λ not too high or $\dot{b}$ close to zero), and the following proposition summarize all these results.

Proposition 2 *Assuming (H1) and (H2), the set-aside pivot η_s (respectively the quota pivot η_q) is equal to $\overline{\theta}$ when $\overline{v}(\eta_s) \neq \kappa(\eta_s)$ (respectively $\overline{u}(\eta_q) \neq \kappa(\eta_q)$), and is such that $\overline{v}(\eta_s) = \kappa(\eta_s)$ when $\eta_s < \overline{\theta}$ (respectively $\overline{u}(\eta_q) = \kappa(\eta_q)$ when $\eta_q < \overline{\theta}$). The quota pivot η_q is never greater than the set-aside pivot η_s.*

In other words, when a farm θ is supplied by the two contracts, the set-aside contract leads it to increase its production of amenities $q_1(\theta)$ and to decrease its agricultural production $q_2(\theta)$ comparatively to the quota contract.

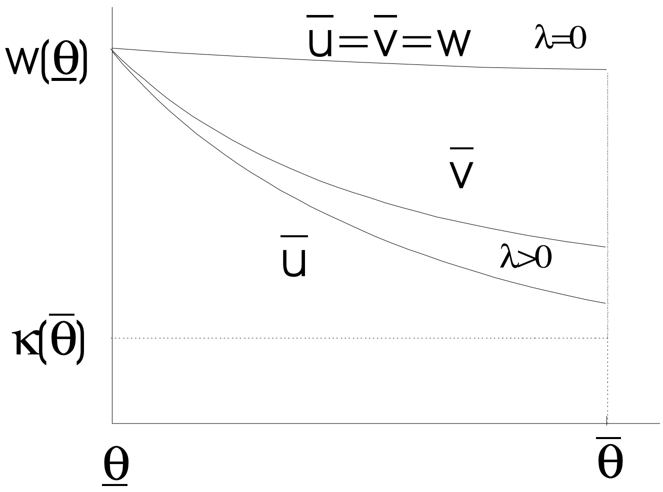

Figure 1: Threshold productivity when all firms contract in the two contract cases (λ low).

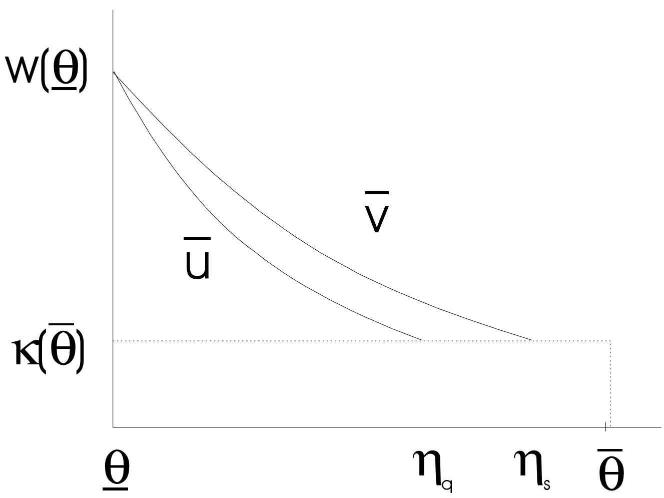

Figure 2: Threshold productivity when only a subset of farms is expected in contracting.

4.3 Comparing the rents and comparing welfare

Note first that if one of the pivots η is lower than $\overline{\theta}$, the differential of the rent and the transfer are equal to 0 in η. Let us focus on the function $\Delta(\theta)$ defined as the difference between the individual rents of the contracts so that:

$$\Delta(\theta) = R_s(\theta) - R_q(\theta)$$

This can be rewritten with the help of relations extracted from the proposition 1 :

$$\begin{aligned}\Delta(\theta) &= t(\eta_s) - \tau(\eta_q) - \int_\theta^{\eta_s} l(\overline{v}(y), y)\dot{s}(y)dy \\ &- \int_\theta^{\eta_q} \frac{l(\overline{u}(y), y)}{\overline{u}(y)}\dot{\psi}(y)dy - \int_{\overline{u}(\theta)}^{\overline{v}(\theta)} l(x,\theta)h(x,\theta)dx\end{aligned}$$

After some substitutions, computations of integrals by parts and derivations, we get the expression of the differential of this function :

$$\begin{aligned}\dot{\Delta}(\theta) &= \int_{\overline{u}(\theta)}^{\overline{v}(\theta)} \left(b(\theta)\frac{\partial H(x,\theta)}{\partial\theta} - \frac{\partial l(x,\theta)}{\partial\theta}h(x,\theta)\right)dx \\ &-b(\theta)\left(1 - \frac{\kappa(\theta)}{\overline{u}(\theta)}\right)\left(\int_{\underline{u}}^{\overline{x}} \frac{\partial H(x,\theta)}{\partial\theta}dx\right) \qquad (13)\end{aligned}$$

Because of $(H2)$ and $\overline{v}(\underline{\theta}) = \overline{u}(\underline{\theta}) = w(\underline{\theta})$, we have $\dot{\Delta}(\underline{\theta}) > 0$. When $\eta_q < \overline{\theta}$ we have $\dot{\Delta}(\eta_q) < 0$. Moreover $\Delta(\eta_q) > 0$ ($R_q(\eta_q) = 0$ and $R_s(\eta_q) > 0$). This implies that the contracting farms characterized by a high θ are supplied by a rent greater whith the set-aside contract than with the quota contract.

We examine now the polar case $\lambda = 0$. That implies $\eta_s = \eta_q = \overline{\theta}$, $\Delta(\overline{\theta}) = R_s(\overline{\theta}) = R_q(\overline{\theta}) = 0$ (by the definition of the pivot) and $\overline{v}(\theta) = \overline{u}(\theta) = w(\theta)$ for any θ. Moreover $\dot{\Delta}(\theta) > 0$ for any θ. Then $\Delta(\theta)$ is increasing and necessarily $\Delta(\theta) < 0$ for any θ. In other words, the set contrat supplies the farm θ a rent lower than what is supplied by the quota contract, whilst there is no change in the two farm productions when the contract changes.

By continuity, the figures 3 and 4 show the two contrasted situations in the case of λ small and in the case of λ high as a mean of summarising the previous results.

Proposition 3 *Assuming $(H1)$, $(H2)$ and $(H5)$ the individual rent obtained by any producer is greater with the contract involving quota than with the contract involving set-aside when λ is close to* 0.

As a corollary, when $(H5)$ holds, the global rent of the quota case is greater than the global rent of the set-aside case. Note the paradox of a greater rent related to an equivalent welfare when $\lambda = 0$.

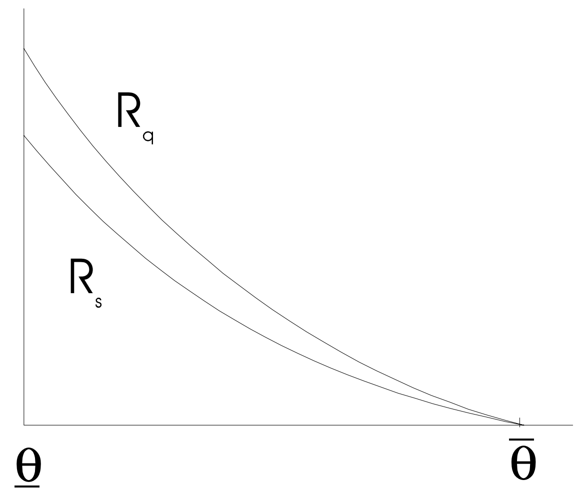

Figure 3: Rents when all farms contract in the two contract cases in the case of λ low.

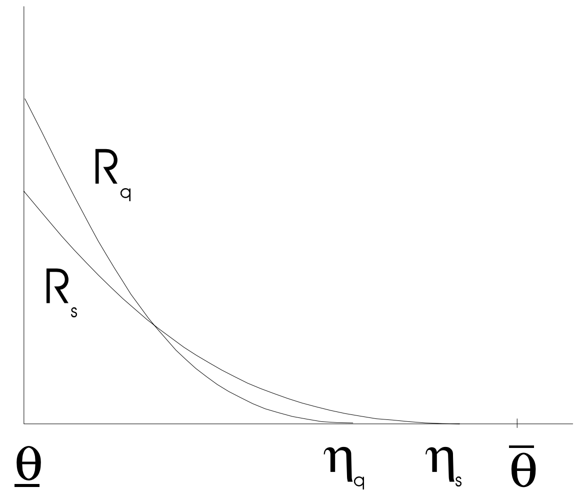

Figure 4: Rents when only a subset of farms is expected in contracting in the case of λ high.

Let us now study the welfare difference given by the programs related to the two contracts. Let us focus on the case of all farms contracting, in other words $\eta_s = \eta_q = \overline{\theta}$. Starting from previous expression of welfare, we can write the difference

$$W_s - W_q = -\lambda(R_s(\theta) - R_q(\theta)) + \int_{\Theta} \int_{\overline{u}(\theta)}^{\overline{v}(\theta)} k(x,\theta)h(x,\theta)dxf(\theta)d\theta$$

The proposition 3 leads immediately to conclude that when the assumptions required are satisfied then the set-aside contract dominate the quota contract in the sense of the public interest.

Proposition 4 *Assuming* $(H1)$ *and* $(H2)$*, the net social welfare induced by the two types of contracts are equal when* $\lambda = 0$*. Moreover assuming* $(H5)$ *the welfare induced by the contract involving set aside is greater than the welfare induced by the contract involving quota when* λ *is positive close to* 0*.*

These results are not similar to the results obtained by Maskin and Riley and also to the results obtained by Bontems and Bourgeon for the case when both incentive schemes imply the same ranking of agents regarding the productivity parameter. We can expect first that our result holds when regulation on input and output related to two different goods is more complex, indeed our environnemental good is exactly equivalent to the input of the agricultural good. And our result holds always even if there is no collective value given to this input ($m = 0$). As a concluding remark, we have more often to admit that some theoretical results depend strongly on the technology. They depend too on the respective identity and role of agents on one hand and principal on the other hand.

5 Conclusions

In this paper, we analyze the simultaneous regulation of several goods produced on agricultural land such as crops and environmental amenities. This analysis is conducted using a general model of agricultural production where all agricultural land is used to produce two different goods. The principal can regulate these productions either through production quotas or through set aside requirements for production of a specific good. In other words the principal may regulate the output or the input. Without loss of generality we choose here to regulate the input of one good and the output of the other good. The paper focuses on information asymmetry about some farm performance index creating adverse selection. We derive incentives constraints to help us solve our problem with contract theory.

We consider two applications of this model to agro-environmental policies. The first application is traditional set-aside and production quotas to limit agricultural production. The second application is wetland creation on agricultural land to increase environmental amenities. Both those applications are easily represented in the model developed.

We show that under some assumption about the distribution of the plots according to some productivity parameter we necessarily have a decreasing set-aside requirement by the contract and an increasing quota requirement with regard to the farm performance index. Roughly the assumption required is a more general version of the usual stochastic dominance assumption encountered in this kind of adverse selection problems. The decreasing rent implies that the regulator proposes the contract to the subset of farms with lowest performance if he wants to decrease the production of the good related positively to the performance index. This is the case for example in a program to reduce traditional agricultural production. This decreasing rent holds too if the principal wants instead to increase the production of the other good related to production of environnemental amenities.

In the polar case when public funds are non costly we show that the net social welfare induced by the two types of contracts are equal, and under some additional assumption the individual rent obtained by any producer is greater with the contract involving quota than with the contract involving set-aside. In general we also show that if the goal of the regulation is to decrease the production of the quota good it is better to use a set aside contract. This is the case in a program to limit agricultural production. This is also the case in the contratsed situation when the principal aims to increase the production of amenities.

These results differ to the results obtained by Maskin and Riley and the results obtained by Bontems and Bourgeon for the case when both incentive schemes imply the same ranking of agents regarding the productivity parameter.

A Annexes

A.1 The differential of the rent in the set aside contract

Note that the expression for the rent can be rewritten in following way.

$$R_s(\theta) = t(\theta) + (a(\theta) - b(\theta)\,\overline{v}(\theta) + c(\theta))\,H(\overline{v}(\theta), \theta) + \int_{\kappa(\theta)}^{\overline{v}(\theta)} b(\theta)\,H(x, \theta)dx$$

Differentiating this expression gives:

$$\begin{aligned}\dot{R}_s(\theta) &= \dot{t}(\theta) + (a(\theta) - b(\theta)\overline{v}(\theta) + c(\theta))\left(h(\overline{v}(\theta),\theta)\dot{\overline{v}}(\theta) + \frac{\partial H(\overline{v}(\theta),\theta)}{\partial\theta}\right)\\ &+\left(\dot{a}(\theta) - \dot{b}(\theta)\overline{v}(\theta) - b(\theta)\dot{\overline{v}}(\theta) + \dot{c}(\theta)\right)H(\overline{v}(\theta),\theta)\\ &+b(\theta)H(\overline{v}(\theta),\theta)\dot{\overline{v}}(\theta) - b(\theta)H(\kappa(\theta),\theta)\dot{\kappa}(\theta)\\ &+\int_{\kappa(\theta)}^{\overline{v}(\theta)}\left(\dot{b}(\theta)H(x,\theta) + b(\theta)\frac{\partial H(x,\theta)}{\partial\theta}\right)dx\end{aligned}$$

Replacing for the incentive constraint $((b(\theta)\overline{v}(\theta) - c(\theta) - a(\theta))\dot{s}(\theta) = \dot{t}(\theta))$, $\dot{\kappa}(\theta) = \frac{\dot{a}(\theta)+\dot{c}(\theta)}{b(\theta)} - \kappa(\theta)\frac{\dot{b}(\theta)}{b(\theta)}$, and note that $\dot{s}(\theta) = h(\overline{v}(\theta),\theta)\dot{\overline{v}}(\theta) + \frac{\partial H(\overline{v}(\theta),\theta)}{\partial\theta}$ we can then solve the integrals and simplify to obtain:

$$\begin{aligned}\dot{R}_s(\theta) &= \left(\dot{a}(\theta) - \dot{b}(\theta)\overline{v}(\theta) + \dot{c}(\theta)\right)H(\overline{v}(\theta),\theta)\\ &-H(\kappa(\theta),\theta)\left(\dot{a}(\theta) + \dot{c}(\theta) - \kappa(\theta)\dot{b}(\theta)\right)\\ &+\int_{\kappa(\theta)}^{\overline{v}(\theta)}\left(\dot{b}(\theta)H(x,\theta)\right)dx + \int_{\kappa(\theta)}^{\overline{v}(\theta)}\left(b(\theta)\frac{\partial H(x,\theta)}{\partial\theta}\right)dx\end{aligned}$$

Note that using integration by parts we have:

$$\int_{\kappa(\theta)}^{\overline{v}(\theta)}\left(\dot{a}(\theta) - \dot{b}(\theta)x + \dot{c}(\theta)\right)h(x,\theta)dx =$$
$$\left(\dot{a}(\theta) - \dot{b}(\theta)\overline{v}(\theta) + \dot{c}(\theta)\right)H(\overline{v}(\theta),\theta) - \left(\dot{a}(\theta) - \dot{b}(\theta)\kappa(\theta) + \dot{c}(\theta)\right)H(\kappa(\theta),\theta)$$
$$+\int_{\kappa(\theta)}^{\overline{v}(\theta)}\left(\dot{b}(\theta)\frac{\partial H(x,\theta)}{\partial\theta}\right)dx$$

Finally we have:

$$\dot{R}_s(\theta) = \int_{\kappa(\theta)}^{\overline{v}(\theta)} b(\theta)\frac{\partial H(x,\theta)}{\partial\theta} + \left(\dot{a}(\theta) - \dot{b}(\theta)x + \dot{c}(\theta)\right)h(x,\theta)dx$$

A.2 The differential of the rent in the quota contract

Note that the expression for the rent can be rewritten in following way.

$$R_q(\theta) = \tau(\theta) + (a(\theta) - b(\theta)\overline{u}(\theta) + c(\theta))H(\overline{u}(\theta),\theta) + \int_{\kappa(\theta)}^{\overline{u}(\theta)} b(\theta)H(x,\theta)dx$$

Differentiating this expression gives:

$$\begin{aligned}
\dot{R}_q(\theta) &= \dot{\tau}(\theta) + \left(\dot{a}(\theta) - \dot{b}(\theta)\,\overline{u}(\theta) - b(\theta)\,\dot{\overline{u}}(\theta) + \dot{c}(\theta)\right) H(\overline{u}(\theta),\theta) \\
&+ \left(a(\theta) - b(\theta)\,\overline{u}(\theta) + c(\theta)\right)\left(h(\overline{u}(\theta),\theta)\dot{\overline{u}}(\theta) + \frac{\partial H(\overline{u},\theta)}{\partial\theta}\right) \\
&+ b(\theta)\,H(\overline{u}(\theta),\theta)\dot{\overline{u}}(\theta) - b(\theta)\,H(\kappa(\theta),\theta)\dot{\kappa}(\theta) \\
&+ \int_{\kappa(\theta)}^{\overline{u}(\theta)} \left(\dot{b}(\theta)\,H(x,\theta) + b(\theta)\,\frac{\partial H(x,\theta)}{\partial\theta}\right) dx
\end{aligned}$$

Replacing for the incentive constraint ($\left(\frac{a(\theta)+c(\theta)}{\overline{u}(\theta)} - b(\theta)\right)\dot{\psi}(\theta) = \dot{\tau}(\theta)$), $\dot{\kappa}(\theta) = \frac{\dot{a}(\theta)+\dot{c}(\theta)}{b(\theta)} - \kappa(\theta)\frac{\dot{b}(\theta)}{b(\theta)}$, and note that $\dot{\psi}(\theta) = -\overline{u}(\theta)h(\overline{u}(\theta),\theta)\dot{\overline{u}}(\theta) - \overline{u}\frac{\partial H(\overline{u},\theta)}{\partial\theta} - \int_{\overline{u}}^{\overline{x}} \frac{\partial H(x,\theta)}{\partial\theta}dx$, we can simplify to obtain:

$$\begin{aligned}
\dot{R}_q(\theta) &= \left(\frac{a(\theta)+c(\theta)}{\overline{u}(\theta)} - b(\theta)\right)\left(-\int_{\overline{u}}^{\overline{x}} \frac{\partial H(x,\theta)}{\partial\theta}dx\right) \\
&+ \left(\dot{a}(\theta) - \dot{b}(\theta)\,\overline{u}(\theta) + \dot{c}(\theta)\right) H(\overline{u}(\theta),\theta) \\
&- H(\kappa(\theta),\theta)\left(\dot{a}(\theta) + \dot{c}(\theta) - \kappa(\theta)\dot{b}(\theta)\right) \\
&+ \int_{\kappa(\theta)}^{\overline{u}(\theta)} \left(\dot{b}(\theta)\,H(x,\theta) + b(\theta)\,\frac{\partial H(x,\theta)}{\partial\theta}\right) dx
\end{aligned}$$

Note that using integration by parts we have:

$$\int_{\kappa(\theta)}^{\overline{u}(\theta)} \left(\dot{a}(\theta) - \dot{b}(\theta)\,x + \dot{c}(\theta)\right) h(x,\theta)dx =$$
$$\left(\dot{a}(\theta) - \dot{b}(\theta)\,\overline{u}(\theta) + \dot{c}(\theta)\right) H(\overline{u}(\theta),\theta) - \left(\dot{a}(\theta) - \dot{b}(\theta)\,\kappa(\theta) + \dot{c}(\theta)\right) H(\kappa(\theta),\theta)$$
$$+ \int_{\kappa(\theta)}^{\overline{u}(\theta)} \left(\dot{b}(\theta)\,H(x,\theta)\right) dx$$

Finally we have:

$$\begin{aligned}
\dot{R}_q(\theta) &= \left(b(\theta) - \frac{a(\theta)+c(\theta)}{\overline{u}(\theta)}\right)\left(\int_{\overline{u}}^{\overline{x}} \frac{\partial H(x,\theta)}{\partial\theta}dx\right) + \\
&\int_{\kappa(\theta)}^{\overline{u}(\theta)} b(\theta)\,\frac{\partial H(x,\theta)}{\partial\theta} + \left(\dot{a}(\theta) - \dot{b}(\theta)\,x + \dot{c}(\theta)\right) h(x,\theta)dx
\end{aligned}$$

A.3 Characterization of the threshold performance indexes

The social net benefits can be rewritten as following:

$$\begin{aligned} W_s &= C + \Omega_s \\ W_q &= C + \Omega_q \end{aligned}$$

with

$$\begin{aligned} C &= \int_{\Theta} \left[(a+c+m)q_1(\kappa(\theta),\theta) + (b-(1+\lambda)n)q_2(\kappa(\theta),\theta) - c \right] f(\theta)d\theta \\ \Omega_s &= \max_{\overline{v}} \int_{\underline{\theta}}^{\eta_s} \left[\begin{array}{c} (a+c+m)(q_1(\overline{v}(\theta),\theta) - q_1(\kappa(\theta),\theta)) \\ +(b-(1+\lambda)n)(q_2(\overline{v}(\theta),\theta) - q_2(\kappa(\theta),\theta)) - \lambda t(\theta) \end{array} \right] f(\theta)d\theta \\ \Omega_q &= \max_{\overline{u}} \int_{\underline{\theta}}^{\eta_q} \left[\begin{array}{c} (a+c+m)(q_1(\overline{u}(\theta),\theta) - q_1(\kappa(\theta),\theta)) \\ +(b-(1+\lambda)n)(q_2(\overline{u}(\theta),\theta) - q_2(\kappa(\theta),\theta)) - \lambda \tau(\theta) \end{array} \right] f(\theta)d\theta \end{aligned}$$

The programs can be rewritten after transformation of the transfer terms using the first order incentive conditions and after integration by part.

$$\begin{aligned} \int_{\underline{\theta}}^{\eta_s} t(\theta)f(\theta)d\theta &= t(\eta_s)F(\eta_s) - \int_{\underline{\theta}}^{\eta_s} \left(b\left(\theta\right)\left(\overline{v}(\theta) - \kappa\left(\theta\right)\right)\dot{s}(\theta)F(\theta)d\theta \\ \int_{\underline{\theta}}^{\eta_q} \tau(\theta)f(\theta)d\theta &= t(\eta_q)F(\eta_q) - \int_{\underline{\theta}}^{\eta_q} \left(\frac{a\left(\theta\right)+c(\theta)}{\overline{u}(\theta)} - b\left(\theta\right)\right)\dot{\psi}(\theta)F(\theta)d\theta \end{aligned}$$

That allows us formally to set the problem as an optimal control problem which becomes, in the two cases:

$$\begin{aligned} \Omega_s &= \max_{\overline{v}(\cdot)} \int_{\underline{\theta}}^{\eta_s} \varpi_s(\overline{v}(\theta),\dot{\overline{v}}(\theta),\theta)d\theta - \lambda \left[t(\eta_s) - \left(b\left(\eta_s\right)\overline{v}(\eta_s) - c(\eta_s) - a\left(\eta_s\right)\right)s(\eta_s)\right]F(\eta_s) \\ \Omega_q &= \max_{\overline{u}(\cdot)} \int_{\underline{\theta}}^{\eta_q} \varpi_q(\overline{u}(\theta),\dot{\overline{u}}(\theta),\theta)d\theta - \lambda \left[\tau(\eta_q) - \left(\frac{a\left(\eta_q\right)+c(\eta_q)}{\overline{u}(\eta_q)} - b\left(\eta_q\right)\right)\psi\left(\eta_q\right)\right]F(\eta_q) \end{aligned}$$

$$\begin{aligned} \varpi_s(\overline{v},\dot{\overline{v}},\theta) &= f[(\kappa b+m)\left(q_1(\overline{v},\theta) - q_1(\kappa,\theta)\right) + (b-(1+\lambda)n)\left(q_2(\overline{v},\theta) - q_2(\kappa,\theta)\right)] \\ &\quad -\lambda\left[b(\overline{v}-\kappa)f + (\dot{b}\overline{v} + b\dot{\overline{v}} - \dot{c} - \dot{a})F\right]q_1(\overline{v},\theta) \\ \varpi_q(\overline{u},\dot{\overline{u}},\theta) &= f\left[(\kappa b+m)\left(q_1(\overline{u},\theta) - q_1(\kappa,\theta)\right) + (b-(1+\lambda)n)\left(q_2(\overline{u},\theta) - q_2(\kappa,\theta)\right)\right] \\ &\quad -\lambda\left[b(\frac{\kappa}{\overline{u}}-1)f + \dot{b}(\frac{\kappa}{\overline{u}}-1)F + b\frac{\dot{\kappa}\overline{u} - \kappa\dot{\overline{u}}}{\overline{u}^2}F\right]q_2(\overline{u},\theta) \end{aligned}$$

The problem is now written in a way that allow us to use the Euler relation. For the set aside contract given that $q_2(w,\theta) = \int_w^{\overline{x}} xh(x,\theta)\,dx$ and $\frac{\partial q_2(w,\theta)}{\partial w} = -wh(w,\theta)$ we obtain :

$$m + (1+\lambda)\left((\kappa - \overline{v})b + n\overline{v}\right) = \lambda \frac{F}{f}\left(\dot{b}\overline{v} - \dot{c} - \dot{a} - b\frac{\frac{\partial H(\overline{v},\theta)}{\partial \theta}}{h(\overline{v},\theta)}\right)$$

For the quota contract we obtain:

$$m + (1+\lambda)\left((\kappa - \overline{u})b + n\overline{u}\right) = \lambda \frac{F}{f}\left(\dot{b}\overline{u} - \dot{c} - \dot{a} + \frac{b\kappa}{h(\overline{u},\theta)\overline{u}^2}\int_{\overline{u}}^{\overline{x}} x\frac{\partial h(x,\theta)}{\partial \theta}dx\right)$$

A.4 Derivation of the change of welfare with regard to the threshold performance index.

Recall that we have

$$\begin{aligned} W_s &= C + \Omega_s \\ W_q &= C + \Omega_q \end{aligned}$$

with in optimum

$$\begin{aligned} C &= \int_\Theta \left[(a+c+m)q_1(\kappa(\theta),\theta) + (b-(1+\lambda)n)q_2(\kappa(\theta),\theta) - c\right] f(\theta)d\theta \\ \Omega_s &= \int_{\underline{\theta}}^{\eta_s} \left[(\kappa b + m)(q_1(\overline{v}(\theta),\theta) - q_1(\kappa(\theta),\theta)) + b(-(1+\lambda)n)(q_2(\overline{v}(\theta),\theta) - q_2(\kappa(\theta),\theta)) - \lambda t(\theta)\right] f(\eta_s) \\ \Omega_q &= \int_{\underline{\theta}}^{\eta_q} \left[(\kappa b + m)(q_1(\overline{u}(\theta),\theta) - q_1(\kappa(\theta),\theta)) + b(-(1+\lambda)n)(q_2(\overline{u}(\theta),\theta) - q_2(\kappa(\theta),\theta)) - \lambda t(\theta)\right] f(\eta_q) \end{aligned}$$

and $\overline{v}(\theta)$, $\overline{u}(\theta)$ satisfying 10 and 11. Recall that the rent of the pivot farm is null. Let us differentiate and replace for $t(\eta_s)$ and $\tau(\eta_q)$ and we obtain:

$$\begin{aligned} \frac{\partial W_s}{\partial \eta_s} &= \frac{\partial \Omega_s}{\partial \eta_s} = f(\eta_s)\int_{\kappa(\eta_s)}^{\overline{v}(\eta_s)} k(x,\eta_s)h(x,\eta_s)dx \\ \frac{\partial W_q}{\partial \eta_q} &= \frac{\partial \Omega_q}{\partial \eta_q} = f(\eta_q)\int_{\kappa(\eta_q)}^{\overline{v}(\eta_q)} k(x,\eta_q)h(x,\eta_q)dx \end{aligned}$$

References

[1] P.D. Baron and R.B. Myerson. Regulating a monopolist with unknown costs. *Econometrica*, 50(4), 1982.

[2] Philippe Bontems and Jean-Marc Bourgeon. Creating countervailing incentives through the choice of instruments. *Journal of Public Economics*, 76:181–202, 2000.

[3] Jean-Marc Bourgeon, Pierre-Alain Jayet, and Pierre Picard. An incentive approach to land set-aside programs. *European Economic Review*, (39):1487–1509, 1995.

[4] P. Dasgupta, P. Hammond, and E. Maskin. The implementation of social choice rules: Some results on incentive compatibility. *Review of Economic Studies*, 46:185–216, 1979.

[5] M. Gisser. Price support, acreage controls, and efficient redistribution. *Journal of Political Economy*, (101):584–611, 1993.

[6] J.R Green and J-J Laffont. *Incentives in Public Decision Making*. Studies in Public Economics. North-Holland, 1979.

[7] P.-A. Jayet. Evaluation d'une politique de retrait des terres pour la régulation d'un marché agricole. *Annales d'Economie et de Statistique*, (61), 2001.

[8] Fahad Kahlil and Jacques Lawarrée. Input versus output monitoring: Who is the residual claimant? *Journal of Economic Theory*, 66:139–157, 1995.

[9] Eric Maskin and John Riley. Input versus output incentive schemes. *Journal of Public Economics*, 28:1–23, 1985.