Agricultural Policies and Agri-Environmental Regulation: Efficiency versus Political Perspectives[1]

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This draft, February 2011

Abstract.
This paper theoretically investigates the joint and endogenous determination of both production and agri-environmental transfers in developed countries' agriculture. While agri-environmental regulation is motivated by market failures in the delivery of environmental benefits (soil cover, landscapes, pollution abatement, and so on), production support may only be due to political interests.

We then explore how both policy instruments interact and how political economic factors—namely farmers' special interest groups, inequality aversion, and partial concerns for environmental amenities—induce deviation from first-best and second-best policies. More inequality-averse and more amenity-oriented policy-makers, as well as social and cultural differences in citizens' preferences for agricultural landscapes between the EU and the US, can explain differences in support levels, trends, and composition. This also supports the evidence that agri-environmental regulation is more effective and individual-specific in the US than in the EU. Finally, we conclude that future WTO negotiations and policy reforms can partially restore efficiency.
Keywords: Agricultural Policy, Agri-Environmental Programs, Imperfect Information, Inequality Aversion, Special Interest Groups, Environmental Externalities.
JEL Codes: D62, D63, D72, D82, Q18, Q58

1 Introduction

The agricultural sector is characterized by high levels of support and protection in many developed countries. In 2009, the support for producers in OECD areas was estimated by the Producer Support Estimate (PSE)[2] at $253 billion (OECD, 2010). This was equivalent to 22% of the aggregate gross receipts of OECD farm producers, down from 28% in 2005 and 37% in 1986-88 (OECD, 2008). Along with the decline in the level of support, there has been a shift toward support that is more decoupled from actual or current production, which has become increasingly attached to various compliance conditions. This gives farmers more freedom in their production choices.[3]

[1]We are grateful to Alban Thomas and Philippe Bontems for useful comments on an earlier version of this paper. We also thank seminar participants at the Hebrew University of Jerusalem and Bar-Ilan. Useful comments provided by Yacov Tsur.

[2]PSE is the annual sum of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that support agriculture, regardless of their nature, objectives or impacts on farm production or income. The %PSE measures the transfers as a share of gross farm receipts.

[3]Regarding welfare effects of decoupled payments to farmers, Moschini and Sckokai (1994) have shown that decoupling is an efficient supportive policy for a given farmer's welfare objective and usually desirable, even in a distorted economy in which lump-sum taxation is not feasible.

This paper explores the role of political and social preferences on agricultural support levels and their related composition, taking the case of agri-environmental regulation achieved through specific agri-environmental programs (AEPs) as a support component coexisting with other means of production support.

The levels of the agricultural (commodity) output affect the positive (e.g. open spaces and biodiversity) and negative (e.g. fertilizers and pesticide runoff) environmental (non-commodity) outputs, which are subject to market failure. This is further complicated by the heterogeneous conditions under which agriculture is performed, yielding spatial variability in productivity and its associated costs of both commodity and environmental outputs. Theoretically, first-best agri-environmental policies require the use of a mix of instruments to account for the heterogeneity in the production conditions (Lankoski, 2003; Lankoski et al., 2008).[4] This is done, for instance, within AEPs by differentiated (first-best) and uniform (second-best) policy instruments—a mix of fertilizer tax and buffer strip subsidy—to promote multifunctional agriculture. In practice, developed countries mainly use a mix of price support programs to raise farm income, and a combination of subsidies plus direct regulations (imposition of best-practice standards) to deal with both adverse and beneficial environmental effects (Lichtenberg, 2002).[5]

The design of policy instruments should also take into account the phenomenon of asymmetric information and its associated adverse selection, when individual producers have more information about their own production and/or cost structure than the policy-maker (Wu and Babcock, 1996; Lichtenberg, 2002; Hart and Latacz-Lohman, 2005; Bontems et al., 2005; Ozanne and White, 2007, 2008; Yano and Blandford, 2009). Several comparative studies show that agri-environmental policies follow citizens' social preferences for environmental amenities, which are linked to historical and cultural values (Bielik et al., 2007; Baylis et al., 2008).

The literature on the political economy of agricultural policies has shown that supportive policies in developed countries can also be motivated by governance failures and farmers' special interest groups (see Swinnen, 2010 for a comprehensive survey of the literature). In practice, there is strong evidence that policy choices are made under political pressure (Daugbjerg and Swinbank, 2007; Tanguay et al., 2004). Actually, the fact that distorting policy instruments still dominate in most developed countries can be attributed to the fact that the design of agricultural policies and support composition and levels are still significantly motivated by political economic factors rather than efficiency considerations.

This paper attempts to bridge the gap between the literature on efficient AEPs and that on the political economy of agricultural policies. The theoretical analysis considers a social planner (regulator) and a continuum of farmers who contract within a Principal-Agent framework. Agricultural production entails negative and positive externalities and the regulator may use a combination of two-policy instruments: a distorting, production-based payment, and agri-environmental payments aimed at encouraging farmers to adopt environmentally beneficial practices. The stylized theoretical model enables to derive optimal mixes of policy instruments, to assess the impacts of asymmetric information, to compare first-best and second-best

[4] Heterogeneity between farmers is related to differences in land quality, human capital, etc.

[5] Lichtenberg (2002) evaluated the efficiency of widely used AEPs such as: the requirement to use best-management practices, restrictions on the use of a specific polluting input, taxing polluting inputs and subsidizing environmental amenities. The author also provides general considerations and a review of the economic relationships between agricultural and environmental sectors, including formal and empirical models.

discriminatory optimal policies to uniform ones, and to conduct a sensitivity analysis with respect to parameters such as land distribution, marginal cost of public funds and output market price. The uniqueness of the model is that it is simple, including "only" two policy instruments, but at the same time, it is general enough to capture the complexity of a broad set of situations (AEPs) in a unified theoretical framework. Moreover, noticing that actual agricultural policies do not follow socially optimal conditions, we extend the theoretical analysis to include political favoritism (resulting from non-benevolent policy-makers subject to political pressure from farmers' lobbies) toward farmers' profits and the (negative) attitude of policy-makers toward income inequality among farmers. In a recent study, Ellison et al. (2010) investigated taxpayer's preferences for farm policy in the US and found out that people act altruistically toward small farmers thereby exhibiting aversion to inequality.

To the best of our knowledge, theoretical analysis of the impact of political parameters on the adjustments of agri-environmental instruments under conditions of asymmetric information is an original contribution to the literature. Through the lens of our theoretical insights, we further discuss the change in agricultural policies in the EU and the US over the last 15 years and relate the main differences in their design across countries through an analysis of political and behavioral parameters. Specifically, differences between EU and US agri-environmental regulations are explained by differences in environmental and amenity concerns among farmers and policy-makers, which is theoretically consistent with the observations made by Baylis et al. (2008). This may not only reflect different political processes but also different preferences of urban residents.

The remainder of the paper is organized as follows. In section 2, we present the optimal choice of farmers who face two policy instruments. In section 3, we derive the socially optimal mix of policy instruments accounting for farmers' reaction, and compare differentiated (first-best) to uniform or linear (second-best) instruments. The effect of imperfect information in a contract-theoretical framework is investigated in section 4. In section 5, we allow for the social welfare function to be affected by political preferences and inequality-aversion toward farmers' profits. Section 6 attempts to explain the patterns of PSE and payment to agri-environmental services (PES) over time and across OECD countries, building on the comparison between the US and the EU, via the lens of our theoretical analysis. Finally, section 7 concludes the paper.

2 Theoretical framework

We consider a social planner (regulator) and a continuum of farmers who contract within a Principal-Agent framework. The farmer decides on the level of agricultural intensification (inducing non-point source pollution) and the amount of land to cultivate under an AEP, denoted by P, that imposes lower intensification and also provides for amenity externalities. For the sake of simplicity, we do not consider that the land cultivated outside the AEP brings positive amenities.

The regulator can use two kinds of policy instruments or conditional transfers: a production-incentive transfer, $T(Y)$, conditional on total production Y, and a reward, $S(L^P)$, conditional on the land covered by the agri-environmental contract L^P, both entail social and deadweight costs. The combined use of the two policy instruments, addresses different objectives. The AEP, $S(L^P)$, is assumed to yield additional social welfare by imposing regulation on the use of polluting fertilizers and specific cultivation methods preventing top-soil erosion or biodiversity losses, which overall provides an amenity value on landscapes and reduces environmental damage related to agricultural production. This program brings about additional cultivation costs for the farmers who are compensated by agri-environmental payments for each unit of land enrolled in the program. At the same time, farmers' production is supported by conventional price support schemes to fulfill the farmers' welfare objective. However, the latter instrument is distorting and may entail additional pollution and attenuate the effect of the AEPs. First, we present farmers' optimal choice when facing these two policy instruments of production levels and level of adoption of the AEP (how much land to enroll). Second, we derive the socially optimal mix of policy instruments accounting for farmers' reaction under perfect information. Asymmetric information will be introduced in section 4. Political economy parameters will be introduced in section 5.

2.1 The farmer's problem under uniform transfers

Farmers are heterogeneous with respect to their production efficiency, which also involves more polluting emissions for the inefficient farmers (depending on farmer and farm characteristics) at a given level of production. This is captured through a parameter θ (the farm's efficiency type that belongs to $[\underline{\theta},\overline{\theta}]$ following a cumulative distribution $F(\theta)$, which is common knowledge among both parts. However, the type itself may be private information.

Farm's efficiency then affects production and cost functions. Production y of agricultural output per unit of land requires a polluting input, x, and a non-polluting output, z, such that:

$$Y(\theta) = y(x(\theta), z(\theta), \theta)L$$

where Y is total farm-level production and L is the amount of cultivated land. Each first derivative of the production function with respect to its argument is positive, and second-order own derivatives are negative. Last, cross second-order derivatives between inputs and types are positive (single-crossing property), meaning that marginal production increases with farmer type (efficiency condition). Similarly, this may be reflected in the cost function:

$$C(\theta) = C(y(\theta), L(\theta), \theta) = C_1(y(\theta), \theta)L(\theta) + C_2(L(\theta), \theta)$$

such that marginal costs of production and land cultivation are increasing, C_y and $C_L > 0$, C_{yy} and $C_{LL} > 0,$ but cost is decreasing and convex with farmer's type (negative first-order C_θ and positive second-order $C_{\theta\theta}$ derivatives). The cross second-order derivatives $C_{y\theta}$ and $C_{L\theta}$ are negative to satisfy the single-crossing property. Note that $C_y = C_{1y} \cdot L$ is a linear function of **L**. This general cost function implicitly accounts for specific costs of land cultivation that may be independent of productivity y.

We assume that farmers produce a homogeneous aggregate agricultural good, irrespective of whether the output is cropped on land covered by P. Let w be the exogenous price of the aggregate agricultural output. Taking all prices and regulatory tools as exogenous, the farmer's choice lies around productivity levels under both P and not, and on the land-allocation choice, that is, the amount of land L^P to devote to the AEP, while the remaining land L^{NP} is devoted to crops without contractual conditions. We assume that under P, $x(\theta) < \bar{x}$, the level of low intensification is imposed by P (set by the regulator), and that this standard is sufficiently low so that for all types of θ, $x(\theta) = \bar{x}$ and

$$y^P(\theta) = y(\bar{x}, z(\theta), \theta)$$

This constraint also reflects higher production costs (due to input-allocation inefficiencies) of one unit of y^P compared to the same unit of y^{NP}. For mathematical convenience, we introduce a parameter $a > 1$ such that we distinguish now between two cost functions

$$C^P(\theta) = C(ay^P(\theta), L^P(\theta), \theta) = C_1(ay^P(\theta), \theta)L^P(\theta) + C_2(L^P(\theta), \theta) \text{ and}$$

$$C^{NP}(\theta) = C(y^{NP}(\theta), L^{NP}(\theta), \theta) = C_1(y^{NP}(\theta), \theta)L^{NP}(\theta) + C_2(L^{NP}(\theta), \theta).$$

The parameter a must reflect the standard input regulation $\bar{x}$ and is increasingly convex as $\bar{x}$ decreases and becomes increasingly constraining, i.e., $a = a(\bar{x})$ with $a' < 0$ and $a'' > 0$. Note that the representation of the additional costs of the AEP in this general cost function can embed several AEP designs (such as idle land, fertilizer tax, low intensification standards, and so on). Hence, this cost function enables us to cope with a general level of agri-environmental regulation, irrespective of AEP contents.

The profit-maximizing program under a uniform (linear contracting where $T = tY$ and $S = sL^P$) policy is then (assuming that optimal solutions entail positive $L^P(\theta)$, $y^P(\theta)$, and $y^{NP}(\theta)$ and the participation of all types) is given by:

$$\max_{L^P(\theta), L^{NP}(\theta), y^P(\theta), y^{NP}(\theta)} \pi(\theta) = [(w+t)(y^P(\theta)L^P(\theta) + y^{NP}(\theta)L^{NP}(\theta)] + sL^P - C^P(\theta) - C^{NP}(\theta) \quad (2)$$

$$\text{such that } L^P + L^{NP} = L \quad (3)$$

with the associated Lagrange multiplier ν and where t and S are uniform tax or subsidy rates. First-order conditions entail:

$$\begin{aligned} &y^P : (w+t)L^P(\theta) = aC_{ay^P}(\theta) = aC_{1ay^P} \cdot L^P(\theta) \\ &\Rightarrow (w+t) = aC_{1ay^P}(ay^P(\theta), \theta) \end{aligned} \quad (4)$$

$$\begin{aligned} &y^{NP} : (w+t)L^{NP}(\theta) = C_{y^{NP}}(\theta) = C_{1y^{NP}} \cdot L^{NP}(\theta) \\ &\Rightarrow (w+t) = C_{1y^{NP}}(y^{NP}(\theta), \theta) \end{aligned} \quad (5)$$

$$L^P : (w+t)y^P(\theta) + s = C_{L^P}(\theta) + \nu \quad (6)$$

$$L^{NP} : (w+t)y^{NP}(\theta) = C_{L^{NP}}(\theta) + \nu \quad (7)$$

Note from (4) and (5) that $C_{1ay^P}(ay^P(\theta), \theta) = C_{1y^{NP}}(y^{NP}(\theta), \theta) / a$, implying (recall that $a>1$ and $C_{1yy} > 0$): $y^{NP}(\theta) > ay^P(\theta) \Rightarrow \Delta y(\theta) \equiv y^{NP}(\theta) - y^P(\theta) > 0$.

Extracting v gives: $s-(w+t)\Delta y(\theta)=C_{L^P}(\theta)-C_{L^{NP}}(\theta)$.

Note that if *s* vanishes or is very low then the area planted for the program, L^P, is smaller than L^{NP}

2.2 Social welfare and externalities

In principle, *T* and *S* should account for all other social gains and losses driven by the agricultural production and internalize them to farmers so as to provide an efficient amount of environmental externalities. First, using the polluting input creates environmental damage D, which is a transformation (monotonically increasing) of the sum of farmers' polluting emissions E. Each farmer has an individual emission function g such that:

$$g(\theta)=g(Y(\theta),\theta)=g(Y^P(\theta)+Y^{NP}(\theta),\theta)$$

where emissions are an increasing and convex function of total production g_Y and $g_{YY}>0$, and a decreasing function of farmer type, $g_\theta \leq 0$. Since $y^{NP}>y^P$, marginal emissions per unit of land enrolled in the program is lower than the one under no-program Lastly, marginal emissions of both productions decrease with farmer type (negative cross second-order derivative, i.e., single-crossing property), i.e., and $g_{Y\theta}<0$.

The aggregate damage function can then be written:

$$D=D(\int_\theta g(\theta)dF(\theta))=D(E)$$

which is an increasing and convex function of aggregate emission, i.e., D' and $D''>0$.

Second, the AEP generates a positive amenity externality A, which is due to its landscape and recreational value (public good), potential for agri-tourism, and other ecosystem benefits such as soil conservation, biodiversity, and so on. As already mentioned, the amenity value is a function of overall land cultivated and agricultural landscapes (see Fleischer and Tsur, 2009, for example). We assume here that only land cultivated under the AEP brings a positive amenity value,[6] and this value is increasing with aggregate land but with decreasing marginal returns so that:

$$A=A(\int_\theta L^P(\theta)dF(\theta))$$

is an increasing and concave function.

Therefore, the social optimum as a choice of a social planner should account for farmers' profits and the above two externalities. In addition, transferring money is costly (no lump-sum transfers), with an associated marginal cost of public funds λ (deadweight loss).

3 First-best solution

3.1 The general non-linear discriminatory policy mix

[6]How do AEPs foster amenity benefits? The additional costs of production under an AEP may be due not only to input allocation inefficiencies but also to investments in agri-tourism and eco-tourism, or some of the subsidies may be given in terms of public goods such as rural development (Feinerman and Komen, 2003) investments. In turn, the program's regulation is itself a generator of additional amenity benefits. A simplifying assumption is then to treat amenities as only generated from P.

We now introduce two non-linear mechanisms for production support (or taxation) and for the AEP:

$$T(Y(\theta),\theta) = T(Y^P(\theta) + Y^{NP}(\theta),\theta) = T(\theta)$$
$$S(L^P(\theta),\theta) = S(\theta)$$

such that all farmers (including the least efficient one) are assumed to remain producing, through a fixed-transfer component if needed. Farmers' profit becomes:

$$\pi(\theta) = wY^P(\theta) - C^P(\theta) + wY^{NP}(\theta) - C^{NP}(\theta) + T(Y(\theta),\theta) + S(L^P(\theta),\theta)$$

yielding the following farm-level first-order conditions:

$$\begin{aligned} y^P &: L^P(\theta)[w + T'(Y(\theta))] = aC_{ay^P}(\theta) = aC_{1ay^P} \cdot L^P(\theta) \\ &\Rightarrow (w + T'(Y(\theta))) = aC_{1ay^P}(ay^P(\theta),\theta) \end{aligned} \tag{8}$$

$$\begin{aligned} y^{NP} &: L^{NP}(\theta)[w + T'(Y(\theta))] = C_{y^{NP}}(\theta) = C_{1y^{NP}} \cdot L^{NP}(\theta) \\ &\Rightarrow (w + T'(Y(\theta))) = C_{1y^{NP}}(y^{NP}(\theta),\theta) \end{aligned} \tag{9}$$

$$L^P : y^P(\theta)(w + T'(Y(\theta))) + S'(L^P(\theta)) = C_{L^P}(\theta) + \nu \tag{10}$$

$$L^{NP} : y^{NP}(\theta)(w + T'(Y(\theta))) = C_{L^{NP}}(\theta) + \nu . \tag{11}$$

According to the contractual setup, the regulator (or principal) must offer a menu of contracts before knowing which type of agent he is facing. The objective function of the regulator is then to maximize social expected profit according to the probability distribution of types in the farmer population which depends on the benefit of any contract menu $\{(T(\theta), S(\theta), Y(\theta), L^P(\theta))\}$. Formally, the principal shoud solve:

$$\begin{aligned} \max_{\{(T(\theta),S(\theta),Y(\theta),L^P(\theta))\}} & \int [wY(\theta) - C^P(\theta) - C^{NP}(\theta)]dF(\theta) + A(\int_\theta L^P(\theta)dF(\theta)) \\ & - D(\int_\theta g(Y(\theta),\theta)dF(\theta)) - \lambda \int_\theta [T(Y(\theta)) + S(L^P(\theta))]dF(\theta) \end{aligned}$$

such that the participation constraint of the most inefficient farmer hold, as well as the incentive-compatibility (IC) constraint whenever the principal has imperfect information about agents' types. Noting that $T(\theta) + S(\theta) = \pi(\theta) - wY^P(\theta) + C^P(\theta) - wY^{NP}(\theta) + C^{NP}(\theta)$, the optimization variables can be changed as follows, and in the case of perfect information:

$$\begin{aligned} \max_{\{y^P(\theta),y^{NP}(\theta),L^P(\theta),L^{NP}(\theta)\}} & \int_\theta [\pi(\theta)dF(\theta) + A(\int_\theta L^P(\theta)dF(\theta)) - D(\int_\theta g(\theta)dF(\theta)) \\ & - (1+\lambda)\int_\theta [\pi(\theta) - wY^P(\theta) + C^P(\theta) - wY^{NP}(\theta) + C^{NP}(\theta)]dF(\theta) \end{aligned} \tag{12}$$

Such that $L^P + L^{NP} = L$

The participation constraint of the least inefficient farmer implies that $\pi(\underline{\theta}) = \underline{\pi}$, the reservation level of farm profit. Assuming further that the regulator does not face a binding budget constraint, yields the following first-order conditions (utilizing the envelope theorem via substitution of the farmers' optimal responses):

$$y^P : -D' \frac{\partial g}{\partial Y} L^P(\theta) = (1+\lambda)(T'(Y(\theta))L^P(\theta)$$

$$y^{NP} : -D' \frac{\partial g}{\partial Y} L^{NP}(\theta) = (1+\lambda)(T'(Y(\theta)))L^{NP}(\theta)$$

$$L^P : A' - D' \frac{\partial g}{\partial Y} y^P(\theta) = (1+\lambda)(y^P(\theta)T'(Y(\theta)) + S'(L^P(\theta)) - \nu)$$

$$L^{NP} : -D' \frac{\partial g}{\partial Y} y^{NP}(\theta) = (1+\lambda)(y^{NP}(\theta)T'(Y(\theta)) - \nu)$$

Extracting ν for all efficiency types yields:

$$T'(Y(\theta)) = -\frac{D' g_Y}{1+\lambda} \leq 0 \tag{13}$$

$$S'(L^P(\theta)) = \frac{A'}{1+\lambda} \geq 0 \tag{14}$$

Note that in the general case, land distribution among farmers does not matter since it is possible for the regulator to internalize the individual marginal environmental cost of each farmer's type, and not the aggregate one, through non-linear transfers (see next subsection for the linear case).

Condition (13) means that the marginal rate of T is always negative, i.e., T' is the marginal taxation of production. It can also be shown that marginal taxation increase with production: $T''(Y(\theta)) = -\frac{D''}{1+\lambda} g_Y^2 - \frac{D' g_{YY}}{1+\lambda} \leq 0$. Overall, socially desirable production-based transfers will follow a negative decreasing and concave function.

The impact of farmer's efficiency (θ) on marginal taxation, given by, $\frac{\partial T'(Y(\theta),\theta)}{\partial \theta} = T''(Y(\theta)) \cdot Y'(\theta) - \frac{D' g_{Y\theta} + D'' g_\theta g_Y}{1+\lambda}$ is of ambigous sign since $Y'(\theta)$ is indeterminate.

Condition (14) shows that the AEP marginal subsidy is positive. Deriving S' one more time, yields $S''(L^P(\theta)) = \frac{A''}{1+\lambda} \leq 0$. So, we can conclude that the first-best AEP marginal subsidy is a positive and decreasing function of land covered by the program. The impact of farmer’s type (θ) on marginal subsidy is also ambigous.

Finally, it can be shown that the functions $T'(Y(\theta))$ and $S'(L^P(\theta))$ cross each other only once, determining the policy optimum, based on their specific concavity, monotonicity, and signs (see Figure 1). Indeed, from the first order conditions and under our assumptions about emission, amenity and damage function we get (assuming negligible third-order derivatives[7]):

[7]Note that under this assumption, differentiating the first-order conditions of the farmer's optimization problem with respect to S’ and T’ is sufficient to prove that $\frac{\partial^2 Y}{\partial S'^2} \leq 0$. It can be also shown by the same calculations that

$$\frac{\partial T'}{\partial S'} = -[\frac{D''}{1+\lambda} g_Y^2 + \frac{D' g_{YY}}{1+\lambda}] \frac{\partial Y}{\partial S'} = T'' \frac{\partial Y}{\partial S'} > 0$$

$$\frac{\partial^2 T'}{\partial S'^2} = -\frac{D''}{1+\lambda}[2g_Y + g_Y g_{YY}] \frac{\partial Y}{\partial S'}^2 - T'' \frac{\partial^2 Y}{\partial S'^2} < 0$$

$$\frac{\partial S'}{\partial T'} = \frac{A''}{1+\lambda} \frac{\partial L^P}{\partial T'} > 0$$

$$\frac{\partial^2 S'}{\partial T'^2} = \frac{A''}{1+\lambda} \frac{\partial^2 L^P}{\partial T'^2} > 0$$

Proposition 1 *The first-best level of agri-environmental regulation when using a transfer* $T(\theta)$ *that depends on overall production* $Y(\theta)$ *and* $S(\theta)$ *as a function of* $L^P(\theta)$, *the amount of land covered by the AEP, is such that:*

- $T(\underline{\theta}) + S(\underline{\theta}) = \underline{\pi(\theta)} - pY_P(\underline{\theta}) + C_P(\underline{\theta}) - pY_{NP}(\underline{\theta}) + C_{NP}(\underline{\theta})$, *where* $\underline{\pi(\theta)}$ *is the reservation profit of the least efficient farmer*
- T *is negative, decreasing and convex with respect to total production* $Y(\theta)$; $T(\theta)$ *relies on the relative efficiency effects between production costs and pollution abatement along efficiency types*
- S *is a positive, increasing and concave function of* $L^P(\theta)$ *and has an ambiguous pattern with respect to* θ
- *For each* θ, *marginal transfers are determined by conditions (13) and (14)*

3.2 The linear uniform policy setting

Let us now examine the (constrained) optimal policy solution when marginal rates of transfer are bound to be constant and equal to t and S, respectively. Due to administrative burden, an optimally differentiated policy may be too complex to manage in practice (although it could be simplified by linearizing it by parts). The superiority of the linear contract may also be due to the fact that in the discriminated non-linear case, asymmetric information can lead to inefficiencies (due to the lack of an enforceable truth-revealing mechanism). The uniform policy setting is then a mechanism which does not rely on elicitation of information and which is simple to administer (Gren, 2004). It is also a specific case of the more general optimal first-best policy derived above. The social planner's problem becomes (under the same assumptions as in the non-linear case):

$$\max_{t,S} W = \int_\theta \pi(t,S,\theta)dF(\theta) + A(\int_\theta L^P(t,S,\theta)dF(\theta)) - D(\int_\theta g(t,S,\theta)dF(\theta))$$
$$-(1+\lambda)S\int_\theta L^P(t,S,\theta)dF(\theta) - (1+\lambda)t\int_\theta [Y^P(t,S,\theta) + Y^{NP}(t,S,\theta)]dF(\theta) \quad (15)$$

such that

$$\pi(\theta) = \max_{L^P(\theta), L^{NP}(\theta), y^P(\theta), y^{NP}(\theta)} \pi(\theta); L^P + L^{NP} = L \quad (16)$$

$\frac{\partial Y}{\partial S'}$, $\frac{\partial L^P}{\partial T'}$, and $\frac{\partial^2 L^P}{\partial T'^2} < 0$. Calculations are available from the authors upon request.

$$L^P(\theta) = \underset{L^P}{\text{argmax}}\,\pi(\theta) \quad (17)$$

$$Y^P(\theta) = y^P(\theta)L^P(\theta); y^P(\theta) = \underset{y^P}{\text{argmax}}\,\pi(\theta) \quad (18)$$

$$Y^{NP}(\theta) = y^{NP}(\theta)L^{NP}(\theta); y^{NP}(\theta) = \underset{y^{NP}}{\text{argmax}}\,\pi(\theta) \quad (19)$$

Noting from eq. (2) that $t[Y^P(\theta)+Y^{NP}(\theta)]+SL^P(\theta) = \pi(\theta) - pY^P(\theta)+C^P(\theta)-pY^{NP}(\theta)+C^{NP}(\theta)$, the social planner's problem becomes (change of optimizing variables is explained in appendix A.1.2):

$$\max_{\int y^P(\theta), \int y^{NP}(\theta), \int L^P(\theta), \int L^{NP}(\theta)} \int_\theta \pi(\theta)dF(\theta) + A(\int_\theta L^P(\theta)dF(\theta)) - D(\int_\theta g(\theta)dF(\theta))$$

$$-(1+\lambda)\int_\theta [\pi(\theta) - wY^P(\theta) + C^P(\theta) - wY^{NP}(\theta) + C^{NP}(\theta)]dF(\theta))$$

$$\text{such that } L^P(\theta) + L^{NP}(\theta) = L(\theta)$$ [8]

Proposition 2 sums up the findings of this problem. Appendix A2 formally discusses the proof of the proposition and the role of land distribution in the optimal uniform policy mix.

Proposition 2 *Under linear contracting, socially optimal agri-environmental regulation entails a production tax which equalizes aggregate marginal environmental damage, and a land subsidy under an AEP which equalizes marginal amenity and marginal social cost savings. The latter is negative and decreases when total land distribution favors efficient farmers.*

$$t = -\frac{D'}{1+\lambda}\frac{\int_\theta g_Y(\theta)L(\theta)dF(\theta)}{\int_\theta L(\theta)dF(\theta)} \quad (20)$$

$$S = \frac{A'}{1+\lambda} + \frac{D'}{1+\lambda}\int_\theta [g_Y(\theta) - \frac{\int_\theta g_Y(\theta)L(\theta)dF(\theta)}{\int_\theta L(\theta)dF(\theta)}]\Delta y(\theta)dF(\theta) \quad (21)$$

where $\Delta y(\theta) = y^{NP}(\theta) - y^P(\theta)$, *the productivity gap for a given type between its productivity levels under* P *and the one under not P .*

Proof. *See appendix A2.*

Hence, while optimal production-incentive policy is a taxation that equalizes aggregate marginal environmental damage, the program subsidy adjusts the marginal amenity according to land distribution among types, taking into account the marginal effect of the AEP subsidies on both aggregate pollution abatement and marginal tax revenues. The difference between

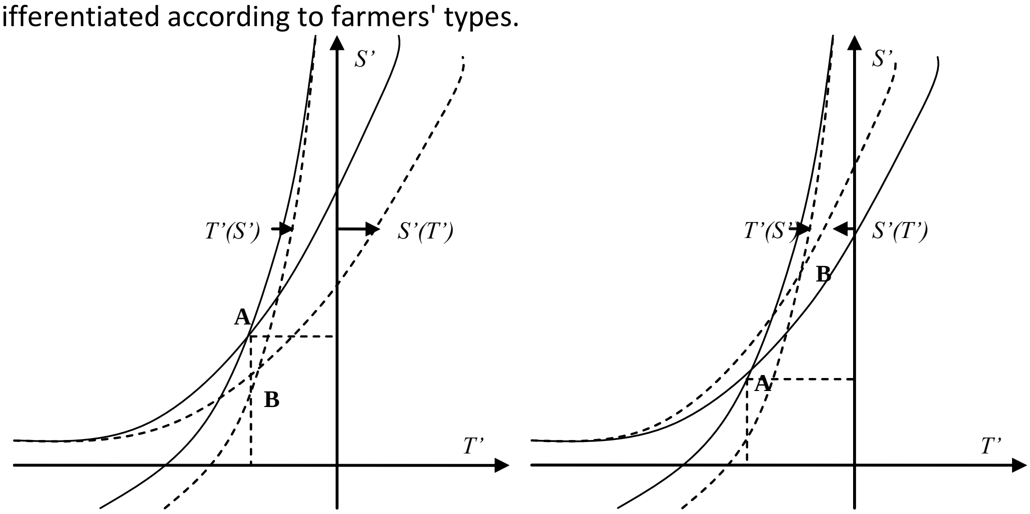
[8]Note that *L(ϑ)* is taken as an exogenous distribution of farmland over farmers' efficiency types. Distribution of land may also be an endogenous choice of the social planner if land policy becomes endogenous together with agri-environmental regulation. This question is, however, outside the scope of this paper. Interestingly, we will provide a sensitivity analysis of our results with respect to land distribution (more formally in the appendix), and will discuss the issue of land markets and policies.

optimal linear schemes and the non-linear ones derived above stem from the fact that, when no discrimination among farmers is possible, the regulator is forced to account for the aggregate effects of its policy, instead of tailoring each instrument to each farmer. In appendix A2, we show how land distribution affects optimal land subsidies and production optimal taxation.

In brief, whenever land distribution is uniform among farmers' types, then optimal taxation of production will be such that marginal tax will equalize marginal damage caused by the average polluting emissions. Optimal marginal AEP subsidy will be below the marginal amenity because efficient farmers pay more taxes than their marginal contribution to environmental damage. They thus produce below the social optimal level, and have in turn more incentives to adopt the AEP, at a given subsidy rate. The reverse holds for inefficient farmers, but under uniform land distribution, the incentive effect from efficient farmers is larger. This AEP marginal subsidy will be adjusted downward when land distribution favors efficient farmers, or upward in the reverse case (see A2 for more details).

3.3 Comparative statics

Crossing of the functions, $T^{'}(S^{'})$ and $S^{'}(T^{'})$ (which can also be applied to the linear case, see appendix A3), leads to the optimal social response, which involves a positive land subsidy for P and a taxation for each production unit in all cases. It is then possible to derive some comparative statics by examining the sensitivity of these two functions to the parameters, as shown in Figure 1. With respect to the marginal cost of public funds λ that entails a deadweight loss, there is a rightward shift of both $T^{'}(S^{'})$ and $S^{'}(T^{'})$, leading to ambiguous effects on both instruments. Figure 1 depicts the case in which this induces a reduction of the tax on production and a decrease in the land subsidy as a move from optimal point A to B. The effect of a involves a rightward shift of $T^{'}(S^{'})$ and a leftward shift of $S^{'}(T^{'})$, leading to a production tax reduction and an increase in the land subsidy from point A to B. Note that these comparative statics must be differentiated according to farmers' types.



[Figure 1: Effect of *λ* (left) and *a* (right) on (S'*,T''*) optimum]

It can be shown that more costly transfers (higher λ) entail lower production taxation, producing the same effect than more efficient farmers.[9] More constraining AEPs (higher a) entail also less production taxation (more pollution abatement), as well as more land subsidization (improving incentives to undertake the AEP). An increase in the value of output *w* encourages more AEP marginal subsidization since farmers have less incentives to undertake the program.

Parameter	S'(T')	T'(S')	S'*	T'*
λ	-	+	?	+
a	+	+	+	+
F(ϑ)	-	+	?	+
W	+	-	+	?

[Table 1. Comparative statics of first-best policy instruments]

3.4 Endogenous AEPs

The nature of the program is of major importance to the level of environmental benefits and its associated producers' costs. While so far we simply assumed that the regulations of the AEP will induce a specific cost structure for each farm, the higher is the level of a, the higher is the level of the amenities that a consumer will enjoy from a given amount of land enrolled in the AEP. But after some threshold level, the land will have to be set aside, and this may entail a loss in landscape value if consumers prefer agricultural landscape. Hence, we can refine the amenity function such that:

$$A = A(\int_\theta L^P(\theta, a) dF(\theta); a)$$

where the function A is concave and has an inverted U-shape form as a function of its second argument. Then, if a is optimally chosen by the regulator, optimal taxes and subsidies will be adjusted according to marginal amenities and levels of environmental damage (see the above comparative statics with respect to a). Inserting the new amenity function into the welfare objective of the regulator, it is easy to show that the optimal first-best a is such that:

$$\frac{\partial A}{\partial a} = 0 \qquad (22)$$

Indeed, using the farm-level first-order conditions and those of the regulator, (13) and (14), as well as the envelope theorem, leads to eq. (22). Hence, the optimal level of AEP regulation depends solely on consumer preference for agricultural amenities. The following respective effects of a on amenities and environmental damage, taxpayers' burden, and producers' profits are all fully endogenized within the regulator's optimal transfer rules and the farmers' production choices so that:

$$\frac{\partial A}{\partial \int_\theta L^P(\theta) dF(\theta)} \int_\theta \frac{\partial L^P(\theta)}{\partial a} dF(\theta) - D' \int_\theta g_Y(\theta) \frac{\partial Y(\theta)}{\partial a} dF(\theta)$$

[9]A change in the parameter $F(\theta)$ refers to a first-order stochastic shift of the cumulative distribution function of types.

$$+(1+\lambda)\int_{\theta}[w\frac{\partial Y(\theta)}{\partial a}-\frac{\partial C(\theta)}{\partial a}]dF(\theta)-\lambda\int_{\theta}\frac{\partial \pi(\theta)}{\partial a}dF(\theta)=0$$

Note that the above condition for optimal a will be the same for all farmers, if AEPs can be differentiated among farmers.

4 Second-best solution

When farmers' efficiency type is private information pertaining to the individual farmer, then the Principal (the social planner) has to satisfy an incentive-compatibility (IC) constraint, to ensure that efficient farmers will not mimic inefficient ones in order to derive more rents. In this case, the Principal will be forced to give an informational rent to the efficient types so that this will induce them to truthfully reveal their type.

The IC constraint can be written in the following way:

$$\pi(\theta,\theta)=\max_{\tilde{\theta}}\pi(\theta,\tilde{\theta})=\max_{\tilde{\theta}}\pi(\theta,\tilde{\theta})=T(\tilde{\theta})+S(\tilde{\theta})+pY^{P}(\tilde{\theta})-C^{P}(\tilde{\theta},\theta)+pY^{NP}(\tilde{\theta})-C^{NP}(\tilde{\theta},\theta) \quad (23)$$

when $\theta=\tilde{\theta}$, which means that it is optimal for farmers to announce their true type and where $\tilde{\theta}$ is the announced type by farmer θ when selecting the menu $\{T(\tilde{\theta}),S(\tilde{\theta}),Y(\theta,\tilde{\theta}),L^{P}(\theta,\tilde{\theta})\}$.
The first-order condition of the (IC) entails:

$$\frac{\partial \pi(\theta,\tilde{\theta})}{\partial \tilde{\theta}}_{/\tilde{\theta}=\theta}=\underbrace{T^{'}(\tilde{\theta})+S^{'}(\tilde{\theta})+pY^{P'}(\tilde{\theta})+pY^{NP'}(\tilde{\theta})_{/\tilde{\theta}=\theta}}_{\pi'(\theta)}-\frac{\partial C^{P}(\theta,\tilde{\theta})}{\partial \tilde{\theta}}-\frac{\partial C^{NP}(\theta,\tilde{\theta})}{\partial \tilde{\theta}}=0$$
$$\Leftrightarrow \pi'(\theta)=\frac{\partial C^{P}(\theta)}{\partial \theta}+\frac{\partial C^{NP}(\theta)}{\partial \theta}\geq 0 \quad (24)$$

must hold for all θ, applying the envelop theorem and according to our assumptions. Second-order differentiation implies:

$$\pi^{''}(\theta)=0\Leftrightarrow -\frac{\partial^{2}C^{P}(\theta,\theta)}{\partial \theta^{2}}-\frac{\partial^{2}C^{P}(\theta,\theta)}{\partial \theta \partial Y^{P}}Y^{P'}(\theta)-\frac{\partial^{2}C^{NP}(\theta,\theta)}{\partial \theta^{2}}-\frac{\partial^{2}C^{NP}(\theta,\theta)}{\partial \theta \partial Y^{NP}}Y^{NP'}(\theta)=0$$

while the local (in the neighborhood of θ) second-order condition of the IC constraint is:

$$-\frac{\partial^{2}C^{P}(\theta,\theta)}{\partial \theta^{2}}-\frac{\partial^{2}C^{NP}(\theta,\theta)}{\partial \theta^{2}}\leq 0$$

which, combined with the above expression, yields:

$$-\frac{\partial^{2}C^{P}(\theta,\theta)}{\partial \theta \partial Y^{P}}Y^{P'}(\theta)\geq \frac{\partial^{2}C^{NP}(\theta,\theta)}{\partial \theta \partial Y_{NP}}Y_{NP}^{'}(\theta)\Leftrightarrow Y_{P}^{'}(\theta)+Y_{NP}^{'}(\theta)=Y^{'}(\theta)\geq 0 \quad (25)$$

under our assumptions and because optimal farmer behavior is such that marginal costs under *P* and *NP* are equalized. Transfers should ensure that total production will still increase according to types (as a sufficient condition to satisfy the IC constraint). This condition may not be automatically satisfied for all optimal transfer rules. If it is not, then the second-order condition of the IC constraint will be binding and a pooling equilibrium over a range of farmer types will emerge, meaning that they will all produce the same Y.

Incorporating the IC constraint into the social welfare problem, we note that:

$$\int_{\underline{\theta}}^{\theta}\pi^{'}(\theta)dF(\theta)=\pi'(\theta)-\underline{\pi'[(\theta)}=-\int_{\underline{\theta}}^{\theta}[\frac{\partial C^{P}(u,u)}{\partial\theta}+\frac{\partial C^{NP}(u,u)}{\partial\theta}]du$$

The new problem of the social planner when satisfying IC is:[10]

$$\max_{\{y^P(\theta),y^{NP}(\theta),L^P(\theta),L^{NP}(\theta)\}} A(\int_{\theta}L^{P}(\theta)dF(\theta))-D(\int_{\theta}g(\theta)dF(\theta))+\lambda\int_{\theta}\int_{\underline{\theta}}^{\theta}[\frac{\partial C^{P}(u,u)}{\partial\theta}$$

$$+\frac{\partial C^{NP}(u,u)}{\partial\theta}]du]dF(\theta)-(1+\lambda)\int_{\theta}-wY^{P}(\theta)+C^{P}(\theta)-wY^{NP}(\theta)+C^{NP}(\theta)]dF(\theta)-\lambda\underline{\pi(\theta)}$$

which is equivalent to (integrating by parts):

$$\max_{\{y^P(\theta),y^{NP}(\theta),L^P(\theta),L^{NP}(\theta)\}} A(\int_{\theta}L^{P}(\theta)dF(\theta))-D(\int_{\theta}g(\theta)dF(\theta))-(1+\lambda)\int-wY^{P}(\theta)+C^{P}(\theta)$$

$$-wY^{NP}(\theta)+C^{NP}(\theta)]dF(\theta)+\lambda\int_{\theta}[\frac{\partial C^{P}(\theta,\theta)}{\partial\theta}+\frac{\partial C^{NP}(\theta,\theta)}{\partial\theta}][\frac{1-F(\theta)}{f(\theta)}]]dF(\theta)-\lambda\underline{\pi(\theta)} \quad (26)$$

These new (negative) terms (the two last ones of eq. (26)) compared to the perfect-information case correspond to the social cost of the IC mechanisms, which entails an informational rent given to farmers with an aggregate cost of $\lambda\int_{\theta}[\frac{\partial C^{P}(\theta,\theta)}{\partial\theta}+\frac{\partial C^{NP}(\theta,\theta)}{\partial\theta}][\frac{1-F(\theta)}{f(\theta)}]]dF(\theta)$. Accordingly, this modifies the first-order conditions of the regulator's problem with respect to the first-best case:

$$y^{P}:-D^{'}\frac{\partial g}{\partial Y}L^{P}(\theta)+\lambda\frac{\partial^{2}C^{P}(\theta)}{\partial\theta\partial y}][\frac{1-F(\theta)}{f(\theta)}]=(1+\lambda)T^{'}(Y(\theta))L^{P}(\theta)$$

$$y^{NP}:-D^{'}\frac{\partial g}{\partial Y}L^{NP}(\theta)+\lambda\frac{\partial^{2}C^{NP}(\theta)}{\partial\theta\partial y}][\frac{1-F(\theta)}{f(\theta)}]=(1+\lambda)(T^{'}(Y(\theta)))L^{NP}(\theta)$$

$$L^{P}:A^{'}-D^{'}\frac{\partial g}{\partial Y}y^{P}(\theta)=(1+\lambda)(y^{P}(\theta)T^{'}(Y(\theta))+S^{'}(L^{P}(\theta))-\nu)$$

$$L^{NP}:-D^{'}\frac{\partial g}{\partial Y}y^{NP}(\theta)=(1+\lambda)(y^{NP}(\theta)T^{'}(Y(\theta))-\nu)$$

assuming that $\frac{\partial^{2}C^{P}(\theta)}{\partial\theta\partial L^{P}}=\frac{\partial^{2}C^{NP}(\theta)}{\partial\theta\partial L^{NP}}=0$, that is, marginal cost of land cultivation is independent of θ and our measure of efficiency only applies to marginal cost of production and pollution.

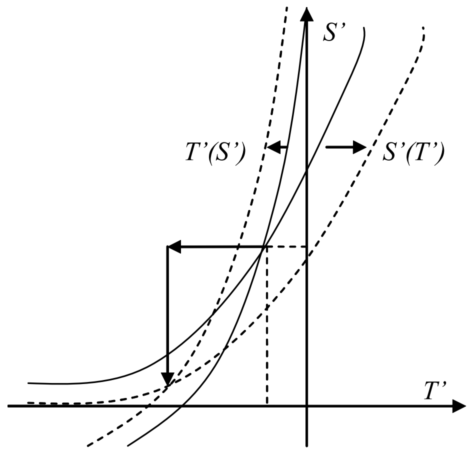
We then get the following first-order conditions for all types:

$$T^{'}(Y(\theta))=-\frac{D^{'}g_{Y}}{1+\lambda}+\frac{\lambda}{1+\lambda}[\frac{\partial^{2}C^{P}(\theta)}{\partial\theta\partial y}+\frac{\partial^{2}C^{NP}(\theta)}{\partial\theta\partial y}][\frac{1-F(\theta)}{f(\theta)}] \quad (27)$$

[10]The change of optimizing variables is explained in appendix A1.

$$S'(L^P(\theta)) = \frac{A'}{1+\lambda} + \frac{\lambda}{1+\lambda}[\frac{\partial^2 C^P(\theta)}{\partial\theta\partial y} + \frac{\partial^2 C^{NP}(\theta)}{\partial\theta\partial y}][\frac{1-F(\theta)}{f(\theta)}]\Delta y(\theta) \quad (28)$$

Note that both marginal land subsidy and production transfer become lower relative to the perfect information case (see eqs. (13) and (14)), everything else held constant, because of the informational rent that increases the social cost of transfers. Hence, production taxation should be increased and land subsidies should be reduced. Note that the most efficient farmer will induce no distortions since $\frac{1-F(\bar{\theta})}{f(\bar{\theta})} = 0$, so that there is no distortion at the top (standard in incentive theory).



[Figure 2: Effect of imperfect information on social optimum]

Figure 2 (dotted lines represent optimal transfer rules in the second-best case and full lines in the first-best case) illustrates that relative to the first-base case, asymmetric information will increase marginal taxation , more so for lower efficiency types under the monotonic hazard rate property,[11] with the same pattern for reduced land subsidies. This is to prevent efficient farmers from mimicking inefficient ones (dissuasive taxation) and gives them a rent to truthfully reveal their private information. Hence, imperfect information may change the optimal shape of production taxation as a function of type. Marginal taxation remains around the same levels for efficient types (no distortion at the top) but is higher for low-efficient farmers. This is also to ensure that the taxation scheme will satisfy eq. (25).

Proposition 3 *The second-best level of agri-environmental regulation under imperfect information entails marginal transfers described by first-order conditions (27) and (28), higher marginal taxation of production and lower marginal subsidization of P relative to perfect information for a given type with no distortion at the top (decreasing distortion with efficiency). Transfers should ensure that farmers' production and profits are not decreasing with their type.*

[11] $\frac{1-F(\theta)}{f(\theta)}$ is assumed to decrease with θ. $d\left[\frac{1-F(\theta)}{f(\theta)}\right] \Big/ d\theta < 0$

Considering an endogenous AEP, the second-best a with respect to the welfare objective function will be such that:

$$\frac{\partial A}{\partial a} = -\lambda \int_\theta L^P(\theta) \frac{\partial^2 C^P(\theta)}{\partial\theta\partial y} \frac{\partial y^P}{\partial a} [\frac{1-F(\theta)}{f(\theta)}] dF(\theta) + \lambda \int_\theta L^P(\theta) \frac{\partial^2 C^P(\theta)}{\partial\theta\partial y} \frac{\partial y^P}{\partial a} [\frac{1-F(\theta)}{f(\theta)}] dF(\theta) = 0 \quad (29)$$

With respect to eq. (22), there are two terms arising from the effects of a on the informational rent, but they fully offset each other. The negative welfare effect of *a* is due to an increase in the informational rent. On the other hand, inefficient farmers will pay more taxes and receive less subsidies, which enable to make savings on public spendings. Hence, the optimal level of a is the same as in the first-best case. However, it may be that inefficient farmers will need to be compensated by larger payments to ensure their participation.

It is important to note that imperfect information does not change the result obtained for the first-best policy that AEP transfers should be positive while production should be marginally taxed. The next section aims to introduce political economy parameters (political rents derived by farmers' lobbies, inequality aversion, and partial concerns for environmental externalities) to explain why in reality we see production support rather than taxation.

Importantly, we assumed that positive amenities (landscape and recreation) were only driven by the enrollment of land under the AEP (no other amenities otherwise), which is an oversimplification. Of course, other agricultural land not enrolled under the AEP may provide positive amenities, and if this outweighs the deadweight cost of public funds and the marginal damage caused by pollution, then T' can be positive (with or without AEP subsidy). In a highly productive agriculture, this is not likely to be the case, but a less productive (albeit more environmentally friendly) agriculture not enrolled in an AEP could provide net social benefits and should be subsidized (e.g. cattle-rearing in the highlands). The fact that socially detrimental agriculture (from the standpoint of social and environmental amenities) continues to be subsidized, even in a more decoupled way and irrespective of any cross-compliance with agri-environmental regulations, means that that it is backed by additional political support.

5 Political preferences and inefficiencies

5.1 Effects of political economy parameters on optimal contract design

In practice, agricultural policies do not follow optimal social conditions, such as those derived above. A simple glance at the budgets of agricultural policies in OECD countries exhibits significant production support, which is likely to be inefficient and make AEPs less effective. The purpose of this section is to introduce a political preference for farmers' profits, which supports additional production incentives and therefore explains why production is actually subsidized instead of being taxed.[12]

While aggregate production is politically supported, we also assume that policy-makers are inequality-averse, that is, they are willing to redistribute farm incomes among farmers (in line with the recent policy setup, see next section). To this end, we introduce a general political weight function H of individual profits which is strictly concave and such that:

[12]This can be due to the non-benevolence of policy-makers subject to political pressure from farmers' lobbies. Here we consider exogenous farmers' lobbying pressure.

$$H^{'} \geq (1+\lambda); H^{''} < 0$$

The marginal weight of an individual farmer's profit is greater than the social cost of transfers, which we define as political favoritism. Marginal weight decreases with profits and farmer type (concavity), implying inequality aversion. In addition, we consider that amenities and pollution are only partially internalized by the regulator.[13]

The politically weighted welfare function becomes:

$$W = \int_\theta W(\theta)dF(\theta) = \int_\theta (H(\pi(\theta)) - (1+\lambda)\pi(\theta))dF(\theta) + \gamma A(\int_\theta L^P(\theta)dF(\theta)) - \delta D(\int_\theta g(\theta)dF(\theta))$$
$$-(1+\lambda)\int_\theta [C^P(\theta) + C^{NP}(\theta) - wY^P(\theta) - wY^{NP}(\theta)]dF(\theta) \qquad (30)$$

where γ and δ lie on the interval $[0,1]$ and represent the degree of internalization of the positive (*A*) and negative (*D*) externalities, respectively. Under perfect information, optimal solutions are unchanged and are the same as (13) and (14), except that marginal amenities and environmental damage are reweighed, which may lead to production subsidies (i.e., to positive T') rather than taxes (see eq. (13)). However, under imperfect information and subject to the IC constraint in (25), the regulator's problem becomes:

$$\max_{\{y^P(\theta), y^{NP}(\theta), L^P(\theta), L^{NP}(\theta)\}} \gamma A(\int_\theta L^P(\theta)dF(\theta)) - \delta D(\int_\theta g(\theta)dF(\theta)) - (1+\lambda)\int_\theta - wY^P(\theta) + C^P(\theta) - wY^{NP}(\theta)$$
$$+ C^{NP}(\theta)]dF(\theta) - \int_\theta [[\frac{\partial C^P(\theta,\theta)}{\partial \theta} + \frac{\partial C^{NP}(\theta,\theta)}{\partial \theta}][H' - (1+\lambda)][\frac{1-F(\theta)}{f(\theta)}] - \underline{\pi(\theta)}]dF(\theta) \qquad (31)$$

yielding the following first-order conditions for all types:

$$T^{'}(Y(\theta)) = -\frac{\delta D^{'} g_Y}{1+\lambda} + [(1+\lambda) - H'][\frac{\partial^2 C^P(\theta)}{\partial \theta \partial y} + \frac{\partial^2 C^{NP}(\theta)}{\partial \theta \partial y}][\frac{1-F(\theta)}{f(\theta)}] \qquad (32)$$

$$S^{'}(L_P(\theta)) = \frac{\gamma A^{'}}{1+\lambda} + [(1+\lambda) - H'][\frac{\partial^2 C^P(\theta)}{\partial \theta \partial y} + \frac{\partial^2 C^{NP}(\theta)}{\partial \theta \partial y}][\frac{1-F(\theta)}{f(\theta)}]\Delta y(\theta) \qquad (33)$$

Note that, even under $\gamma = \delta = 1$, imperfect information can be solely responsible for supporting production subsidies under political favoritism because the information rent (negative in (27) and (28)) becomes a positive political rent in eqs. (32)-(33) (since $H^{'} \geq (1+\lambda)$). Indeed, $T^{'}(Y(\theta))$ is positive whenever:

$$[\frac{1-F(\theta)}{f(\theta)}][H' - (1+\lambda)] \geq -\frac{\delta D^{'} g_Y}{1+\lambda} / [\frac{\partial^2 C^P(\theta)}{\partial \theta \partial y} + \frac{\partial^2 C^{NP}(\theta)}{\partial \theta \partial y}]$$

which is possible since the LHS is positive under political favoritism and is ensured when δ is sufficiently low, γ is high (to ensure low marginal environmental damage), or both. Likewise in eq. (33), the AEP subsidy increases when compared to first-best (14) and second-best (28)

[13]The degree of externality internalization is also a political choice, which may reflect voting outcomes, environmental friendly associations and farmers' collective action, as well as a lack of coordination in environmental regulation among administrations. We also treat it as an exogenous parameter.

solutions. Imperfect information and inequality aversion combine here to help low-efficient farmers obtain higher production subsidies (marginally) than efficient farmers. Indeed, if $\delta = 1$,

$$\frac{dT^{'}(Y(\theta))}{d\theta} = \frac{dT^{'}(Y(\theta))}{d\theta}_{FB} - [H"\pi'(\theta)\frac{1-F(\theta)}{f(\theta)} + [H' - (1+\lambda)]d\frac{1-F(\theta)}{f(\theta)}/d\theta][\frac{\partial^2 C^P(\theta)}{\partial\theta\partial y} + \frac{\partial^2 C^{NP}(\theta)}{\partial\theta\partial y}]$$
$$\Rightarrow \frac{dT^{'}(Y(\theta))}{d\theta} \leq \frac{dT^{'}(Y(\theta))}{d\theta}_{FB} \leq \frac{dT^{'}(Y(\theta))}{d\theta}_{SB} \quad (34)$$

where *FB* stands for first best. Since there is still no distortion at the top (i.e., $T^{'}(Y(\bar{\theta})) = T^{'}(Y(\bar{\theta}))_{FB}$), this means that low-efficient farmers receive higher *T'* than under first-best rules (and also second-best by transitivity) because the *T'* curve has a sharper decreasing slope according to efficiency type than the first-best one (see Figure 3 to see taxation patterns along types). Hence, the effect of imperfect information on the provision of incentives to farmers (lower incentives for low-efficient types, no distortion at the top) in proposition 3 is now modified (higher incentives for low-efficient types, no distortion at the top). However, to satisfy the IC constraint, the transfers *T* and *S* must still ensure that more efficient farmers produce more according to eq. (25), which is less likely to hold because inefficient farmers have higher *T'* relative to the first-best rules (see just above). Hence, inequality aversion will increase the production and profits of low-efficient farmers up to some pooling equilibrium in which a range of farmers will produce the same amount.[14] It can also lead to uniform policies with flat rates of subsidization (linear contracting), irrespective of farmers' types or outputs. This will be the case whenever the welfare loss due to the binding condition (25) (or its related shadow cost) overtakes the inefficiencies driven by uniform instruments (due to non-discrimination among types), but the latter may be more appropriate for high inequality-averse regulators. Note that inequality aversion increases the likelihood that such a pooling equilibrium will emerge.

Proposition 4 *The combination of political favoritism, inequality aversion, and imperfect information renders production support* (i.e., $T^{'} > 0$) *feasible. Positive T' as an optimal solution is more likely when political concerns for environmental damage weaken, those for amenity benefits strengthen, or both.*[15]

Note that the effect of imperfect information is common for both policy instruments, while γ and δ are specific explanatory parameters of policy deviations from the social optimum. Inefficiencies due to political biases and favoritism may then be explained through the identification of these three parameters {δ, γ, *H'(.)*}. In addition, one can conjecture on how

[14]Note that we cannot determine where such an interval will be located on the distribution of farmers' types. This would require knowing the functional forms of the *ϑ-d*istribution and cost functions, emission, damage, and amenity functions. Political favoritism (that is $H^{'} - (1+\lambda)$) makes *T'* increase for a given type.

[15] The high-efficiency types (for whom $[1-F(\theta)]$ approaches zero), should still be taxed according to first-order condition (33), as shown in Figure 3. This may not occur in real politics because of political pressure of efficient farmers within their farmers' unions. Another point is that full discrimination of policy instruments never occur and these are generally approximated by piecewise linear contracts. High-efficiency farmers can thus locate on a positive *T'* linear regime while they benefit from a lower marginal rate of support than low-efficient farmers.

inefficient both policy instruments are due to these parameters when compared to the socially optimum benchmark of Section 3.

As in the second-best and first-best cases, the optimal a will also satisfy condition (22). Here, the informational rent (in (27)-(28)) is replaced by a political rent (in (32)-(33)) that marginally decreases with a but in the meantime, inefficient farmers receive the equivalent amount of marginal subsidies under first-order conditions (32) and (33). While a will still be at its first-best level, production and land transfers will deviate from first and second best since they include political components of farmer favoritism, inequality aversion, and partial internalization of the environmental externalities.

5.2 Farmer exclusion and compensations

Political interference is then likely to induce inefficiencies from a social welfare point of view, because the increased transfers to inefficient farmers will result in externality levels that deviate from first-best ones (too much pollution and not enough amenities). Nevertheless, political mechanisms may attenuate those inefficiencies by eliminating a subset of overly inefficient farmers through transfer design. To do so, the transfers should be set such that the participation constraint of the inefficient farmers will not be satisfied, requiring transfers that should just ensure that the first farmer willing to produce brings zero or positive welfare in eq. (30). This means that the policy-maker wants to allow the first farmer θ^a to produce so that $W(\theta^a) = 0; \forall \theta < \theta^a, W(\theta) < 0$, and will exclude all less efficient ones through transfer design. Then, $\theta^a > \underline{\theta} <=> W^{'}(\underline{\theta}) > 0$ or $\theta^a = \underline{\theta}$ otherwise. All farmers below θ^a (if any) will convey negative welfare from the policy-maker's standpoint and should be excluded.

Such a mechanism may, however, meet with popular discontent (i.e. be unpopular for the median voter) and may not be politically supported or feasible under farmers' collective action. To make the political mechanism with exclusion enforceable, we add a new constraint to the Principal-Agent problem with political preferences, building on the approach of Lewis et al. (1989):

$$\int_{\theta} \varphi(\pi(\theta) - \pi^0(\theta)) dF(\theta) \geq \alpha \tag{35}$$

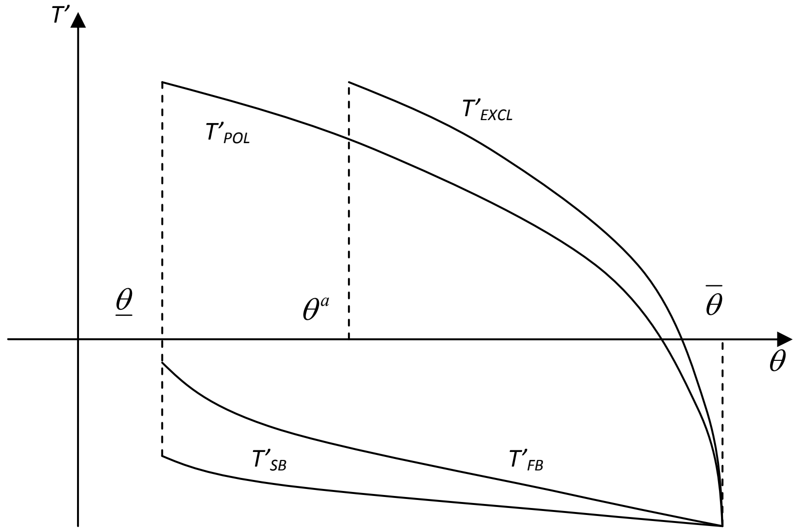
where φ is the probability function guaranteeing that with a compensation level of $\pi(\theta)$ conveyed to each farmer of type θ or lower, all of these farmers will enjoy and support the policy (under which each one of them will be excluded and compensated) and where $\pi^0(\theta)$ is the farmer's profit under the no-exclusion policy. Specifically, $\varphi(\pi(\theta) - \pi^0(\theta)) = 1$ whenever $\pi(\theta) \geq \pi^0(\theta)$ and zero otherwise among the excluded population. This means that an exogenously determined portion α of the excluded farmer population has to be satisfied with the policy when compared to a non-intervening or status-quo situation. The farmer who is indifferent between policy exclusion and status quo is denoted $\hat{\theta}$ such that $F(\hat{\theta}) \geq \alpha$, meaning that all farmers below $\hat{\theta}$ should be satisfied, even if they are excluded. For this to work, all excluded farmers should receive the status-quo profit of $\hat{\theta}$, $\pi(\theta) = \pi^0(\hat{\theta})$ and only the necessary (predetermined by α) part of them will be better off with the compensation scheme. These compensations can be viewed as payments for land retirement by inefficient farmers, and will make the exclusion policy enforceable. Note that the more binding the political acceptability constraint (i.e., the higher the level of α), the higher the level of $\hat{\theta}$, and the higher the total compensation costs ($\pi(\hat{\theta})\cdot[\hat{\theta}-\underline{\theta}]$) since profit increases with efficiency type.

However, compensating all excluded farmers may cost more than the gains earned by their elimination, as measured by the negative welfare associated with their production. So the first farmer allowed to produce will be the one for whom compensation starts to be more costly than its negative welfare contribution. Then when α increases, per-farm compensation ($\pi(\hat{\theta})$) increases and it may be well that $W(\theta^a)<0$.

Formally, with the exclusion and compensation schemes, the new optimization problem of the regulator is:

$$\max_{T(\theta),S(\theta),\theta^a,Y(\theta),L^P(\theta)} \int_{\theta^a} W(\theta)dF(\theta)-(1+\lambda)F(\theta^a)\pi^0(\hat{\theta}) \qquad (36)$$

such that (35) determines $\hat{\theta}(\alpha)$.



[Figure 3: Optimal marginal taxation with and without exclusion]

Since compensation entails a deadweight cost, the compensation is made at the minimum level at which eq. (35) is binding. The first-order conditions entail that *S'* and *T'* still satisfy conditions (32) and (33), except that *F(.)* and *f(.)* are truncated and refer, respectively, to the conditional cumulative distribution and the density function given that all types are above θ^a. Figure 3 depicts the case of *T'* as a function of efficiency type when there is exclusion (T'_{EXCL}) compared to the political mechanism without exclusion (T'_{POL}) and the first-best (T'_{FB}) and second-best (T'_{SB}) cases.

Additional first-order conditions are:

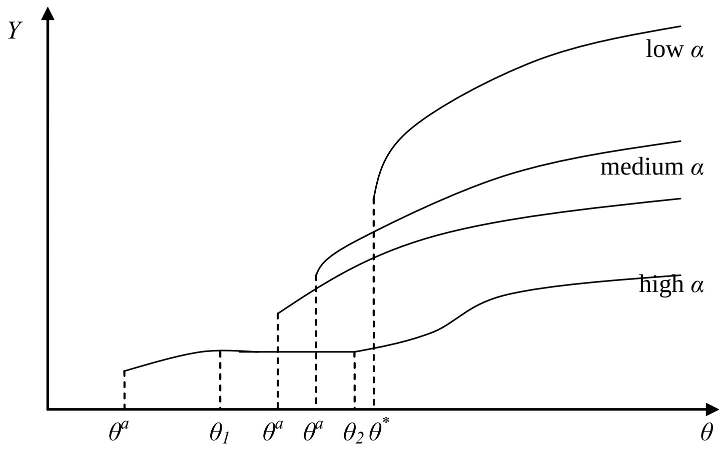
$$\begin{aligned}&\hat{\theta}=F^{-1}(\alpha)\\&-W(\theta^a)=(1+\lambda)\pi^0(\hat{\theta})\end{aligned} \qquad (37)$$

Note that when *α=0*, then there is no need to compensate anyone: the indifferent farmer becomes the least efficient one ($\hat{\theta}=\underline{\theta}$) and the first farmer who is allowed to produce is the one for whom the welfare contribution is zero. In this case, the political mechanism is authoritarian.[16] With increasing *α*, the first allowed producer will be of a lower efficiency type and will add negative welfare to the regulator because it will be too costly to compensate him for the exclusion (the higher the α, the higher $\widehat{\theta}(\alpha)$ and the higher the compensation payment for each one of the excluded farmers, $\pi(\widehat{\theta}(\alpha))$). Whenever θ^a becomes lower than $\hat{\theta}$ (i.e., the number of excluded farmers is lower than the number of farmers required to satisfy the constraint in (35)), it will be sufficient to compensate excluded farmers with $\pi^0(\theta^a)$ instead of $\pi^0(\hat{\theta})$.

Being able to exclude the inefficient farmers means that agricultural support can be spent more efficiently to help efficient farmers provide more environmental amenities and decrease pollution. Modifying eqs. (32) and (33) with the new (truncated) distribution and density functions of the population of non-excluded farmers implies that both marginal supports, $T^{'}$ and $S^{'}$, will increase for a given (producing) type (due to the increase in the monotonic hazard ratio $[\frac{1-F(\theta)}{f(\theta)}]$).

The cost of exclusion, as just shown, increases with *α.* So an increase in *α* will result in a reduction of both *T'* and *S'* for a given type, and will allow inefficient farmers to produce, and pollute, marginally more than is optimal while not providing the equivalent amount of amenities. Since marginal support decreases for a given type, then production will also decrease with *α* for a given type.

Finally, note that when α is very high, almost all farmers are allowed to produce, but production should again decrease for a given type relative to lower levels of α so that it may become impossibly to satisfy the second-order condition of the IC constraint (25). In this case, there may be a production pooling on an interval, say $[\theta_1, \theta_2]$, above θ^a such as displayed in Figure 4, which depicts production levels according to types for three levels of α.



[Figure 4: Effect of an increase in *α* on individual production with endogenous policy response]

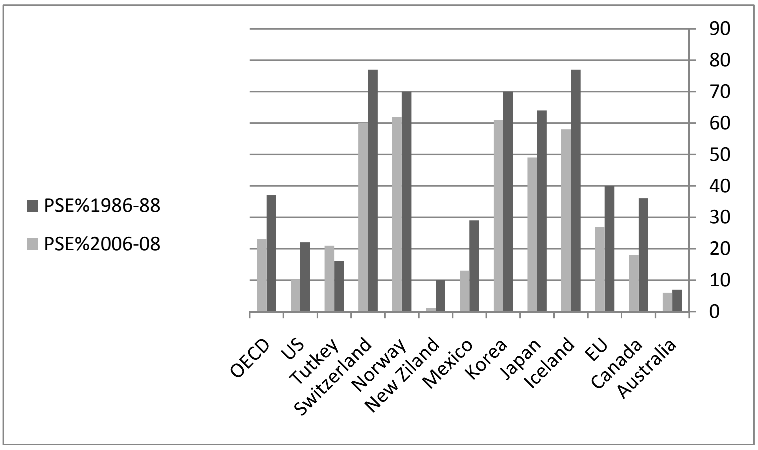
[16]This means that the political ruler or the regulatory agency has a costless and full-enforcement capacity without political constraints or elector concerns.

In short, political acceptability has inefficiency consequences that lead to more production by inefficient farmers and less production by efficient ones, since policy-makers have to account for negative externalities provided by low-efficient farmers and reduce incentives for efficient farmers. In extreme cases, this may lead to a pooling equilibrium and/or uniform policies. For these reasons, political acceptability has effects analogous to inequality aversion.

Proposition 5 *The optimal political mechanism entails a level of farmer exclusion such that (37) holds and* $W'(\underline{\theta}) > 0$*, otherwise there is no exclusion. The level of the political acceptability constraint (35) will tighten the scope of exclusion and reduce production incentives for a given type who participates in agricultural production, as well as marginal subsidies for land devoted to the AEP.*

6 Comparison of US and EU agricultural policies

The Producer Support Estimate (%PSE)—the monetary value of policy transfers expressed as a percentage of gross farm receipt—is considered by OECD to be a key measure of the level of support provided to the agricultural sector. By this measure, support to OECD agriculture has been declining moderately but steadily since it was first measured in 1986. As mentioned in the introduction, although all (with the exception of Turkey) OECD members are on the same path of reducing support, there are still large variations in the %PSE (Figure 5).



[Figure 5: Average %PSE in 1986-88 and 2006-08 by country (source: OECD, 2009)]

The composition of the support has also undergone a few incremental changes in most OECD countries, often referred to as "reforms". The main elements of the various reforms include (OECD, 2008): 1. a decline in the share of the potentially most production- and trade-distorting forms of support (those linked to output and non-constrained use of variable inputs), accompanied by an increase in payments based on area, animal numbers and income, with payments based on non-current (historical or fixed) eligibility parameters gaining increased importance; 2. support payments are increasingly attached to various compliance conditions aimed at strengthening the viability of rural areas, such as improved environmental performance, and 3. producers are given more flexibility in their production decisions:

payments are less tied to producing a specific commodity, either by allowing a group of commodities to be eligible for payment, or by having no production requirements to receive payment.

The major 2003 policy reform of the EU Common Agricultural Policy (CAP) had a significant impact on the evolution of agricultural policies in developing countries: moving away from distortive support toward lower support and more market orientation. The main features of this reform were: the decoupling of direct support by the creation of a Single Farm Payment (SFP) based on historical reference to replace part or all of the area and (cattle) head payments, and a strengthening of Rural Development Regulation measures through modulation of direct payment and the introduction of mandatory cross-compliance rules (e.g., Gohin, 2006; Osterburg et al., 2005), among others. The conclusion of the GATT Uruguay Round Agreement on Agriculture and the subsequent role of the WTO have significantly affected the evolution of CAP-making (Daugbjerg and Swinbank, 2007).

The remainder of this section endeavors to explain the patterns of AEPs over time and across OECD countries, building on a comparison between the US and the EU, through the lens of our theoretical analysis. Comprehensive review of the agri-environmental policy known as "payments (to farmers) for environmental services", PES, and its comparison to other policy instruments (such as environmental taxes, command and control regulations and integrated conservation) can be found in Engel et al. (2008). Additional empirical literature explores the importance of agri-environmental policies within the global agricultural policy framework.[17]

6.1 PSE and PES: Comparative evidence between the EU and the US

Comparison of AEPs between the EU and the US can be found in Baylis et al. (2008), who demonstrated that despite similar origins, AEPs in the two regions differ in both their specific objectives and their implementation. For example, AEPs in most member states of the EU-15 have the additional objective of using agriculture as a driver for rural development (see also Feinerman and Komen, 2003), while the US AEPs focus almost entirely on reducing agriculture's negative externalities and promoting wildlife conservation. In parts of the EU, land is perceived to attain its highest environmental value when used for farming. In contrast, in large parts of the US, land is perceived to attain a higher environmental value when it is taken out of farming and returned to its natural state. The policy-makers' pursuit of these different objectives may be due to different policy-making and negotiation processes (federal vs. member states) and different social-political preferences reflecting the specific historical and cultural background of agriculture. Environmental payments are also more individual-specific and auction-based in the US (mechanism design) than in the EU (more uniform), likely due to more inequality aversion in Europe, and policy-makers' larger difficulty in making inefficient farmers abandon land. As a result, environmental payments in the US are found to be more efficient in the provision of net environmental externalities than in Europe.

Table 2 presents the average PSE levels for the years 1986-88 and 2006-08 and the average

[17] Latacz-Lohmann and Hodge (2003) reviewed the development of the agri-environmental policy and its main instruments in Europe and considered the prospects for future developments. Similar reviews were also conducted by Piorr (2003) and Osterburg et al. (2005). The first stressed the need to develop an internationally acknowledged catalogue of agri-environmental indicators and the second focused on the connection between agricultural support payments in the EU and compliance with environmental standards.

PES levels for the years 1996-98 and 2006-08 for the EU and the US. Inspection of the table shows that the rate of decrease in both PSE and PSE% between the periods 1986-88 and 2006-08 is significantly higher in the US. Specifically, PSE decreased by 24.1% in the EU and by 55.6% in the US and PSE% decreased by 32.5% in the EU and by 54.5% in the US. In contrast, PES increased during the period 1996-98 and 2006-08 by 30.1% in the US and by 58.6% in the EU. The percentage of PES in gross farm receipt in 2006-08 is low and similar for the EU and the US, but this notwithstanding, its percentage in the total PSE is 2.6 times larger in the US (16.22%) than in the EU.

	EU			USA		
	1986-88	**1996-98**	**2006-08**	**1986-88**	**1996-98**	**2006-08**
PSE*	182,029	-	138,233	66,100		29,338
PSE %	40%		27%	22%		10%
Gross farm receipts (GFR)*	455,072		511,974	300,450		293,380
PES*		5,387	8,539		3,645	4,760
PES/GFR (2006-08)			1.67%			1.62%
PES/PSE (2006-08)			6.18%			16.22%

*USD million, 2007 prices

[Table 2: PSE and PES estimates for the EU and the US (source: OECD, 2009)]

The PES values in Table 2 are included in the PSE and are classified in the OECD report in five categories. It should be stressed that the PES data only include those agri-environmental measures that provide payments to farmers for undertaking farming practices designed to achieve specific objectives that go beyond what the environmental regulations require (OECD, 2009). Farm support relating to respecting regulations (environmental cross-compliance) and payments to less favored areas are not included here as agri-environmental payments. In other words, the PSE levels themselves do not account for all of a country's efforts to reach its agricultural-related environmental goals. The categories and the percentages of the payments in each category in the total PES are displayed in Table 3.

Payments for environmental services	**EU (%)**		**US (%)**	
	1996-98	**2006-08**	**1996-98**	**2006-08**
1: Based on input use with input restrictions	2.66	8.31	10.27	28.28
2: Technical assistance	0.00	0.05	21.79	24.10
3: Based on land/animals enrolled into an AEP with input restrictions	81.68	74.83	0.00	0.00
4: Based on long-term resource retirement	12.21	8.87	67.61	46.66
5: Based on specific environmental achievements not related to production	3.45	7.94	0.33	0.96

[Table 3: Structure of PES in the EU and the US (source: OECD, 2009)]

The values in Table 3 are consistent with the analysis of Baylis et al. (2008). European policy attempts to limit the abandonment of agricultural land, which generates positive environmental externalities; at the same time, it acknowledges that agricultural production yields some negative externalities. This attitude explains why in 1996-98, over 80% of the PES was devoted to category 3, which includes payments for specific voluntary farming practices (with constraints on polluting inputs and payments based on current area or animal numbers), while only about 12% paid for category 4—long-term retirement of cultivated land. In 2006-08, the percentage of PES allocated to category 3 decreased by about 8%, but the total sum allocated to this category increased by about 45% (from 4,400 to 6,390 million 2007 USD). The increase in the PES percentages of categories 1 and 5 suggests that EU policies are focusing more and more on the mitigation of externalities that are by-products of farming intensification by limiting the use of non-land (polluting) agricultural inputs and encouraging positive landscape externalities.

In the US, the focus of AEPs is to mitigate the negative environmental externalities associated with increased use of marginal farmland. Indeed, more than 2/3 of the PES was devoted to encouraging long-term land retirement (category 4) in 1996-98, and nothing was devoted to category 3—the most significant category in the EU. In addition, the US subsidize farmers to reduce the amount of pollution while retaining intensive production systems (Baylis et al., 2008). Indeed, more than 30% of the PES in 1996-98 was devoted to categories 1 and 2 (less than 3% was devoted to these categories in the EU). Comparison of 1996-98 and 2006-08 in the US shows that its AEPs still focus almost entirely on reducing negative agricultural externalities, with a lower percentage devoted to category 4 (although it still remains the major category) and significantly higher percentage to category 1.

To explain the above empirical evidences we explore below a few possible explanatory channels. For a comparative analysis, we first need to introduce specific citizens' preferences regarding their valuation of rural landscapes. As introduced in subsection 3.4, we assumed that citizens' utility from rural landscapes (positive amenities) increases with respect to the total amount of land enrolled in AEPs and is an inverted U-shape function of a, because citizens value agricultural landscapes with conservation programs (natural or cultural) up to the point at which too many farmers abandon land or there is too much idle land, for a given amount of land enrolled in the AEP.

According to Baylis et al. (2008), European citizens value agricultural landscapes more than abandoned and idle ones for cultural and historical patrimonial reasons, while in the US, citizens prefer less cultivated and natural landscapes. Hence, for a given amount of total land enrolled in the environmental program, $\int L^P$, one can reasonably assume that the peak of the amenity value function $A(a)$ in the US will lie at the right of the European one. US regulators will thus be more willing to design less restrictive agri-environmental contracts relative to Europe, with higher a, all else being held constant. In the following subsection, we account for these key differences in amenity functions between the EU and the US.

6.2 Policy changes and differences: explanatory channels

One can reasonably infer from the evolution of agricultural policies in developed countries that agricultural externalities are being increasingly accounted for by policy-makers. In our model, this means that γ and δ have increased over time, but likely in a heterogeneous fashion across countries. To be able to explain how this translates in terms of *T'* and *S'*, we now recompute average *T'* and *S'* for the EU and the US based on the aforementioned PSE and PES values.

	EU		US	
	1986-88	2006-08	1986-88	2006-08
T/(wY) ($/$)	.711	.495	.397	.129
S/L^P ($/ha)	Negligible	271	Negligible	193

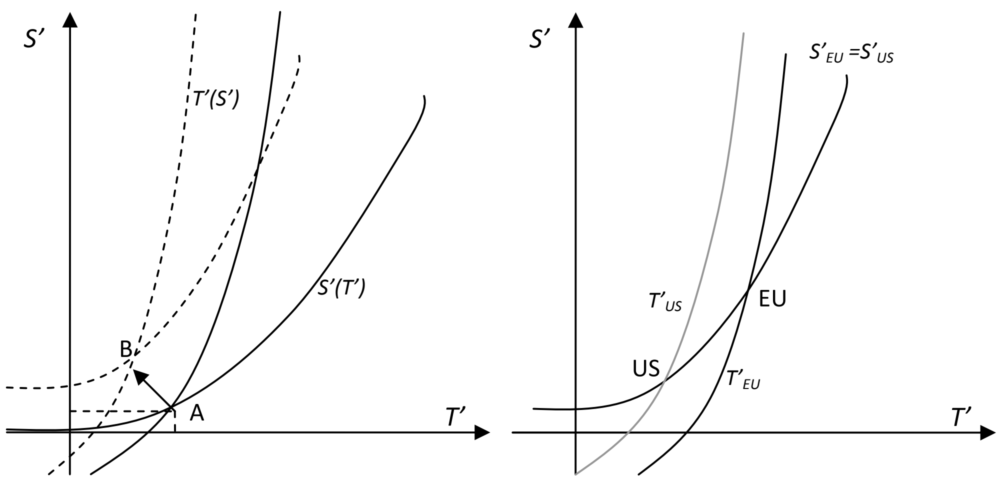
Note: The values of agricultural production (*wY*) are from FAO (2010). The L^P values—31.5 million ha in the EU and 18.6 million ha in the US—are based on EU (2010) and USDA (2010), respectively. The values of T and S were taken from Table 2.

[Table 4: Proxies of T' and S' in the EU and the US in 2007 constant USD]

The first row in Table 4 represents the average rate of production support and the second one represents average AEP subsidy rate per hectare. We thus take these figures as average proxies for *T'* and *S'*.

Note from our key equations in the political mechanisms, (32) and (33), that an increase in δ will make the function $T^{'}(S^{'})$ shift downward and *ceteris paribus,* an increase in γ will make the function $S^{'}(T^{'})$ shift upward. This entails a substitution of transfers from *T'* to *S'* such as depicted by the move from A to B in Figure 6 (left). To explain the actual patterns presented in Table 4, both parameters must have increased such that the current ratio δ/γ pertains to a certain interval centered around 1, not to mention the increasingly stringent constraint on national budgets for production support which has arisen from WTO negotiations over the last decade.

To explain why average *T'* has decreased to a lower level in the US than in the EU, δ/γ in the US has to have increased more than in Europe. In that case, the downward shift of *T'* in the US is larger than in the EU, leading to lower production support *T'* (see Figure 6, right, when the *S'* curves in the EU and US are assumed to be identical and with already-shifted *T'* curves), as shown in Table 4. This may also explain why the level of *S'* in the US is lower than that in the EU (but with a comparable PES/GFR ratio) whenever the US and EU lie on the same *S'* curve, meaning that both kinds of marginal support, *T'* and *S'*, will be higher in the EU than in the US.



[Figure 6: Change in the political equilibrium with time (left) and US-EU differences (right)]

According to Baylis et al. (2008) and the revealed preferences of regulators in the US and EU regarding environmental externalities, it can be reasonably stated that in our model, δ has increased more rapidly in the US relative to Europe, while the reverse holds for γ, which is consistent with the above condition. In Figure 6 (right), these features shift the *T'* curve of the US to the right of the EU curve while keeping the same *S'* curves. However, a higher γ in Europe means that its *S'* curve must be higher than the one for the US, which occurs only when we assume the same levels of *a* in the EU and the US. But this is not the case: the level of *a* in the US is higher than that in the EU (as explained earlier). Higher *a* motivates individual US farmers to devote less land to an AEP *per se* (relative to EU farmers), and therefore each unit of L^P has a higher marginal value of amenity (meaning the same *A* function with respect to total land devoted to the AEP, but not with respect to the second argument). In addition, the yield gap $\Delta y = y^{NP} - y^P$ will be higher in the US, because higher *a* induces higher AEP costs for farmers. These two effects have a positive impact in eq. (33) such that the *S'* curves in the US and EU may be close because the effect of higher δ in the EU is outweighed by the higher marginal amenities and yield gap in the US in this equation. Figure 6 then shows the situation in which both S' curves are similar (and thus are approximated by one identical curve).

The inequality aversion terms enter indirectly into eqs. (32) and (33) through the positive term $-[H'-(1+\lambda)][\frac{\partial^2 C^P(\theta)}{\partial\theta\partial y}+\frac{\partial^2 C^{NP}(\theta)}{\partial\theta\partial y}][\frac{1-F(\theta)}{f(\theta)}]$ which decreases with farmer's efficiency type due to the inequality aversion of the policy-makers (see (34)). Low-efficient farmers thus have more production incentives under the political mechanisms analyzed in Section 5 than under first-best and second-best rules, and distortions of incentives for low-efficient farmers widen with inequality aversion.[18] The effect of inequality aversion on AEP incentives is more ambiguous (for S'). Incentive distortions can make eq. (25) more likely to bind (the second-order condition for the IC), and when this is the case, pooling equilibrium and production subsidies might take the form of a uniform contract with flat subsidy rates, as already conjectured in Section 5.

Thus, inequality aversion entails additional inefficiency in the regulatory setup. This is line with the evidence that US AEPs are more effective at providing agricultural amenities than those of Europe and are more auction-based—and therefore discriminating, while they are more uniform in Europe and less constraining (less compliance rules) with more inequality-averse regulators in the EU relative to the US.

Inequality aversion, however, does not necessarily lead to an increase in *T'* and *S'* for a given type but only ensures some degree of redistribution. The effect on *T'* and *S'* depends on the incentive-redistribution effects on marginal pollution and amenities.

Regarding the effect of inequality aversion on AEP subsidies, for instance, low-efficient farmers receive more *T'* and *S'* than under inequality indifference but have a lower Δy (see eq. (33)); therefore, the overall effect is ambiguous, not to mention that it is not known how marginal amenities vary with types (depending on the distribution of overall land). If land is

[18]This is because of the concavity of function *H(.)* (i.e., *H''<0*) and because of the monotonic hazard rate property. The ambiguity regarding the effect on S' lies in the fact that this positive term is multiplied by *Δy* which increases with efficiency type.

distributed efficiently (that is, to more efficient types), then inequality aversion will tend to offset this distribution and will therefore encourage low-efficient farmers in the provision of amenities through AEPs since their contribution to marginal amenities will be higher.

It then becomes impossible to explain differences in *T'* and *S'* between the US and EU through differences in inequality aversion. But more inequality aversion explains more redistribution in Europe[19] and lower efficiency of AEPs together with EU citizens' preferences for agricultural landscapes (leading to lower *a*).

For cultural and historical reasons, it is more difficult to exclude farmers in the EU (land retirement). Less socially acceptable authoritarian contractual designs in Europe may entail additional inefficiency and may also lead to pooling equilibria, as shown in the previous section (Proposition 5 and Figure 4). This would decrease *T'* and *S'* for a given type but more farmers would be allowed to produce (see section 5).

This political acceptability constraint (eq. (35)) can thus be seen as leading to more uniform contracts in Europe, such as those induced by more inequality aversion. Hence, political acceptability also has ambiguous effects on *T'* and *S'*. Higher overall and average marginal support in the EU relative to the US (Tables 2 and 4) may be due to the importance of the farmer population effect (more farmers to subsidize) relative to the inefficiency effect (less production incentives and subsidies per farmer or per hectare).

The decrease in total aggregate (PSE) and marginal (*T'+S'*) support with time cannot, however, be explained by less political favoritism (it is not likely that the pressure from farmers' lobbies has lessened). Likewise, favoritism is not likely to be less in the US than in Europe with respect to explaining differences in support levels, rather, the opposite is probably true (Baylis et al., 2008; Engel et al., 2008). Only differences in *a*, *γ, and δ* can explain this pattern, as well as the guidelines and pressure stemming from WTO negotiations over time. On the other hand, the continuing pressure of farmers' unions and their influence over the determination of agricultural policies means that production will remain supported (even with more decoupled programs) rather than taxed.

Conjecture 1 *The substitution of producers' support policies from production-based to AEP transfers can be explained by a balanced increase in both γ and δ over time and/or an effective constraint on the budget of agricultural policies arising from WTO negotiations. These elements may explain the overall decrease in T' but are not sufficient. Differences between the US and EU (higher T' and S' in the EU but less efficient AEPs) can be explained by a higher δ/γ in the US, in addition to more inequality-averse regulators in Europe, a higher political feasibility of authoritarian policies in the US, and accounting for social differences in valuing agricultural amenities.*

7 Concluding remarks: normative and positive lessons

This paper shows that decoupled payments in the agricultural sector of OECD countries does not change the logic of production support because of some political economy factors (pressure from farmers' groups and inequality aversion) pertaining to policy-making in agriculture. Rather,

[19]The total amount of support is limited for big farms in Europe with more redistribution to small farms. Likewise, there is additional production and AEP support to disadvantaged rural areas (e.g. highlands and wetlands).

they change the magnitude and composition of the support.

By explicitly introducing exogenous political economy factors—namely farmers' special interest groups (leading to political favoritism), inequality aversion, and only partial concerns for environmental amenities—into the objective function of regulators, we are able to explain why current agricultural policies still involve large inefficiencies. We can also conjecture on whether changes in these factors over time and across countries can explain some of the observed evolution of agricultural support and related payments. For instance, the growing demand for more environmentally friendly agriculture is likely to have driven the substitution of direct production support by PES (from *T'* to *S'* in our theoretical model), while differences in social preferences between US and EU citizens regarding agricultural landscapes can explain differences in the nature of the AEPs. However, the current low level of PES compared to overall production support means that environmental externalities are far from being fully internalized by policy-makers. Future WTO negotiations may well promote more efficient policies by encouraging more decoupling of producer support in the form of agri-environmental payments and by putting more pressure on national budgets for direct and indirect production support.

Further research should focus on a determination of our identified key political parameters and treat them as endogenous. The lack of coordination between agricultural and environmental policies may also explain the low relative level of internalization of environmental benefits within the agricultural policy framework. This may be due to different political games played at the same time (interest groups applying pressure while citizens vote for environmental considerations, with different processes in the EU and US). Another channel stems from the institutional differentiation between agricultural policy-makers (prone to lobbying) and environmental agencies.[20]

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[20]This multi-principal structure of agri-environmental regulation is likely to induce coordination failures and to not achieve full internalization (agency problems) of agriculture-related environmental externalities (see Sharp and Bromley, 1979; Weinberg and Kling, 1996; Baron, 1985 for coordination problems in agri-environmental regulation).

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Appendix

A.1 Appendix: change in the optimizing variables

A.1.1 Non-linear general case with imperfect information

Taking expression (12) and incorporating the participation constraint and the IC constraint give use the optimization problem stated in Section 4. We directly incorporate the IC constraint in the optimization problem, such as commonly done in the incentive theoretical literature (Laffont and Martimort, 2001).

Using $\pi'(\theta, \widetilde{\theta})_{\widetilde{\theta}=\theta} = \frac{\partial C^P(\theta,\theta)}{\partial \theta} + \frac{\partial C^{NP}(\theta,\theta)}{\partial \theta}$ from (24), the problem becomes

$$\max_{\{y^P(\theta), y^{NP}(\theta), L^P(\theta), L^{NP}(\theta)\}} A(\int_\theta L^P(\theta)dF(\theta)) - D(\int_\theta g(\theta)dF(\theta)) + (1+\lambda)\int wY^P(\theta) - C^P(\theta)$$

$$+ wY^{NP}(\theta) - C^{NP}(\theta)]dF(\theta) + \lambda\int_\theta [\frac{\partial C^P(\theta,\theta)}{\partial \theta} + \frac{\partial C^{NP}(\theta,\theta)}{\partial \theta}][\frac{1-F(\theta)}{f(\theta)}]]dF(\theta) - \lambda \underline{\pi(\theta)}$$

which yields the solutions derived in Section 4. Note that when there is perfect information, eq. (25) does not need to be satisfied and the problem simplifies to:

$$\max_{\{y^P(\theta), y^{NP}(\theta), L^P(\theta), L^{NP}(\theta)\}} A(\int_\theta L^P(\theta)dF(\theta)) - D(\int_\theta g(\theta)dF(\theta))$$
$$+ (1+\lambda)\int wY^P(\theta) - C^P(\theta) + wY^{NP}(\theta) - C^{NP}(\theta)]dF(\theta)$$

because of the envelop theorem, such as done in Section 3.

A.1.2 Linear case

In the linear contracting case, transfer schemes are imposed in a given shape on the Principal and must be uniform for all farmers:

$$T(Y(\theta)) = K + tY(\theta)$$
$$S(L^P(\theta)) = k + SL^P(\theta)$$

so that the Principal does not need to know individual farmer's types and already knows the distribution function since it is common knowledge. The different contract menus are uniform so that only the aggregate one matters. Since marginal rates of transfer are constant, it is not possible to discriminate among farmers, and the social planner only cares about the aggregate effect of its policy on production land enrolled under P. Setting K and k such that the most inefficient farmer is allowed to produce, the linear contract solves:

$$\max_{t, S, \int Y(\theta)dF(\theta), \int L^P(\theta)dF(\theta)} \int [wY(\theta) - C^P(\theta) - C^{NP}(\theta)]dF(\theta) + A(\int_\theta L^P(\theta)dF(\theta))$$
$$- D(\int_\theta g(Y(\theta))dF(\theta)) - \lambda\int_\theta tY(\theta) + SL^P(\theta)]dF(\theta)$$

Using $\int_\theta tY(\theta) + SL^P(\theta)]dF(\theta) = \int_\theta [\pi(\theta) - wY^P(\theta) + C^P(\theta) - wY^{NP}(\theta) + C^{NP}(\theta)]dF(\theta),$ the problem (using the envelop theorem and considering no information problem) can be changed to:

$$\max_{\int_\theta y^{NP}(\theta),\int_\theta y^P(\theta),\int_\theta L^{NP}(\theta),\int_\theta L^P(\theta)} (1+\lambda)\int[wY(\theta)-C^P(\theta)-C^{NP}(\theta)]dF(\theta)$$
$$+A(\int_\theta L_P(\theta)dF(\theta))-D(\int_\theta g(Y(\theta))dF(\theta))$$

which leads to the solutions derived in proposition 2.

A.2 Proof of proposition 2

The problem laid out in the linear contracting framework entails the following first-order conditions (applying the envelop theorem to farmers' response):

$$y^P: -D'\int_\theta g_Y(\theta)L^P(\theta)dF(\theta)=(1+\lambda)\int_\theta[aC_{y^P}(\theta)-wL^P(\theta)]dF(\theta)$$
$$y^{NP}: -D'\int_\theta g_Y(\theta)L^{NP}(\theta)dF(\theta)=(1+\lambda)\int_\theta[C_{y^{NP}}(\theta)-wL^{NP}(\theta)]dF(\theta)$$
$$L^P: A'-D'\int_\theta g_Y(\theta)y^P(\theta)dF(\theta)=(1+\lambda)\int_\theta[C_{L^P}(\theta)-wy^P(\theta)]dF(\theta)$$
$$L^{NP}: -D'\int_\theta g_Y(\theta)y^{NP}(\theta)dF(\theta)=(1+\lambda)\int_\theta[C_{L^{NP}}(\theta)-wy^{NP}(\theta)]dF(\theta)$$

Accounting for the optimal response of farmers in eqs. (4)-(7), we get:

$$-D'\int_\theta g_Y(\theta)L^P(\theta)dF(\theta)=(1+\lambda)t\int_\theta L^P(\theta)dF(\theta)$$
$$-D'\int_\theta g_Y(\theta)L^{NP}(\theta)dF(\theta)=(1+\lambda)t\int_\theta L^{NP}(\theta)dF(\theta)$$
$$A'-D'\int_\theta g_Y(\theta)y^P(\theta)dF(\theta)=(1+\lambda)\int_\theta[S+ty^P(\theta)-v(\theta)]dF(\theta)$$
$$-D'\int_\theta g_Y(\theta)y^{NP}(\theta)dF(\theta)=(1+\lambda)\int_\theta[ty_{NP}(\theta)-v(\theta)]dF(\theta)$$

Extracting $\int_\theta v(\theta)dF(\theta)$ gives:

$$t=-\frac{D'}{1+\lambda}\frac{\int_\theta g_Y(\theta)L(\theta)dF(\theta)}{\int_\theta L(\theta)dF(\theta)} \tag{A1}$$

$$S=\frac{A'}{1+\lambda}+\int_\theta[D'\frac{g_Y(\theta)}{1+\lambda}+t][y^{NP}(\theta)-y^P(\theta)]dF(\theta) \tag{A2}$$

$$=\frac{A'}{1+\lambda}+\frac{D'}{1+\lambda}\int_\theta[g_Y(\theta)-\frac{\int_\theta g_Y(\theta)L(\theta)dF(\theta)}{\int_\theta L(\theta)dF(\theta)}]\Delta y(\theta)dF(\theta) \tag{A3}$$

$\int_\theta[D'\frac{g_Y(\theta)}{1+\lambda}+t]\Delta y(\theta)f(\theta)$ may then be interpreted as the amount of aggregate marginal social cost savings (environmental savings minus loss of taxation revenues) per unit of land enrolled in P. This is not necessarily a positive value when accounting for optimal t, which here is negative and therefore stands for a taxation scheme. Indeed, this depends on the distribution of total land among farmers. It can be easily shown that when land allocation is independent of efficiency types and every farmer has the same L, then

$$\int_{\theta}[g_Y(\theta)-\frac{\int_{\theta}g_Y(\theta)L(\theta)dF(\theta)}{\int_{\theta}L(\theta)dF(\theta)}]\Delta y(\theta)dF(\theta)=\int_{\theta}[g_Y(\theta)-\widehat{g_Y(\theta)}]\Delta y(\theta)dF(\theta) \quad \text{(A4)}$$

where $\widehat{g_Y(\theta)}$ is the average marginal emission over farmers' types (assumed as decreasing as a function of type), corresponding to the emission of farmer $\widehat{\theta}$. Therefore, low-efficient farmers bring more savings for additional land enrolled in P since they pollute more than the average and their marginal emission savings more than offset the loss of taxation revenues incurred by the social planner. The situation is reversed for efficient farmers who pollute less than the average type. Note than the term $g_Y(\theta)-\widehat{g_Y(\theta)}$ is weighted by $\Delta y(\theta)$, which is an increasing function of type. Without this weight, $\int_{\theta}[g_Y(\theta)-\widehat{g_Y(\theta)}]dF(\theta)=0$. Therefore, the sign of eq. (A4) is unambiguously negative for uniform land distribution. Indeed, the negative social contribution of efficient farmers (reduction of paid taxes greater than marginal emission savings) due to land cultivation under P is multiplied by higher productivity differentials than for the positive contribution of inefficient ones.

A change in the land distribution would entail some policy adjustments. Under our assumptions, a more efficient distribution of land, meaning more land to more efficient farmers, will induce a downward shift in the average marginal emission to a lower level $\widehat{g_Y(\theta)}$, corresponding to a rightward shift of $\widehat{\theta}$. More efficient land distribution means less production taxation and less aggregate pollution according to eq. (A1), and in turn higher $\Delta y(\theta)$. This means that more farmers will contribute to net positive marginal savings per unit of production and land, but productivity differentials will exhibit even more differences among types. The negative social contribution of efficient farmers will carry more weight when land distribution becomes more efficient, and when compared to the positive part of inefficient farmers. Hence, more efficient land distribution induces less production taxation but also less program subsidies. A necessary condition for which $S=\frac{A'}{1+\lambda}$ is the policy optimum such that land distribution has to favor inefficient farmers.

Overall, land distribution entails two effects. The first one is on aggregate pollution and optimal production taxation. Land distribution that favors efficient farmers (land distribution would exhibit a first-order stochastic dominance over another distribution of land with respect to efficiency types) induces first, a reduction in the level of production taxation due to lower aggregate pollution and second, an increase in the productivity differentials among types due to taxation reduction. This in turn implies that the land subsidy S should be decreased.

A.3 Comparative statics of the uniform policy mix

Eq. (A2) or (A3) yields a social optimal increasing function $S(t)$. Indeed, social benefits brought by the program decrease when incentives for production (thereby pollution) are higher, so that S should be increased to ensure internalization of amenity and pollution externalities. In order to correct for externalities, the land subsidy takes into account the marginal amenity social benefits $\frac{A'}{1+\lambda}$, cost savings (respectively credits) due to a reduction in production-incentive subsidies (respectively taxes) $t\int_\theta [y^{NP}(\theta) - y^P(\theta)]dF(\theta)$ and to marginal reduction in the environmental damage $\int_\theta D' \frac{g_Y(\theta)}{1+\lambda}[y^{NP}(\theta) - y^P(\theta)]dF(\theta)$. This policy function is increasingly convex (first- and second-order derivatives are made up of positive terms only) as shown below and due to the convexity assumption of the environmental damage and polluting emission functions (assuming third-order derivatives are negligible):

$$\frac{\partial S}{\partial t} = D'\int_\theta [\frac{g_{YY}}{1+\lambda}\frac{\partial Y}{\partial t}\Delta y + \frac{g_Y}{1+\lambda}\frac{\partial \Delta y}{\partial t}]dF(\theta) + D''\int_\theta g_Y \frac{\partial Y}{\partial t}dF(\theta)\int_\theta \frac{g_Y}{1+\lambda}\Delta y dF(\theta)$$
$$+\int_\theta [\Delta y + t\frac{\partial \Delta y}{\partial t}]dF(\theta) + \frac{A''}{1+\lambda}\int_\theta \frac{\partial L^P}{\partial t}dF(\theta)$$

$$\frac{\partial^2 S}{\partial t^2} = \frac{A''}{1+\lambda}\int_\theta \frac{\partial^2 L^P}{\partial t^2}dF(\theta) + D'\int_\theta [\frac{g_{YY}}{1+\lambda}\frac{\partial^2 Y}{\partial t^2}\Delta y + 2\frac{g_{YY}}{1+\lambda}\frac{\partial Y}{\partial t}\frac{\partial \Delta y}{\partial t} + \frac{g_Y}{1+\lambda}\frac{\partial^2 \Delta y}{\partial t^2}]dF(\theta)$$
$$+ D''\int_\theta [g_{YY}(\frac{\partial Y}{\partial t})^2 + g_Y\frac{\partial^2 Y}{\partial t^2}]dF(\theta)\int_\theta \frac{g_Y}{1+\lambda}\Delta y dF(\theta) + \int_\theta [2\frac{\partial \Delta y}{\partial t} + t\frac{\partial^2 \Delta y}{\partial t^2}]dF(\theta)$$
$$+ D''\int_\theta g_Y\frac{\partial Y}{\partial t}dF(\theta)\int_\theta [\frac{g_{YY}}{1+\lambda}\frac{\partial Y}{\partial t}\Delta y + \frac{g_Y}{1+\lambda}\frac{\partial \Delta y}{\partial t}]dF(\theta)$$

First-order condition (A1) leads to a decreasing social optimal function $t(S)$ which is negative, meaning taxation. Indeed, production incentives have an overall social cost (due to deadweight cost of transfers and increasing the scope of environmental damage) and reduce incentives to engage land under the program, thereby limiting the scope of amenities. But as S increases, social costs due to production incentives are of lower scope. Therefore $t(S)$ is increasing and concave, as shown below (third-order derivatives are negligible):

$$\frac{\partial t}{\partial S} = \frac{-D'\int_\theta g_{YY}(\theta)\frac{\partial Y}{\partial S}\frac{L(\theta)}{\int_\theta L(\theta)dF(\theta)}dF(\theta) - D''\int_\theta g_Y(\theta)\frac{\partial Y}{\partial S}dF(\theta)\int_\theta g_Y(\theta)\frac{L(\theta)}{\int_\theta L(\theta)dF(\theta)}dF(\theta)}{1+\lambda} > 0$$

$$\frac{\partial^2 t}{\partial S^2} = \frac{-D'\int_\theta g_{YY}(\theta)\frac{\partial^2 Y}{\partial S^2}\frac{L(\theta)}{\int_\theta L(\theta)dF(\theta)}dF(\theta) - 2D''\int_\theta g_Y(\theta)\frac{\partial Y}{\partial S}dF(\theta)\int_\theta g_{YY}(\theta)\frac{\partial Y}{\partial S}\frac{L(\theta)}{\int_\theta L(\theta)dF(\theta)}dF(\theta)}{1+\lambda}$$

$$\frac{-D''\int_\theta [g_{YY}(\theta)\frac{\partial Y}{\partial S}^2 + g_Y(\theta)\frac{\partial^2 Y}{\partial S^2}]dF(\theta)\int_\theta g_Y(\theta)\frac{L(\theta)}{\int_\theta L(\theta)dF(\theta)}dF(\theta)}{1+\lambda}$$