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## On the Efficiency of Decentralized Conservation Policy

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### **Abstract**

Because the environmental and rural benefits or harm can be localized, it could be argued that the decentralization of agri-environmental policy is required to promote a better allocation of public funds. The purpose of this paper is to study how the decentralization of conservation policies affects social welfare. We develop a model of competition among jurisdictions where local governments seek to design and implement agri-environmental programs to maximize a welfare function. The location choice of individuals and the rural amenity supply are endogenous. We find that the decentralization of the agri-environmental policy leads to (i) inefficiently low payment for the production of environmental goods from global welfare viewpoint and (ii) a rise of the consumer's welfare at the expense of farmer's income. These results hold when consumers are heterogeneous.

## **On the Efficiency of Decentralized Conservation Policy**

### **Abstract**

Because the environmental and rural benefits or harm can be localized, it could be argued that the decentralization of agri-environmental policy is required to promote a better allocation of public funds. The purpose of this article is to study how the decentralization of conservation policies affects social welfare. We develop a model of competition among jurisdictions where local governments seek to design and implement agri-environmental programs to maximize a welfare function. The location choice of individuals and the rural amenity supply are endogenous. We find that the decentralization of the agri-environmental policy leads to (i) inefficiently low payment for the production of environmental goods from global welfare viewpoint and (ii) a rise of the consumer's welfare at the expense of farmer's income. These results hold when consumers are heterogeneous.

*Keywords:* Natural amenities, Residential mobility, Conservation policy, Decentralization.

In the most developed countries, public policies seek increasingly to influence the agricultural production of amenities exhibiting the characteristics of externalities or public goods. In the US, in 2007, more than 36 million acres are enrolled under the Conservation Reserve Program which aims at providing technical and financial assistance to eligible farmers and ranchers to encourage environmental enhancement.<sup>1</sup> In the EU, in 2005, the total area covered by agri-environmental contracts in the 15 older Member States was about 25% of the UAA.<sup>2</sup> While EU and US agri-environmental programs are mainly federal, the recent agri-environmental programs indicate a move towards involving more and more local actors because environmental externalities from agricultural activities are often site-specific. In the US, in recent years, policymakers have created the Conservation Reserve Enhancement Program to focus a portion of the resources of the Conservation Reserve Program on local environmental problems.<sup>3</sup> Similarly, local needs and priorities are reflected in the Environmental Quality Incentives Program which promotes agricultural production and environmental quality and provides incentive payments and cost-shares to implement conservation practices.<sup>4</sup> In the EU, the current Rural Development Regulation for 2007-2013 promotes local partnerships to address specific local problems.<sup>5</sup>

Because the environmental and rural benefits or harm can be localized and can differ among regions or counties, it could be argued that the decentralization of agri-environmental policy is required to promote a better allocation of public funds. The responsibility for managing an environmental service should be placed with the jurisdiction whose boundaries encompass the benefits and costs

associated with the provision of the service. However, such decentralization may also have costs due to the spatial mobility of amenities consumers. Indeed, since rural amenities are valued by households, this affects their location choice. The migration literature shows that amenities (including farmland) play a significant role in the location of jobs and workers or retirees (Clark and Hunter 1992; Booth 1999; Duffy-Deno 1997, Duffy-Deno 1998; Deller et al. 2001; Hailu and Rosenberg 2004; Rupasingha and Goetz 2004, Wu and Gopinath 2008). Hedonic price studies also indicate that landscape amenities (open space, woodlands, preservation or wilderness areas) tend to impact property prices (Palmquist, Fritz and Vukina 1997; Irwin 2002; Herriges, Secchi, and Babcock 2003; Ready and Abdalla 2005). As a result, the local governments can manipulate the level of local amenities to attract new residents or tourists. Such a strategic behavior may potentially lead to welfare losses because of coordination failures among jurisdictions. Hence, because any change in the amount and/or type of amenities may potentially impact the location choice of households, we cannot *a priori* conclude whether decentralization dominates centralization.<sup>6</sup>

In this article, we study how the decentralization of the agri-environmental policies affects social welfare. Despite the wealth of the literature on decentralization, and the obvious policy relevance of the subject, it is surprising that, to the best of our knowledge, no academic study has investigated the relative merit of the provision of agri-environmental goods at sub-national level.<sup>7</sup> To address our question, we develop a model of competition among jurisdictions where local governments seek to design and implement agri-environmental

programs to maximize a social welfare function and where the location choice of consumers is endogenous. The production of the environmental good by farmers increases the welfare of residents and is financed by a tax on mobile workers.<sup>8</sup>

Our framework differs in several ways from the existing literature. First, there are numerous models based on Tiebout (1956) studying the optimality of the decentralization of the public good supply. An originality of our analysis lies in the fact that the public good (the environmental good) is not provided by the public sector (like in Tiebout, 1956) but by the private sector (the agricultural sector) which allocates its resources between producing the local public good (the environmental good) with respect to the level of subsidy and producing the private good.<sup>9</sup> In addition, unlike Tiebout (1956), we consider that governments are utility makers.

Second, there is a vast theoretical literature dedicated to the efficiency of decentralized environmental policy, deriving from the contribution of Oates (1972). This environmental federalism literature deals with the "race to the bottom" hypothesis where jurisdictions set non-stringent command-and-control environmental policies to attract firms. Unlike this literature, in our article, the environmental output is produced by an immobile sector (the agricultural sector) while consumers of rural amenities are mobile. Indeed, the traditional literature on the efficiency of decentralized environmental policy considers that the producers of the "environmental good" are mobile while the consumers are immobile.

Our work shows that, even though environmental benefits are localized, the decentralization of agri-environmental policy could be harmful. More precisely, our analysis suggests that decentralization of the agri-environmental policy leads to (i) inefficiently low payment for the production of environmental goods from global welfare viewpoint and (ii) a rise of the consumer's welfare at the expense of farmer's income.

The article is organized as follows. The next section introduces the model by describing the objective function of workers, farmers and governments. We present the benchmark case in section 3 where we determine the optimal payment to farmers for a unified government. Section 4 is devoted to the non-cooperative policy case. We determine household location in this case and compare the welfare in each region with the benchmark case. In section 5, we extend the framework by considering heterogeneous tastes in order to check for the robustness of our main results. Section 6 concludes.

## **Model**

Assume an economy with two regions, labeled  $A$  and  $B$ , two sectors: a farm sector (F) and an industrial sector (I), and two inputs specific to each sector. Because we wish to focus on the pure effects of the forces at play, we consider that regions are symmetric in technology and type of goods produced. The I-sector produces the numéraire under decreasing returns, using labor as the only input. The F-sector produces an agricultural good, using a single input and can also produce an environmental good (or rural amenity). This non-commodity output has local

public good characteristics. We assume there is no interregional environmental externality. In other words, the production of the environmental good is exclusively consumed in the region where the production occurs. As a result, without mobility of consumers, a centralized and decentralized economy is socially equivalent. We will see that, even though the benefits of the environmental output are limited to a jurisdiction, the decentralization of the agri-environmental policy can be welfare-reducing.

Without loss of generality, we assume that each region hosts a single farm. Workers are mobile between regions whereas farmers are immobile. This harmonizes with the characteristics of the farming sector where labor is often less mobile than the other types of labor. Mobility occurs rather in the long run when farmers install and when they retire. We denote by  $l$  the mass of workers in the economy and  $l_r$  the mass of workers living in region  $r=A,B$ . The spatial distribution of workers between regions is endogenously determined. The public sector consists of two local governments providing a payment made directly to farms for producing a local environmental good and using a unit tax rate on wages of workers.

*Consumers.* The utility of a consumer living in region  $r$  is given by:

$$u_r = w_r - t_r + \nu E_r \tag{1}$$

where  $w_r$ ,  $t_r$  and  $E_r$  are the wage rate, the unit tax rate and the stock of environmental good prevailing in region  $r$  respectively. These three variables are endogenously determined. Parameter  $\nu$  is the preference for the environmental good. In section 5, we consider that the workers are heterogeneous in tastes for



the consumption of the environmental good. We will see that the main results hold.

*Industrial sector.* Technology in the industrial sector is identical in both regions. The production function is characterized by decreasing returns and is expressed as follows  $y_r = f(l_r)$  where  $l_r$  is labor, the single input used in this sector. The regional output markets are perfectly competitive and there is no transport cost. The price is the same in each region and is normalized to one. Similarly, regional labor markets are perfectly competitive. Consequently, the equilibrium wage in a region decreases with the mass of worker (*congestion effect*) and is given by

$$w_r = f'(l_r) \quad (2)$$

with  $f''(l_r) \leq 0$  because of decreasing returns<sup>10</sup>. We assume production technology has the following property:  $f'(l_r) + l_r f''(l_r) > 0$ .

*Spatial mobility.* Let  $\lambda$  be the share of workers living in region A so that  $l_A = \lambda l$  and  $l_B = (1 - \lambda)l$ . A spatial equilibrium arises at  $l_r^* \in [0, l]$  when  $\Delta U_r = u_r - u_s = 0$  with  $s \neq r$  or, equivalently,

$$f'(l_r^*) - t_r + vE_r - [f'(l - l_r^*) - t_s + vE_s] = 0 \quad (3)$$

Such equilibrium is stable if and only if the slope of the utility differential is negative in a neighborhood of the equilibrium. Otherwise, the only stable equilibrium is a corner solution. It is easy to check that  $w_r - w_s$  decreases with  $l_r$  (we have  $\partial w_r / \partial l_r < 0$  and  $\partial w_s / \partial l_r > 0$ ) so that workers are prompted to disperse between regions to increase their wage rate. In addition, as expected, workers

have an incentive to locate in the region supplying the highest level of environmental goods and the lowest level of taxation. When there is no difference between regions, workers are identically distributed.

It is also worth stressing that our framework could also apply to tourism or elderly where tourists or retirees would derive utility from activities in the region  $w_r$  (decreasing with the number of tourists/retirees because of congestion effects), and from consuming rural amenities  $E_r$ . The empirical literature shows that amenities from agricultural activities play a role on rural tourism (Vanslebrouck, Van Huylenbroeck, and Van Meensel 2005; Bonnieux and Rainelli 2000). But tourists/retirees would also experience a disutility from a tax  $t_r$  to finance the rural amenities.

*Agri-environmental production.* Technologies used in this sector are modeled in a simple way. Each farmer produces an agricultural good under constant returns and may supply a rural amenity. Farmers are endowed with a fixed amount  $H$  of an input which is perfectly allocable across the two outputs produced by the farmer. This input can be labor or land. For example, in the US, the higher share of public funds dedicated to the agri-environmental policy aims at influencing farmer's choices about how much land to farm (land retirement programs). In the EU, agri-environmental measures such as hedgerow maintenance and buffer strips are labor and/or land intensive.

We consider that one unit of the agricultural good requires  $m$  units of the agricultural input. The price of the agricultural good  $p$  (fixed at the world market) and the price of the agricultural input  $c$  are exogenous and constant. Such

assumptions allow us to abstract from any effect of public policy on agricultural commodities and factor prices. Each farmer may also produce an agri-environmental good with the following technology:

$$E_r = g(h_r) - F \quad (4)$$

with  $g'(h_r) > 0$  and  $g''(h_r) < 0$ .<sup>11</sup> Notice that  $F > 0$  represents a threshold effect in agri-environmental production, and that  $h_r$  is the number of land units dedicated to produce the agri-environmental good. It should be noted that other types of technology exhibiting economies of scope or using non-allocable inputs can be used. However, our main result on the welfare impacts of the decentralization holds because the coordination failures identified in our analysis does not depend on the type of technology (see the "heterogeneity in tastes" section).

Each farmer is endowed with  $H$  units of agricultural input. By considering (4), the profit function for a farm established in region  $r$  can be expressed as follows:

$$\pi_r = p \frac{(H - h_r)}{m} + \rho[g(h_r) - F] - cH \quad (5)$$

where  $h_r$  the number of agricultural input units devoted to agri-environmental production. Each farmer chooses  $h_r$  to maximize his profits. Equilibrium allocation of input  $h_r$  between producing the agricultural good and the environmental good is such as

$$\rho g'(h_r) = M \quad \text{with } M \equiv \frac{p}{m} \quad (6)$$

so that  $h_r^*$  is implicitly defined in (6). Because of  $F$ , the production of this good requires a minimum amount of input, given by  $g(h_r^*) - F > 0$ . The mass of agricultural input units dedicated to the production of the environmental good raises with the payment and the efficiency of the technology to produce this good ( $g'(h_r)$ ) and decreases with the income arising from the agricultural production per input unit ( $M$ ). Finally, by using (6), it is easy to check that

$$\frac{\partial h_r^*}{\partial \rho} = \frac{-g'(h_r)}{\rho g''(h_r)} > 0 \quad (7)$$

As expected, the mass of input units dedicated to the production of the environmental good raises with the payment.

Hence, the impact of the payment on the farmer's profit gives

$$\frac{\partial \pi}{\partial \rho} = (\rho g'(h_r^*) - M) \frac{\partial h_r^*}{\partial \rho} + g(h_r^*) - F > 0 \quad (8)$$

which is positive because of (6).

*Government.* The objective of each government is to maximize the following social welfare function

$$W_r = \theta \pi_r(\rho_r) + (1 - \theta) u_r(w_r, t_r, \rho_r) l_r \quad (9)$$

where  $\theta$  is the weight of farmers in the social welfare function in each region. The weights  $\theta$  and  $1 - \theta$  can be interpreted as measures of the political power of farmers and consumers respectively. By using the budget constraint for each government, we know the relationship between the unit tax rate and the payment for each farmer prevailing in each region:

$$t_r l_r = \rho_r E_r(\rho_r) \quad (10)$$

Each government chooses simultaneously its payment for farmers  $\rho_r$  taking as given the decision of the other government, and anticipating the farmer sector outcomes and the resulting location equilibrium of mobile workers. Hence, given the payments announced by the governments, farmers choose their quantity of agri-environmental good and workers choose their residential place. All players have perfect information and the game is solved by a sub-game perfect equilibrium involving backward induction beginning with the last stage.

### **Unified government (benchmark case)**

In order to identify the sources of potential inefficiency arising from non cooperative agri-environmental policies, we need the benchmark case characterized by the policy of a central government. In this case, the central government sets a single payment ( $\rho$ ) so that farmers have the same profits regardless of their location and the supply of the environmental good is identical in each region. Hence, the population is equally split between both regions and enjoys the same level of wages and tax rates. Hence, the total social welfare function is given by

$$W_T = 2\theta\pi + (1 - \theta)(w - t + vE)l \quad (11)$$

where  $w = f'(l/2)$  and  $t = 2\rho E/l$ . The first order condition is given by

$$\frac{\partial W_T}{\partial \rho} = 2(2\theta - 1)[g(h^*) - F] - (1 - \theta) \left[ g'(h^*) \frac{\partial h^*}{\partial \rho} (2\rho - vl) \right] = 0 \quad (12)$$

Some standard calculations lead to the following equality:

$$\rho = \frac{\nu l}{2} + \frac{(2\theta - 1)[g(h^*) - F]}{(1 - \theta)[g'(h^*)(\partial h^* / \partial \rho)]} \quad (13)$$

Following equation (6),  $h$  is a function of  $\rho$  so that the optimal payment  $\rho^o$  is implicitly defined in (13).

It is straightforward to check that the optimal payment increases with the preference for the environmental good ( $\nu$ ) and with the weight of farmers in the welfare function ( $\theta$ ). When  $\theta$  is relatively high, the agri-environmental policy is implemented to increase the farmers' income. Such a result is expected. However, the impact of the parameters of the agricultural technology on the optimal payment depends on the value taken by  $\theta$ . Table 1 reports the sign of the variation of the optimal payment with respect to the characteristics of the agricultural technology and the preference of the government for each actor.

*[Table 1 about here]*

Some comments are in order. When the farmers are favored, the central government does not encourage the production of environmental good when the technology to produce this good is specified by high fixed costs ( $F$ ) or low marginal productivity ( $g'(h)$ ) and when the income arising from the agricultural production ( $M$ ) is high. In this case, the marginal gain arising from producing the environmental good is low while the marginal loss arising from a fall in the production of the agricultural good is relatively high. In other words, when farmers have a higher weight in the social welfare function, a farmer receives more payments when the marginal productivity in the production of the environmental good is high.

Conversely, when the government favors workers, the payment is set in order to increase the production of environmental good for workers' consumption when its technology induces high fixed costs ( $F$ ) or low marginal productivity ( $g'(h)$ ). In this case, high productivity technology for producing the environmental good induces high payments because the marginal gains for consumers are relatively high. The supply of the environmental good can be relatively high with a relatively low tax rate.

This leads to the following proposition.

**Proposition 1.** *Under a central government, the optimal payment increases with the (fixed and opportunity) costs of environmental production provided that the weight of farmers in the welfare function is not high. When the central government favors farmers, the optimal payment incites farmers to specialize in agri-environmental production when the environmental marginal productivity is high.*

Finally, we have

$$\frac{\partial E(\rho^o)}{\partial \theta} = g'(h) \frac{\partial h^*}{\partial \rho} \frac{\partial \rho^o}{\partial \theta} > 0$$

so that the quantity of agri-environmental goods increases with the weight of farmers in the welfare function. However, the utility arising from the environmental policy is expressed as follows:

$$\xi(\rho^o) \equiv E^o(v - 2\rho^o/l)$$

with  $\xi(\rho^o) = 0$  when  $\theta = 1/2$  (because  $\rho^o(\theta = 1/2) = vl/2$ ) and  $\xi(\rho^o) < 0$  when  $\theta \geq 1/2$ .<sup>12</sup> In other words, the farmers are always better-off when an

environmental policy with payment is implemented ( $\partial\pi/\partial\rho > 0$ ) whereas the workers cannot reach a higher level of utility, except if the central government affects a higher weight to workers in the social welfare function.

### **Non cooperative policies**

In the previous section, we presented the benchmark case and determined the optimal payment to farmers for a unified government. This section is devoted to the non-cooperative policy case. We determine household location in this case and compare the welfare in each region with the benchmark case.

#### *Location of households with respect to the payments*

By considering the implicit expressions of  $l_r^*$  in (3) and of  $h_r^*$  in (6) and the expression of  $E_r$  in (4), it appears that the spatial distribution of workers depends on the payments and on the tax rates. However, tax rates vary also according to payments and the spatial distribution of workers (see (10)). Hence,  $\Delta U_r = 0$  implicitly defines  $l_r^*$  as a function of  $\rho_r$ . Because, we consider only the case where  $l_r^*$  is a stable interior equilibrium, the motion equation of workers is such as  $\partial\Delta U_r/\partial l_r < 0$  for all  $l_r$ . Concerning the impact of the payment in region  $r$  on the location of workers, we have

$$\frac{\partial l_r}{\partial \rho_r} = \frac{\partial \Delta U_r / \partial \rho_r}{-\partial \Delta U_r / \partial l_r}$$

with



$$\frac{\partial \Delta U_r}{\partial l_r} = \frac{\partial (w_r - w_s)}{\partial l_r} + \frac{\rho_r (g(h_r^*) - F)}{l_r^2} - \frac{\rho_s (g(h_s^*) - F)}{(1-l_r)^2}$$

and

$$\frac{\partial \Delta U_r}{\partial \rho_r} = \frac{-\{[g(h_r^*) - F][ -g''(h_r^*)] + [g'(h_r^*)]^2\} \rho_r + v[g'(h_r^*)]^2 l_r}{[-g''(h_r^*)] l_r \rho_r} \quad (14)$$

As mentioned before  $\partial \Delta U_r / \partial l_r < 0$  at the spatial equilibrium so that

$\text{sign}\{\partial l_r / \partial \rho_r\} = \text{sign}\{\partial \Delta U_r / \partial \rho_r\}$ . Hence, the function linking  $l_r$  to  $\rho_r$  defines a bell-shape curve (see figure 1). Taking as given the payment in the other region, for low (resp., high) values of  $\rho_r$ , an increase in  $\rho_r$  pulls (resp. pushes) workers in region  $r$ . There are two effects that have opposite effects on  $l_r$ : a *taxation effect* and an *environmental effect*. On the one hand, an increase in  $\rho_r$  leads to a rise in  $E_r$  raising the utility of workers in region  $r$  as compared to workers in region  $s$  so that workers move to region  $r$ : this is the *environmental effect*. On the other hand, when  $\rho_r$  raises,  $t_r$  increases leading to an outflow of workers: this is the *taxation effect*. Finally, it appears that for a rise in payments from low values, the environmental effect dominates the taxation effect.

[Figure 1 about here]

To summarize,

**Proposition 2.** *In the non cooperative policy case, workers locate as a result of two opposite effects: (i) an attracting effect that is an environmental effect that dominates for low agri-environmental payments and (ii) a repulsive effect that is a taxation effect that dominates for higher agri-environmental payments.*

In addition, it is straightforward to check that

$$\left. \frac{\partial l_r}{\partial v} \right|_{\rho_r > \rho_s} > 0 \quad , \quad \left. \frac{\partial l_r}{\partial F} \right|_{\rho_r > \rho_s} > 0 \quad \text{and} \quad \left. \frac{\partial l_r}{\partial M} \right|_{\rho_r > \rho_s} < 0$$

When payment in region  $r$  is higher than in region  $s$ , a higher taste of workers for the environment attracts workers in the former region, as expected. An increase in  $F$  attracts workers in the region with the highest level of payment. Indeed,  $F$  has no effect on the difference  $E_r - E_s$ . As a result, the environmental effect is higher when  $F$  achieves high values so that the agglomeration of workers is more likely to occur in the region with the highest payment. When payment in region  $r$  is higher than in region  $s$ , the impact of an increase in  $M$  on input dedicated to agri-environmental production is higher in region  $s$  than in region  $r$ . Agri-environmental good decreases more in region  $s$  than in region  $r$ . The taxation effect will be smaller in region  $s$  than in region  $r$ . Workers will move from region  $r$  to region  $s$ . Note also the increase in the number of workers in region  $r$  due to a higher taste of workers for the environment is a decreasing function of  $M$ .

To summarize,

**Proposition 3.** *The region with the lowest payment is more likely to host the higher share of individuals when consumers value weakly the environmental good and when productivity in the agricultural sector is high (high  $M$  and low  $F$ )*

*Nash payment vs. optimal payment*

Under the non cooperative configuration, each local government maximizes (9) with respect to  $\rho_r$  knowing (2), (4), (5), and (10) and anticipating the spatial equilibrium (14). The first order condition for region  $r$  implies

$$\frac{\partial W_r}{\partial \rho_r} = \theta \frac{\partial \pi_r}{\partial \rho_r} + (1-\theta) \left[ \underbrace{\frac{\partial (w_r l_r)}{\partial \rho_r}}_{\text{Revenue Effect}} - \underbrace{\frac{\partial (\rho_r E_r)}{\partial \rho_r}}_{\text{Taxation Effect}} + \underbrace{v \frac{\partial (E_r l_r)}{\partial \rho_r}}_{\text{Environmental Effect}} \right] = 0$$

We identify three types of effects on workers' welfare: a revenue effect, a taxation effect and an environmental effect. The taxation effect is negative whereas the environmental effect is positive. The revenue effect is ambiguous. Indeed, we have

$$\frac{\partial (w_r l_r)}{\partial \rho_r} = \frac{\partial l_r}{\partial \rho_r} \underbrace{[f'(l_r) + l_r f''(l_r)]}_{>0}$$

where  $\partial l_r / \partial \rho_r$  cannot be signed as we have shown in the foregoing subsection.

The aim of our discussion is to compare the benchmark case (unified government) with the non cooperative configuration. Thus, instead of solving the program to find the optimal payment, we write the first order condition of government  $r$  objective function and analyze the sign of the first order derivative at  $\rho = \rho^o$ , the optimal payment of the unified government (see (13)). When  $\partial W_r / \partial \rho_r > 0$  (resp.,  $\partial W_r / \partial \rho_r < 0$ ), there is an over-provision (resp., under-provision) of the environmental good in the non cooperative game as compared to the unified government. Some calculations reveal that

$$\frac{\partial W_r}{\partial \rho_r} = \Gamma(\rho_r) + (1-\theta) \frac{\partial l_r}{\partial \rho_r} (f'(l_r) + l_r f''(l_r) + v E_r) \quad (15)$$

with

$$\Gamma \equiv \theta \frac{\partial \pi_r}{\partial \rho_r} + (1-\theta) \left( -E_r - \rho_r \frac{\partial E_r}{\partial \rho_r} + \nu l_r \frac{\partial E_r}{\partial \rho_r} \right)$$

Evaluating the first order condition at  $\rho_r = \rho_s = \rho^o$  (and thus  $l_r = l/2$ ), we

obtain

$$\left. \frac{\partial W_r}{\partial \rho_r} \right|_{\rho_r = \rho^o} = (1-\theta) \underbrace{\left( f'(l) + l f''(l)/2 + \nu E_r \right)}_{>0} \left. \frac{\partial l_r}{\partial \rho_r} \right|_{\rho_r = \rho^o}$$

where  $\Gamma = 0$  when  $\rho_r = \rho_s = \rho^o$  and

$$\left. \frac{\partial l_r}{\partial \rho_r} \right|_{\rho_r = \rho^o} < 0 \tag{16}$$

The proof is reported in Appendix. As a result, there is under-provision in the non cooperative game as compared to the unified government. Such a result emerges because  $\rho^o$  belongs to the interval in which the environmental effect is dominated by the taxation effect (see figure 2). Starting from the configuration under which agri-environmental policy is centralized (so that  $\rho_r = \rho^o$ ), a decentralization of this policy implies that each region has an incentive to diminish payments for each farmer and, in turn, the tax rate in order to attract more residents. Such a result is due to interregional externality arising from non-cooperative decentralized policies. Indeed, each government does not internalize the consequences of its choice on the well-being of the other region. This externality takes the following expression:

$$\frac{\partial W_s}{\partial \rho_r} = (1 - \theta)(\nu E_s + f'(l_s) - l_s f''(l_s)) \frac{\partial l_s}{\partial \rho_r} > 0$$

To sum up,

**Proposition 4.** *A move from centralized agri-environmental policy to decentralized agri-environmental policy reduces the global welfare and the production of the environmental good.*

In addition, it is worth stressing that the incentive to deviate from the cooperative equilibrium for each region is stronger when the technology used to produce the agricultural good exhibits high levels of productivity (high  $M$ ). In this case, consumers are strongly attracted by the region with the lowest payment (see Proposition 3). This is particularly socially harmful when workers are favored ( $\theta < 1/2$ ) because the optimal payment is relatively high with a cooperative equilibrium (see Proposition 1 or Table 1). However, when the productivity in producing the environmental good is high (low  $F$ ) and when the consumers value weakly rural amenities (low  $\nu$ ), decentralization is less harmful because the optimal payment under a centralized policy is relatively low (see Propositions 1 and 3).

[Figure 2 about here]

Finally, we can conclude that the decentralization of the agri-environmental policy reduces (i) the global welfare regardless of the weight of farmers in the social welfare function and (ii) the farmers' profit ( $\partial \pi / \partial \rho > 0$ , see (8)). The effect of this decentralization on the workers' welfare is ambiguous because the supply of the environmental good decreases while the tax burden shrinks.

However, we have  $\Gamma = 0$  when  $\rho_r = \rho_s = \rho^0$  and  $\partial\pi/\partial\rho > 0$  so that we have  $\partial\xi/\partial\rho < 0$  (the utility arising from the environmental policy increases with a decrease in the payment). Because the wage of workers is not affected by the decentralization of agri-environmental policy, we can conclude that a fall in payment due to a move from centralization to the decentralization of the agri-environmental policy raises the welfare of workers. As previously, this result arises from the fact that  $\rho^0$  belongs to the interval in which the environmental effect is dominated by the taxation effect. Hence,

**Proposition 5.** *A move from centralized agri-environmental policy to decentralized agri-environmental policy reduces the farmers' income and raises the workers' welfare.*

### **Heterogeneity in tastes**

In order to check the robustness of our results, we now consider that consumers are heterogeneous in their perception of the attributes associated with a particular region. Because we consider that such a heterogeneity in tastes is unobservable, we use discrete choice theory. The utility of consumers is now given by

$$u_r = w_r - t_r + vE_r + \varepsilon \quad (1')$$

Hence, the actual matching value between a consumer and region  $r = A, B$  is a random variable  $\varepsilon$  (Anderson, de Palma, and Thisse 1992, chapter 3). In what follows, we assume that the  $\varepsilon$  is identically and independently distributed across individuals according to the double exponential with zero mean and a variance

equal to  $\zeta^2 \mu^2 / 6$ . The choices are governed by the same probability distribution whereas tastes are stochastically uncorrelated. However, actual choices may differ across workers. The fact that the distribution is the double exponential involves little restriction in the case of two regions, while allowing for simple and neat expressions.

Then, the probability that a worker will choose to reside in region  $r$  is given by the logit formula:

$$P_r(\lambda_r) = \frac{\exp[U_r(\lambda_r) / \mu]}{\exp[U_r(\lambda_r) / \mu] + \exp[U_s(\lambda_s) / \mu]}$$

where  $\lambda_r = l_r / l$  (with  $r=A,B$  and  $\lambda_r + \lambda_s = 1$ ) and  $\mu$  expresses the dispersion of individual tastes. The larger  $\mu$  is, the more heterogeneous the workers' tastes are about their residential location. When  $\mu = 0$ , workers are homogenous and behave as in the foregoing sections.

As shown by Anderson, de Palma, and Thisse (1992), the total utility of workers is given by:

$$W_l = u_A l_A + u_B l_B - \mu [\lambda_A \ln \lambda_A + \lambda_B \ln \lambda_B] l$$

In the centralized case, the spatial distribution of workers/consumers maximizing global welfare is given by  $\lambda_r = 1/2$  with  $r=A,B$ . In other words, the central government provides the same payment regardless of the location of farmers. As a consequence, the optimal payment is given by (14).

Turning now to the case where agri-environmental policy is decentralized. From now on, it is convenient to set  $\lambda \equiv \lambda_A$  (so that  $\lambda_B = 1 - \lambda$ ). The residential location of workers changes according to the following equation of spatial mobility:

$d\lambda/dt = (1-\lambda)P_A(\lambda) - \lambda P_B(\lambda)$  where the first term in the RHS of this equation stands for the fraction of consumers migrating into region  $A$ , while the second term represents those leaving this region for region  $B$ . A spatial equilibrium  $\lambda^*$  arises when  $d\lambda/dt = 0$  or equivalently to

$$(1-\lambda)\exp[U_A(\lambda)/\mu] = \lambda\exp[U_B(\lambda)/\mu]$$

Taking the logarithm of both sides, the spatial equilibrium condition becomes:

$$Z = \Delta U(\lambda) - \mu \ln\left(\frac{\lambda}{1-\lambda}\right) = 0$$

It appears that when  $\rho_A = \rho_B$ ,  $\lambda = 1/2$  is the equilibrium spatial allocation and this equilibrium is stable. We use (14) defining impact of payments on location of consumers, which gives

$$\frac{\partial Z}{\partial \rho_r} = 0 \Leftrightarrow \frac{\partial l_r}{\partial \rho_r} = \frac{-\partial U(\lambda)/\partial \rho_r}{\partial U(\lambda)/\partial \lambda - \mu[\lambda(1-\lambda)]^{-1}}$$

We know that  $\partial U/\partial \lambda < 0$  and  $\partial U/\partial \rho_r < 0$  when  $\rho = \rho^o$ . Hence, we have  $\partial l_r/\partial \rho_r < 0$  when  $\rho = \rho^o$ . As a consequence, our proposition 3 remains valid regardless of the degree of heterogeneity among consumers.

### **Conclusion and future research**

Given the role environmental amenities play in workers' welfare, conservation policies are designed to maintain or increase their provision notably in the agricultural sector. Environmental goods and policy impacts being localized, addressing the issue of decentralizing conservation policy is crucial for determining the optimal institutional structure. This is all the more relevant since



there is a recent move in agri-environmental policies to taking into account local heterogeneity. The aim of the article was to consider the consequences of a decentralization of the agri-environmental policy when natural amenities affect residential choices. We used a model with mobile population and governments subsidizing farmers for the production of agri-environmental goods. Our main result is that *the decentralization of the agri-environmental policy leads to inefficiency low payments for farmers from the global welfare viewpoint*. However, we also show that *while the farmer's income shrinks when decentralization occurs, the welfare of workers increases*. Indeed, when decentralization takes place, each region has an incentive to diminish its payments in order to reduce its tax rate applied on residents to attract more inhabitants (and more tax base).

Our results differ from the environmental federalism standard result where centralization is welfare enhancing due to environmental spillovers from one region to the other. We derive our result in the hypothesis of no environmental spillover. But we uncover a similar mechanism in that the externality is indirect and happens through workers' mobility.

That being said, our results are derived from given hypotheses and as such, our modeling is a first step. It should be noted that heterogeneities in farms' technologies or spillovers effects could be easily introduced in our framework. One challenging issue is when the choice of the type of environmental good to provide is left to the regions. Thus, a critical question is the endogenous choice of the *type* of agri-environmental good that will be optimally financed by regions.

It also should be interesting to consider a spatial economy with a rural/urban structure. The interactions between rural and urban economies are also critical in shaping how natural resources in rural areas are used. The phenomenon of urban sprawl could strengthen the competition between rural municipalities to attract population by favoring environmental amenities. This extension merits also a specific attention.

## Footnotes

<sup>1</sup> <http://www.nrcs.usda.gov/programs/CRP/>

<sup>2</sup> [http://ec.europa.eu/agriculture/publi/reports/agrienv/rep\\_en.pdf](http://ec.europa.eu/agriculture/publi/reports/agrienv/rep_en.pdf)

<sup>3</sup> <http://www.fsa.usda.gov/FSA/webapp?area=home&subject=prod&topic=cep>

<sup>4</sup> <http://www.nrcs.usda.gov/PROGRAMS/EQIP/>

<sup>5</sup> [http://ec.europa.eu/agriculture/rurdev/index\\_en.htm](http://ec.europa.eu/agriculture/rurdev/index_en.htm)

<sup>6</sup> The existence of environmental externalities from one jurisdiction to another is also a key parameter in the environmental federalism literature.

<sup>7</sup> Gundersen et al. (2004) argue that the devolution of agri-environmental policy is expected to promote a better allocation of public funds but the authors do not consider coordination failures that can generate the mobility of households.

<sup>8</sup> In the model, we only focus on the production of a local public good by farmers (positive externality). Considering negative externalities arising from agricultural activities does not change our results.

<sup>9</sup> Note that our approach is more general because it could be applied to the case to forest resources which are viewed as a source of raw materials for wood products and valued for their recreational uses.

<sup>10</sup>  $f'(l)$  denotes the first derivative of  $f(l)$  with respect to  $l$ . The second derivative is subsequently denoted by  $f''(l)$ .

<sup>11</sup>  $g'(h_r)$  denotes the first derivative of  $g(h_r)$  with respect to  $h_r$ . The second derivative is subsequently denoted by  $g''(h_r)$ .

<sup>12</sup> Indeed, we have  $\frac{\partial \xi}{\partial \theta} = (v - 2\rho^o / l) \frac{\partial E^o}{\partial \theta} - \frac{2E^o}{l} \frac{\partial \rho^o}{\partial \theta}$  and  $\rho^o > vl/2$  when  $\theta > 1/2$

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### Appendix.

We show that  $sign \left\{ \frac{\partial l_r}{\partial \rho_r} \Big|_{\rho_r = \rho^0} \right\} < 0$  or, equivalently,  $sign \left\{ \frac{\partial \Delta U_r}{\partial \rho_r} \Big|_{\rho_r = \rho^0} \right\} < 0$

By plugging (6) in (14), we get

$$\frac{\partial \Delta U_r}{\partial \rho_r} = \frac{-[g(h_r^*) - F][ -g''(h_r^*) ] \rho_r - \frac{M^2}{\rho_r} (\rho_r - \nu l_r)}{[-g''(h_r^*) ] l_r \rho_r} \quad (\text{A.1})$$

By rearranging (13) and knowing (6), we obtain the following expression:

$$g(h^*) - F = \frac{(1 - \theta) M^2 \left( \rho^0 - \frac{\nu l}{2} \right)}{(2\theta - 1) \rho^{03} [-g''(h)]} \quad (\text{A.2})$$

Plugging (A.2) in (A.1) when  $\rho_r = \rho^0$  leads to:

$$\frac{\partial \Delta U_r}{\partial \rho_r} = \frac{-\frac{M^2}{\rho^{02}} \left( \rho^0 - \frac{\nu l}{2} \right) \left( \frac{2\theta}{2\theta - 1} \right)}{[-g''(h_r^*) ] l \rho^0}$$

It appears from (13) that  $\rho^0 > \nu l / 2$  when  $\theta > 1/2$  and  $\rho^0 < \nu l / 2$  when

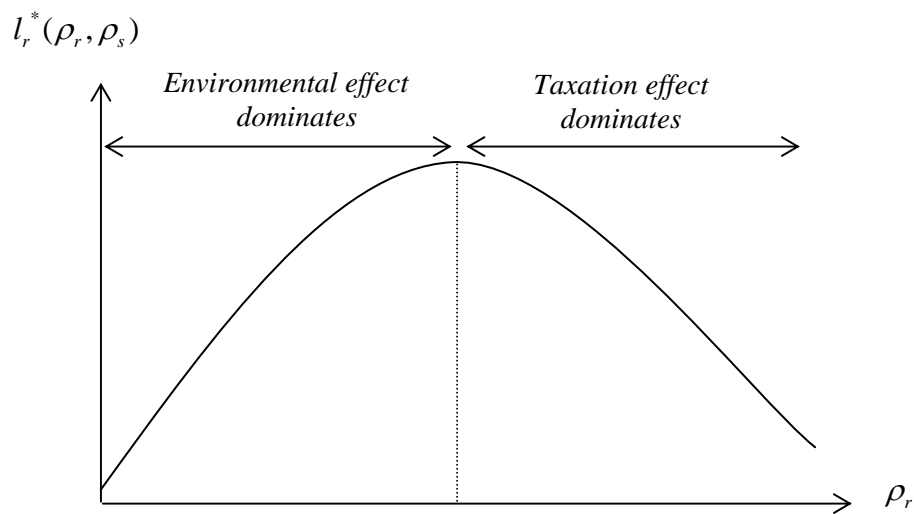
$\theta < 1/2$  so that  $\left( \rho^0 - \frac{\nu l}{2} \right) \left( \frac{\theta}{2\theta - 1} \right) > 0$ . As a result, we can conclude that

$$\frac{\partial l_r}{\partial \rho_r} \Big|_{\rho_r = \rho^0} < 0$$

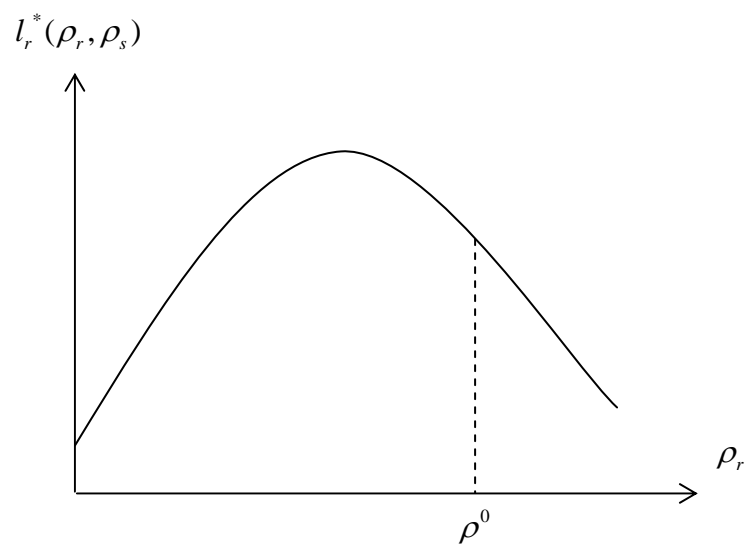
**Table 1: Agricultural Technology and Optimal Payment**

		Environmental Production		Agricultural Production
Parameters of farms		Input productivity	Fixed costs	Income
Group favored in the social welfare function		$\partial \rho^o / \partial g'(h)$	$\partial \rho^o / \partial F$	$\partial \rho^o / \partial M$
$\theta > 1/2$	Farmers	+	-	-
$\theta < 1/2$	Workers	-	+	+





**Figure 1. Residential location and payments in region r taking payment in region s as given**



**Figure 2. Residential location and optimal payment**