Decentralization of agri-environmental policy design: the case of abandoned wetlands in Brittany

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Abstract

In a context of reflections around the next Common Agricultural Policy (CAP) reform, the European Commission is considering the possibility to decentralize the provision of environmental goods towards lower level of governments. We examine the gains of such potential policy using a simple model of an economy constituted of homogeneous regions and considering that agriculture produces jointly local and global public goods. We assume that the central government faces lower deadweight losses than the local government but that the local government can target their subsidies towards the closest farmers. This last assumption is supported by the empirical literature on "distance-decay willingness-to-pay" that stresses that, the closer is the provision area, the higher is the utility derived from the provision of local public good. Our analytical results present the differences of landscape structure (constituted of two areas) and welfare in three cases of governance: full-centralization (EU is in charge of environmental good provision), full-decentralization (local government is in charge of environmental good provision) and mix-centralization-decentralization (EU allocates a share of its budget to the local government for the provision of environmental goods). We apply our analytical results on an original case study: the abandonment of agricultural wetlands in Brittany. Based on this example and the actual CAP budget dedicated for environmental good provision, we illustrate the difference of welfare between the three cases of governance. More specifically, we highlight the optimal share that the European Commission should allocate towards lower levels of government. Our paper is an intermediary work: we are only able to illustrate some results in a two-area landscape. The next steps are to derive the analytical solutions of the optimal shares of the budget and to solve the empirical problem using an Agent Based Model with a continuous landscape.

1. Introduction

Agricultural activities occupies a major part of land areas with, for example, 43.8 % of European Union lands occupied by agriculture in 2014[1]. Agriculture jointly produces agricultural goods and environmental goods, which both affect the welfare of the populations. However, because environmental goods are public goods, their provision influences the welfare of the populations without any existing market to meet supply and demand. The lack of market solutions justify public regulator intervention. Because of its land-intensive occupation, agriculture is a main economic activity providing environmental public goods. It explains that most of public spending regarding environmental goods is allocated to agriculture. In Europe, between 4 and 5 billions are allocated each year to the provision of environmental goods by farmers through the Agro-Environmental Measures (AEM). Even if there are other instruments, AEM are the main subsidies at the disposition of the European Union (EU) to increase the provision of public goods by agriculture. These subsidies are budgeted inside the Common Agricultural Policy, whom budget is fixed by the European authorities. However, there is a trend towards a decrease of the share of the total European budget dedicated to CAP. Anticipating future decrease of budget dotation, the European Commission is thinking on new ways to increase the efficiency of public spending dedicated to public goods[2]. One identified way of improvement is the decentralization of agri-environmental policy.

Indeed, agriculture produces jointly several types of public goods whom beneficiaries are different according to scale. Two types of public goods are usually distinguished according to scale sensitivity of public good beneficiaries: local public goods and global public goods. The beneficiaries of local public good provision are located within a geographical area around the provision area whereas the beneficiaries of global public good are localized all over the world. Today, most of the environmental policies are designed by a centralized government (e.g. the European Commission), resulting to allocation of funds based on average provision costs. This allocation leads to potential spatial mismatch between supply and demand for local public goods. In other words, the benefits of the local public good provision from agricultural activities are not especially integrated on AEM design. The existing financing rules are better suited to global public good provision. The European Commission is currently thinking on the optimal

[1] Figure obtained from the World Bank website: https://data.worldbank.org/indicator/AG.LND.AGRI.ZS [visited 09/11/2017].

[2] https://ec.europa.eu/agriculture/sites/agriculture/files/consultations/qa-cap-modernising.pdf [consulted the 09/12/2017]

level of decentralization towards lower level of government to improve AEM efficiency. The "environmental federalism" literature aims to answer this question (Oates, 2001).

Environmental federalism is an economic literature aiming to answer the following question: which level of government should design and implement environmental policy? This is the same general question as the one answered by the "fiscal federalism" literature, but applied to environmental issues (Oates, 2001). The basic statement of these literatures is that *(i)* there are several levels of government (i.e. a federal system), *(ii)* local government can targeted more effectively public spending but *(iii)* local government incurs more deadweight losses than the central government would face[3]. The literature examines thus the effectiveness of decentralization based on the trade-off between welfare losses due to uniform standards (uniform taxes or subsidies) and transaction costs. A large literature on this issue has been developed based on Tiebout (1956)[4]. However, contrary to Tiebout, most of the literature consider that there exists provision spillovers between jurisdictions. The conclusion of this literature is that instruments that generate benefits contained within the boundaries of local jurisdictions present a high interest for decentralized environmental management whereas global environmental problems require central government intervention (Tiebout & Houston, 1962). However, environmental federalism literature does not examined cases where global and local environmental goods are jointly created. One aim of our paper is to overcome this issue.

This paper aims to support the reflections around the future CAP reform. Considering that agriculture generates both local and global public goods, we examine how decentralization could improve the efficiency of environmental payments. The underlying question that the paper aims to answer to is: what share of the CAP budget dedicated to environmental good provision should be transferred to the local government to maximize the efficiency of the CAP budget? We develop a theoretical model where we explicitly consider two levels of government (central – the European Union – and local – the main city of a watershed –) which can both finance public good provision.

There are some originalities in our paper. First, similarly to Bougherara & Gaigné (2008), we consider that the suppliers of public goods are not the public sector (as it uses to be in fiscal

[3] In other terms, the design of agri-environmental policies faces economies of scale.
[4] Tiebout (1956) considers that local public goods are financed by local administration and can only benefit to the territory it represents. Its theory is that, if there were enough local administrations, individuals would choose to live in territories according to public good provision, revealing by the way their true preference for public goods. This theory relies on the assumption of perfect residential mobility, which creates competition among territories: people can thus "vote with their feet" to express their preferences for public good provision. Tiebout concluded that jurisdiction might not need politics to insure public good provision.

federalism literature) but the private sector (i.e. the agricultural sector). Second, we especially consider that public good suppliers jointly produces two types of public goods: local and global ones. This explains why both local and central government are interested in the way the public funds are spent. Third, we consider that both suppliers and consumers of public goods are immobile, i.e. that there is no competition between local jurisdictions. Like Tiebout & Houston (1962), we are more interested in how two levels of government should share a budget to insure the highest possible utility under a budget constraint. Fourth, we consider that the local government can integrate that the utility of local public good provision decreases with the distance between its provision and the beneficiaries. This last assertion has been stressed out by the growing empirical literature of "distance-decay willingness-to-pay" (León et al., 2016; Sutherland & Walsh, 1985). This literature stresses that the utility derived from the provision of local public goods decreases with the distance between the production area and the area of consumption. The larger the distance is, the less the value of the public good consumption is (Bateman et al., 2006; Jørgensen et al., 2013; León et al., 2016; Pate & Loomis, 1997; Rolfe & Windle, 2012). Utilization of distance decay theory is the empirical counterpart of the public good scale issue first presented by Ostrom et al. (1961) and leading to overlapping of public good boundaries. To our knowledge, these empirical evidences have never been integrated to the environmental federalism issues, despite their obvious link. Fifth, we integrate an exogenous budget constraint. Indeed, the budget constraint does currently exist for environmental good provision from agriculture, notably due to WTO legislations. Contrary to the existing literature on environmental federalism, we thus consider that both government are constrained by the budget, i.e. that both government cannot choose the budget they would allocate to public good provision.

Our work shows that the decentralized governance reduces the total amount of financed lands but that the public goods are produced closer to the local government. The effectiveness of decentralization compared to centralization depends on the value derived from local and global public goods produced on each unit of land and the additional deadweight losses incurred by the city. We apply our analytical results on a suitable case study: the abandonment of agricultural wetlands in Brittany. This application underlines the potential usefulness of our analytical results to the future CAP 2020-reform for the financing of environmental goods. It also stresses the potential usefulness of Payment for Environmental Services (PES) as a complementary instrument for environmental good provision.

The article is organized as follows. The next section presents the theoretical model which analyzes the trade-offs between the centralized and the decentralized governments. Section 3 is devoted to the empirical applications of the analytical results. We discuss the theoretical and empirical results in the fourth section. Section 5 concludes.

2. Model

a. Description of the problem

Assume an economy constituted of homogenous regions and a centralized government. The centralized government and the main city of the region can both govern the public good provision. Each region contains a farming sector, constituted of two spatially disjoint farmers, labeled F_1 and F_2. F_1 and F_2 are respectively located to a distance d_1 and d_2 to the main city of the region, with $d_1 < d_2$. Otherwise, the farmers are homogenous. The farmers produce agricultural goods on a fixed quantity of lands and can produce public goods on $\overline{X}$ units of land with suitable environmental quality. Each farmer as the same amount of suitable environmental quality lands, i.e. $\overline{X}_1$ (the quantity of suitable environmental quality lands which can be managed by F_1) is equal to $\overline{X}_2$. The $\overline{X}$ units of land can be allocated to the production of public goods or not (the land units are either farmed or abandoned). The farmed (or managed) lands are respectively noted as X_1 and X_2 with $X_1 + X_2 \leq \overline{X}$ (by consequence, there are $\overline{X} - (X_1 + X_2)$ unit of abandoned lands).

The management of X_1 and X_2 leads to the joint production of local and global public goods. In the illustrative case of agricultural wetlands from Brittany, their management by agriculture increases water quality (i.e. a local public good) but also carbon sequestration (i.e. a global public good). The utility derived from the production of the local public goods is captured by the main city of the region where the production occurs. The utility derived from the production of the local public goods decreases with the distance. As a result, for the same levels of X_i ($i \in \{1;2\}$), X_1 is more valuable than X_2 for the city. The other regions do not benefit from the local public goods produced in the region where the production occurs. The utility derived from the production of the global public goods is captured by all the regions of the economy (including the region where the production occurs). The value derived from the production of the global pubic goods does not depend on d_1 and d_2.

The region can benefit from a given budget $\overline{B}$ to finance the public goods. $\overline{B}$ is exogenous and can only finance the provision of public goods by F_1 and F_2. We find that the exogeneity of $\overline{B}$ is a reasonable assumption, at least for the financing of public goods by agriculture. Indeed, only a minority share of the budget of the CAP (itself almost exogenous considering the political tensions) is dedicated to the production of environmental public goods. Even if the share can increase, it seems reasonable to consider that the budget for public good is binding, especially with regard to the existing legislative constraints from the WTO on agricultural supports. The budget can be spent either by the main city of the region or by the central government. Indeed, the choice of public good provision within a given region can be made either by the central government (case of *full-centralization*), by the main city of the region (case of *full-decentralization*) or by both the main city and the centralized government at the same time (case of *mix-centralization-decentralization*). The central government decides to allocate $\overline{B}$ between itself and the city, knowing that the transfer towards the city incurs deadweight losses due to additional transaction costs. We assume that the central government does not support any deadweight losses when it manages the full budget. In addition, when the centralized government manages the budget alone, it maximizes the utility of the whole economy but without perfect knowledge of the utility derived from the local good provision. As a consequence, the centralized government attributes the same value for X_1 and X_2. We will see that it leads to an under-provision of public goods from F_1 compared to the social optimum. In the opposite, when the main city manages the budget alone ($\overline{B}$ minus the deadweight losses), it maximizes the utility of the region. Contrary to the central government, the city has a perfect knowledge of the utility derived from the consumption of local public goods but does not consider the benefits derived by the rest of the economy from the production of global public goods. We will see that it leads to an under-provision of public goods from F_2 compared to the social optimum.

Considering that regions are homogenous and that there is no mobility of inhabitants between each region, we can resolve this problem considering one region and the centralized government. The centralized government takes into account the utility of the other cities of the economy derived from the consumption of the global public goods into the considered region.

Public good production. We assume that the farmers produce agricultural goods on a fixed quantity of lands and that they derive an exogenous profit from this production. In addition, the farmers can produce public goods on $\overline{X}$ with marginally increasing costs. The farmers maximize the profit from the production of public goods. The program of F_i is:

$$\Pi_i = \rho_i X_i - \frac{1}{2} c X_i^2 \qquad (1)$$

where ρ_i is the subsidy proposed to the farmers for each unit of X_i and c is the parameter of the quadratic cost function. The level of ρ_i depends on the entity in charge of the provision of the public good. Each farmer chooses X_i under the constraint $X_i \leq \overline{X}_i$ in order to maximize her profit. **In the presented analytical results, we assume that the constraint is not binding, i.e. that the given budget for the provision of public goods prevents $X_i = \overline{X}_i$.**

Maximizing (1) on X_i leads to the following FOC:

$$\frac{\partial \Pi_i}{\partial X_i} = \rho_i - c X_i^* = 0$$

Which leads to:

$$X_i^* = \frac{\rho_i}{c} \qquad (2)$$

Each farmer will allocate lands to the production of public goods until the costs she incurs from the farming of the last unit of land equals the benefits she gets from the subsidy.

Main city. The utility of the main city of the region is linear and given by:

$$U_{city} = \frac{v}{d_1} X_1 + \frac{v}{d_2} X_2 + w(X_1 + X_2) \qquad (3)$$

where w is the marginal utility derived by the inhabitants of the main city from the consumption of global public goods provided by F_1 and F_2 and v/d_i is the marginal utility derived from the consumption of the local public goods provided by F_1 and F_2, in line with the distance decay literature related to willingness-to-pay for the local public goods. The preferences for local and global public goods are exogenous. The objective of the main city is to allocate its budget (noted B_{city})[5] between X_1 and X_2 in order to maximize its utility. Thus, the government of the city maximizes (3) under the constraint:

[5] Note that $B_{city} < \overline{B}$ because of the deadweight losses.

$$B_{city} = p_1 X_1 + p_2 X_2 \quad (4)$$

where p_1 is the subsidy proposed by the city to F_1 and p_2 is the one proposed to F_2. The city has to choose p_1 and p_2 to maximize (3). In the case the main city is fully in charge of the financing of the public goods, we have $\rho_1 = p_1$ and $\rho_2 = p_2$.

Central government. The objective of the central government is to maximize the utility of the whole economy. Contrary to the government of the main city, the central government does not know the relationship between the utility derived from the consumption of the local public goods and the distance. We assume that it considers that the utility of the main city of the region for the consumption of local public goods does not depend on the distance. On the opposite, it knows perfectly the utility derived from the consumption of the global public goods, both in the region and the rest of the economy. The central government maximizes the following function:

$$U_{central} = \left(E\left(\frac{v}{d}\right) + w + y \right)(X_1 + X_2) \quad (5)$$

where w is the marginal utility derived from the consumption of the global public goods within the considered region, y is the marginal utility derived from the consumption of the global public goods outside the considered region (i.e. in the rest of the economy) and $E(v/d)$ is the central government's expected value of the utility derived by the main city due to the provision of local public goods within the considered region. The expected value has the following property: $v/d_2 \leq E(v/d) \leq v/d_1$. Because most of the value derived from the provision of global public goods is captured outside from the considered region, we have also $w << y$.When the central government is fully in charge of the financing of the public goods, the objective of the central government is to maximize (4) under the constraint:

$$B_{central} = s(X_1 + X_2) \quad (6)$$

In this case, we have $\rho_1 = \rho_2 = s$.

Knowing that the city is more efficient to finance the local public goods, the central government can also choose to allocate a share of its budget to the government of the city. The transfer equation should insure the following equilibrium:

$$\overline{B} = B_{central} + (1+\tau)B_{city} \quad (7)$$

where τ is the rate of deadweight losses incurs by the city when it is charge of managing public money. The rate of deadweight losses as the following property: $0 \leq \tau < 1$. When $\tau = 0$, the city does not support any additional deadweight losses. ***[For the SFER conference, we have assumed that*** $\tau = 0$***. The results are not stabilized for case where*** $\tau > 0$***.]***

We examine the public good provision properties emerging in the three types of governance, namely the *full-centralization* case, the *full-decentralization* case and the *mix-centralization-decentralization* case. Each government chooses ρ_i for $i \in \{1;2\}$ anticipating the farmers' supply response. We compare the level of X_i, the level of subsidies, the utilities and the welfare (labeled W)[6] of the economy between each case.

b. Comparative statistics

Full-centralization case

This case is the actual one regarding the financing of the public good provision from agriculture in Europe: the EU is in charge to finance the provision of environmental public goods from agriculture within the member states. In this case, the central government knows the costs incur by the farmers (i.e. relation (2)) and propose the level of subsidy to maximize (5) under the budget constraint (6). Introducing (2) into (6) leads to:

$$s = \sqrt{\frac{\overline{B}c}{2}} \qquad (7)$$

The offered subsidy to F_1 and F_2 by the central government increases with $\overline{B}$ and c. Introducing (7) in (2) leads to:

$$X_1^* = X_2^* = \sqrt{\frac{\overline{B}}{2c}} \qquad (8)$$

The quantity of suitable lands allocated to public good provision are the same for F_1 and F_2. They increase when $\overline{B}$ increases and decreases with c. In total, the region F_1 and F_2 allocate $\sqrt{2\overline{B}/c}$ units of land for the provision of public goods. The utility of the central government is thus:

[6] The welfare is equal to $W = U_{city} + x(X_1 + X_2) + \Pi_1 + \Pi_2$.

$$U_{central}=\sqrt{\frac{2\overline{B}\left(E\left(\frac{v}{d}\right)+w+y\right)^2}{c}} \quad (9)$$

The utility increases with the preferences of global public goods and with the expectation value of the preference for local public goods from the city. It also increases with $\overline{B}$ and decreases c. The real utility derived from the city is:

$$U_{city}=\sqrt{\frac{\overline{B}}{2c}}\left(\frac{v}{d_1}+\frac{v}{d_2}+2w\right) \quad (10)$$

Like the rest of the economy, its welfare increases with the preferences for global and local public goods. It also increases $\overline{B}$ and decreases with c. The total welfare (labeled W) derived from the policy is equal to:

$$W^{centralization}=\sqrt{\frac{\overline{B}}{2c}}\left(\frac{v}{d_1}+\frac{v}{d_2}+2(w+y)\right)+\frac{1}{2}\overline{B} \quad (11)$$

The total profit of the farming sector is $\overline{B}/2$ (each farmer captures a profit of $\overline{B}/4$) and the utility derived from the provision of public goods from the city and the rest of the economy is $\sqrt{\overline{B}/2c}\left(v/d_1+v/d_2+2(w+y)\right)$. Because the budget constraint is binding, the welfare does not depend on the expected value of the preferences for local public goods.

Full-decentralization case

This case is a theoretical case. Even if the discussions on CAP reform consider partial decentralization, it is unlikely that the CAP-2020 reform fully decentralizes the financing of public goods. In case of full-decentralization, the city government knows the costs incurred by the farmers (i.e. relation (2)) and propose the level of subsidy to maximize (3) under the budget constraint (4). In case of full-decentralization, the available budget is $B_{city}=\overline{B}/(1+\tau)$. Introducing (2) into (4) leads to:

$$\frac{p_1^2}{c}+\frac{p_2^2}{c}=\frac{\overline{B}}{1+\tau} \quad (12)$$

Which is equivalent to:

$$p_1=\sqrt{\frac{\overline{B}}{1+\tau}c-p_2^2} \quad (13)$$

Introducing relation (13) within (3) (using also relation (2)) leads to:

$$U_{city} = \left(\frac{v}{d_1} + w\right)\frac{\sqrt{\frac{\overline{B}}{1+\tau}c - p_2^2}}{c} + \left(\frac{v}{d_2} + w\right)\frac{p_2}{c} \qquad (14)$$

The city government can then maximize (14) choosing p_2. The maximization leads to the following first order conditions:

$$\frac{\partial U_{city}}{\partial p_2} = -\left(\frac{v}{d_1} + w\right)\frac{p_2}{c\sqrt{\frac{\overline{B}}{1+\tau}c - p_2^2}} + \left(\frac{v}{d_2} + w\right)\frac{1}{c} = 0$$

Which is equivalent to:

$$p_2 = \left[\frac{\frac{\overline{B}}{1+\tau}c\left(\frac{v}{d_2} + w\right)^2}{\left(\frac{v}{d_2} + w\right)^2 + \left(\frac{v}{d_1} + w\right)^2}\right]^{\frac{1}{2}}$$

Or:

$$p_2 = \sqrt{\frac{\frac{\overline{B}}{1+\tau}c}{1 + \left[\frac{\left(\frac{v}{d_1} + w\right)}{\left(\frac{v}{d_2} + w\right)}\right]^2}} \qquad (15)$$

The proposed payment by the city to F_2 depends on the relative distance d_1 and d_2. It increases with d_1 and decreases with d_2. The opposite is found for p_1: the proposed payment by the city to F_1 increases when d_1 decreases[7], i.e. the closest F_1 is from the city. Like in the central government, the subsidy increases with $\overline{B}$ and c. The subsidy decreases with the deadweight losses.

Introducing (15) in (2) leads to:

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[7] We have also $p_1 = \sqrt{\left(\left(\overline{B}/(1+\tau)\right)c\right) \Big/ \left(1 + \left[\left(\frac{v}{d_2} + w\right) \Big/ \left(\frac{v}{d_1} + w\right)\right]^2\right)}$.

$$X_2^* = \sqrt{\frac{\frac{\overline{B}}{1+\tau}}{c + c\left[\frac{\left(\frac{v}{d_1}+w\right)}{\left(\frac{v}{d_2}+w\right)}\right]^2}} \quad (16)$$

The allocation of land by F_2 decreases with the cost parameter, with the deadweight losses and with d_2. X_2^* increases with the budget and with d_1. Contrary to the full-centralization case, the level of provision of X_2^* depends on the preferences of the city inhabitants for local and global public goods. Indeed, the derivatives of $\left(X_2^*\right)^2$ relatively to w and v are:

$$\frac{\partial\left(X_2^*\right)^2}{\partial v} = \frac{\overbrace{\underbrace{\frac{2\overline{B}c}{1+\tau}\left(\frac{v}{d_1}+w\right)\left(\frac{v}{d_2}+w\right)}_{>0}\underbrace{\left(\frac{w}{d_2}-\frac{w}{d_1}\right)}_{<0}}^{<0}}{\underbrace{\left(c\left(\frac{v}{d_2}+w\right)^2 + c\left(\frac{v}{d_1}+w\right)^2\right)^2}_{>0}} < 0 \quad (17)$$

Thus, because the root square function is strictly increasing, we have $\frac{\partial X_2^*}{\partial v} < 0$. Similarly, we have:

$$\frac{\partial\left(X_2^*\right)^2}{\partial w} = \frac{\overbrace{\underbrace{\frac{2\overline{B}c}{1+\tau}\left(\frac{v}{d_1}+w\right)\left(\frac{v}{d_2}+w\right)}_{>0}\underbrace{\left(\frac{v}{d_1}-\frac{v}{d_2}\right)}_{>0}}^{>0}}{\underbrace{\left(c\left(\frac{v}{d_2}+w\right)^2 + c\left(\frac{v}{d_1}+w\right)^2\right)^2}_{>0}} > 0 \quad (18)$$

We thus have X_2^* that increase with w but that decrease with v. This means that, when the city faces a decrease of its preference for local public goods relatively to global ones, the provision of X_2 increases.

Similarly, we have X_1^* which is equal to :

$$X_1^* = \sqrt{\frac{\frac{\overline{B}}{1+\tau}}{c + c\left[\frac{\left(\frac{v}{d_2} + w\right)}{\left(\frac{v}{d_1} + w\right)}\right]^2}} \tag{19}$$

The allocation of land by F_1 decreases with the cost parameter, with the deadweight losses and with d_1. X_1^* increases with the budget and with d_2. Based on similar relations than (17) and (18), we find that X_1^* increases with v but decreases with w. This means that, when the city faces an increase of its preference for local public goods relatively to global ones, the provision of X_1 increases. Comparing (16) and (19) with (8), we find:

$$\frac{X_1^{*,decentralization}}{X_1^{*,centralization}} = \sqrt{\frac{2\left(\frac{1}{1+\tau}\right)\left(\frac{v}{d_1} + w\right)^2}{\left(\frac{v}{d_1} + w\right)^2 + \left(\frac{v}{d_2} + w\right)^2}} \tag{20}$$

$X_1^{*,decentralization}$ is thus higher than $X_1^{*,centralization}$ when τ is lower than $\bar{\tau}$, with $\bar{\tau}$ being equal to:

$$\bar{\tau} = \frac{\sqrt{2\left(\frac{v}{d_1} + w\right)^2}}{\sqrt{\left(\frac{v}{d_1} + w\right)^2 + \left(\frac{v}{d_2} + w\right)^2}} - 1 \tag{21}$$

Note that because the root square function is concave, we do have $\bar{\tau} \geq 0$. Thus, in the case where we assume $\tau = 0$, we have $X_1^{*,decentralization} > X_1^{*,centralization}$. In the opposite, we find that $X_2^{*,decentralization} < X_2^{*,centralization}$ when there is low deadweight losses (when $\tau < \bar{\tau}$).

Based on (16), (19), we can compute the utility of the city in the case of full-decentralization. The utility is:

$$U_{city} = \sqrt{\frac{\frac{\overline{B}}{1+\tau}\left[\left(\frac{v}{d_1} + w\right)^2 + \left(\frac{v}{d_2} + w\right)^2\right]}{c}} \tag{22}$$

Similarly, we can compute the welfare of the economy in the case of full decentralization, which is:

$$W^{decentralization}=\sqrt{\frac{\frac{\overline{B}}{1+\tau}\left[\left(\frac{v}{d_1}+w\right)^2+\left(\frac{v}{d_2}+w\right)^2\right]}{c}}\left[1+\frac{y}{\sqrt{\left(\frac{v}{d_1}+w\right)^2+\left(\frac{v}{d_2}+w\right)^2}}\right]+\frac{1}{2}\left(\frac{\overline{B}}{1+\tau}\right) \quad (23)$$

with the total profit of the farming sector being $\overline{B}/(2+2\tau)$ and the utility derived from the provision of public goods from the whole economy being $\sqrt{\frac{\overline{B}}{(1+\tau)c}\left[\left(\frac{v}{d_1}+w\right)^2+\left(\frac{v}{d_2}+w\right)^2\right]}\left[1+\frac{y}{\sqrt{\left(\frac{v}{d_1}+w\right)^2+\left(\frac{v}{d_2}+w\right)^2}}\right]$. Contrary to the full-centralization case, the profits of the two farmers are different[8], with $\Pi_1>\Pi_2$.

The difference between the welfare in the centralized and the decentralized cases depend on y and τ. Assuming $\tau=0$, the welfare is strictly higher in the centralization case, only if $\sqrt{\left(\frac{v}{d_1}+w\right)^2+\left(\frac{v}{d_2}+w\right)^2}-\sqrt{\left(\frac{v}{d_1}+\frac{v}{d_2}+2w\right)^2}<y$. Due to the properties of concave functions, we verify that $\sqrt{\left(\frac{v}{d_1}+w\right)^2+\left(\frac{v}{d_2}+w\right)^2}-\sqrt{\left(\frac{v}{d_1}+\frac{v}{d_2}+2w\right)^2}>0$. The welfare increases in the centralization case if the preferences for global public good is higher than the curvature of preference for local public good.

Mix centralization-decentralization case

This case should maximize the welfare of the economy if the preferences for local and global public goods are non-null. In case of mix centralization-decentralization, the city government knows the costs incurred by the farmers (i.e. relation (2)) and propose the level of subsidy to maximize:

[8] We have $\Pi_1=\left(\overline{B}/(1+\tau)\right)\Big/\left[1+\left[\frac{(v/d_2+w)}{(v/d_1+w)}\right]^2\right]$ and $\Pi_2=\left(\overline{B}/(1+\tau)\right)\Big/\left[1+\left[\frac{(v/d_1+w)}{(v/d_2+w)}\right]^2\right]$.

$$U_{economy} = U_{city} + U_{rest\_of\_the\_economy} = \frac{v}{d_1} X_1 + \frac{v}{d_2} X_2 + (w+y)(X_1 + X_2)$$
$$s.t.\ \overline{B} = \underbrace{(1+\tau)(p_1 X_1 + p_2 X_2)}_{B_{city}} + s(X_1 + X_2) \qquad (24)$$

For the SFER conference submission, we consider for the moment that $\tau = 0$***. The results are not yet stabilized when we introduce positive deadweight losses.***

In this case, the farmers will allocate lands to the production of public goods such that:

$$X_i^* = \frac{p_i + s}{c} \qquad (25)$$

Based on similar reasoning than (12), (13) and (14), we reach:

$$p_2 + s = \sqrt{\frac{\overline{B}c}{1 + \left[\frac{\left(\frac{v}{d_1} + w + y\right)}{\left(\frac{v}{d_2} + w + y\right)}\right]^2}} \qquad (26)$$

We can deduce X_2^* :

$$X_2^* = \sqrt{\frac{\overline{B}\left(\frac{v}{d_2} + w + y\right)^2}{c\left(\frac{v}{d_2} + w + y\right)^2 + c\left(\frac{v}{d_1} + w + y\right)^2}} \qquad (27)$$

And then X_1^* :

$$X_1^* = \sqrt{\frac{\overline{B}\left(\frac{v}{d_1} + w + y\right)^2}{c\left(\frac{v}{d_2} + w + y\right)^2 + c\left(\frac{v}{d_1} + w + y\right)^2}} \qquad (28)$$

Like the full-centralization and full-decentralization cases, we have X_1^* and X_2^* increasing with the budget and decreasing with c. Based on (17) and (18), we also have X_1^* that increases with v and d_2 and that decreases with y, w and d_1. Similarly, we have X_2^* that decreases with v

and d_2 and that increases with y, w and d_1. Using relations (17) and (18) and the property $y > 0$, we can also derived the following properties:

$$\begin{cases} X_1^{*\_centralization} < X_1^{*\_mix} < X_1^{*\_decentralization} \\ X_2^{*\_centralization} > X_2^{*\_mix} > X_2^{*\_decentralization} \end{cases}$$

The landscape structure (definied by X_1^* and X_2^*) is different between the three types of governance. The full-centralization governance leads to higher level of financing of X_2 than the optimal. The full-decentralization leads to greater levels of X_1 than the optimal.

In the case of null deadweight losses, we have:

$$W = \sqrt{\frac{\overline{B}}{c}\left[\left(\frac{v}{d_1} + w + y\right)^2 + \left(\frac{v}{d_2} + w + y\right)^2\right]} + \frac{1}{2}\overline{B} \qquad (29)$$

This relationship is the highest possible utility reached by the economy.

Our future works will integrate non-null deadweight losses to highlight the classical trade-off of the environmental federalism literature between accuracy (provision of local public goods) and the efficiency on managing budget spending (deadweight losses and transaction costs). We especially want to study the repartition of the budget between the city and the central government.

3. Empirical application: abandonment of wetlands in Brittany

This section presents the case study. We first present the Odet watershed, i.e. the territory that we use for modelling. We then present the selected public goods and discuss the influence of wetland abandonment for their provision. We then compute the welfare of the economy under *full-centralization* case, *full-decentralization* and *mix-centralization-decentralization* cases of governance.

a. The Odet watershed

We consider that the empirical counterpart of the considered theoretical region is the Odet watershed. The Odet watershed presents a density of 325 inhabitants/km², which is partly due to the presence Quimper, the second biggest city of Finistère (western French NUTS3 region). It is large of 329 km², representing 1.2% of the size of the Brittany region. Eight watercourses cross the watershed and they all group within the Odet coastal river. The Odet inhabitants present thus a high demand for local public goods, notably for water purification and flood regulation.

Agriculture still represents an important economic activity of the watershed. The Utilized Agricultural Area (UAA) represents for example about 75% of the total area. The 779 farmers of the watershed (reported in the Agricultural Census of 2010) are mainly orientated towards mixed farming. The density of cows is close to the departmental mean. Farms of the watershed present a lower pig density but a higher poultry density than the departmental means. However, the largest part of the organic nitrogen comes from cattle. Permanent grasslands constitute approximatively the half of the UAA. Among these areas, 3700 Ha are wet grasslands. Taking into account for other kinds of wetlands, there are about 7000 hectares of wetlands in the watershed, i.e. more than 20% of the watershed area. Agricultural wetlands represent 11% of the watershed area.

b. Abandonment of agricultural wetlands and loss of public good provision

The hydric soil characteristics of agricultural wetlands provide a distinct ecosystem from other land types. Wetlands support the provision of many ecosystem services, principally water purification, flood control and carbon sink. They constitute a part of our natural capital (Costanza et al., 1997). Despite the existence of various international agreements and national policies, wetlands have been lost or are under threat. These threats are notably linked to the lack of agricultural productivity on these areas. They require more labor and less capital than other lands. In a context where labor price increased relatively to capital price, wetland managers were incited to turn them into arable lands thanks to drainage works. In France, drainage of wetlands has been forbidden since 1992. Thus, despite the national subsidies, some farmers are incited to sell or abandon their wetlands. It concerns notably high intensive-capital farms. Low intensive-capital farms are more willing to manage wetlands because they value them for forage production.

In France, exhaustive information on wetland management are available in Finistère since 2014. At that time, stakeholders from Finistère have conducted a census of wetlands to provide detailed information on their evolution. A comparison of the registered agricultural wetlands from 2014 with farmers' CAP declarations of the same year highlight that 46% of the agricultural wetlands were not declared for CAP subsidies. Assuming no asymmetric information, we classify these undeclared areas as "abandoned". It represents approximatively

1800 Ha in the Odet watershed, i.e. about 5% of the watershed area. This high abandonment worries local authorities because it conducts to a loss of public good provision.

Indeed, expression of ecosystem services depends on the management of wetlands, notably by the agricultural management (Gerakis & Kalburtji, 1998). It appears that extensive agricultural management such as mowing and grazing provide the highest levels of ecosystem services. Based on benefit transfer functions and cost accounting and taking into account for water filtration, flood control, nursery function, carbon sink and biodiversity habitat, the PROVIDE[9] WP4 demand study conducted in Odet (Bareille et al., 2017) concludes to a minimal environmental services of 440€/Ha (and a maximal value of 1860€/Ha). Authors have computed the environmental service value as the difference of value between ecosystem services provided with and without agricultural management (Engel et al., 2008), considering that abandoned wetlands were similar to afforested wetlands in the long term (Bareille et al., 2017). In the long term, the degradation of abandoned wetland is likely to cause a loss of soil functionality and soil carbon stocks and thus to decrease public good provision.

Here, we consider three types of ecosystem services: water filtration (local public good), carbon sink (global public good) and biodiversity habitat (global public good).

i. Water filtration

Abandoned wetlands are less interesting for society because it decreases net primary production and thus nutrient filtration. Indeed, wet grasslands appear to be the best "natural" water filtration. Mowed and pastured wetlands respectively filter twice and fourth time as abandoned wetlands. Based on the cost of nitrate treatment and under certain assumptions, Bareille et al. (2017) have estimated that the environmental service provided by a farmer is at least of 300€/Ha for mowed wet grasslands and 900€/Ha for pastured wet grasslands. This is the main source of value of agricultural wetlands (Bareille et al., 2017; Jenkins et al., 2010). Because all hydrological flux in the same watershed conducted to Oder river, the value of the environmental service for water quality is only captured by the watershed inhabitants. The contribution of managed wetlands to water quality is thus a local public good without spillovers towards other regions.

[9] PROVIDE ("PROVIding smart DElivery of public goods by EU agriculture and forestry") is a H2020 project on the new governance mechanisms to meet supply and demand for public goods provided by agriculture. Information are available at http://www.provide-project.eu/.

In addition to Bareille et al. (2017), we consider that the closer are the wetlands from Quimper, the closer Quimper inhabitants value them. This result was notably found by Pate & Loomis (1997) on wetlands in California.

ii. Existence value of biodiversity

Contrary to water filtration public goods, existence value of biodiversity is a pure global public good (characterized by both non-rivalry and non-exclusion). Using French budget for biodiversity conservation and distribution of species among agricultural wetlands, abandoned wetlands and other areas (Pykälä, 2003), Bareille et al. (2017) have valued the environmental services to 30 €/Ha at minimum.

iii. Carbon sink

Wetlands participate to carbon sequestration. Scientists estimate that 30% carbon are sequestrated in wetlands worldwide even if they only weight 3 to 4 % of the area. Like the existence value of biodiversity, carbon sequestration provided by wetlands have pure global public good characteristics. Despite their role of carbon sink, wetlands can also be source of emissions of greenhouse gases, notably methane. The contribution of wetland to carbon sequestration depends mainly on its management. Using (Watson et al., 2000) and French carbon tutelary value of 2016, Bareille et al. (2017) have valued the environmental service to 12 €/Ha at minimum.

iv. To sum up

Wetland abandonment at the watershed scale is valued at 800,000 € minimum (and even 1,900,000 € minimum if abandoned wetlands were pastured). The main challenge of potential governance mechanisms is to offer solutions preventing the abandonment of agricultural management and agricultural areas. These mechanisms should incite maintenance of agricultural management to overcome the low agricultural profitability issue and by better valorizing the public goods provided. For the moment, there are only two AEMs for wetland maintenance. The first one offers a contract to pasture or mow wetlands once a year for 150 €/Ha. The second one requires more labor but offer a larger subsidy, about 300 €/Ha. The 150 €/Ha AEM is however the main subscribed contract. A small study conducted in 2015 on ten farmers who have abandoned their wetlands has however conclude that the willingness-to-accept (WTA) of farmers to mowed wetlands once a year was distributed between 100 €/Ha to

600 €/Ha (Bareille et al., 2017)[10]. The current AEM financing is thus not enough for a large part of farmers. In comparison, United States have offered higher incentives to private landowners thanks to the Wetlands Reserve Program.

c. Comparison of governance cases within the Odet watershed

We compare the welfares and the landscape structure in the *full-centralization*, *full-decentralization* and *mix-centralization-decentralization* cases. To compute these figures, we first have to calibrate the parameters of our case study.

i. Calibration of the parameters

We first begin with the budget allocated to environmental good provision within the watershed. A report from the regional public authority in charge of agriculture stresses that farmers of Brittany have received 13.5 millions € through AEM in 2012 (AGRESTE, 2014). Assuming a uniform repartition of AEM based on area, we have a budget constraint $\overline{B} = 162000$(measured in euros) in the Odet watershed. Bareille et al. (2017) have estimated at 400,000 € minimum the value of the actual abandoned wetlands (and even 950,000 € minimum if abandoned wetlands were pastured). We thus verify that $\overline{B}$ is binding. $\overline{B} = 162000$ is obviously the upper range of the real budget allocated to wetland management inside the watershed. The underlying assumption is that the single type of AEM inside the Odet watershed is for wetland management. Anyway, even with this upper range, $\overline{B}$ is binding.

The preferences parameters are easily obtained from Bareille et al. (2017). We have $(w+y) = 42$ (measured in euros per hectare). Assuming that the value is proportional to populations and that all the global public good value is captured inside the EU (this is a restrictive assumption), we have $w = 0.009$(0.02% of European Union citizens lives inside the watershed). We do have $w << y$. For the empirical estimation, we consider that $w = 0$ and $y = 42$[11]. For local public good

[10] Only a single farmer has answered that is WTA was lower than the AEM contract. Including the transaction costs, this may explain why he has abandoned her wetlands.

[11] We can also consider that, because only 7% of world inhabitants lives in European Union, $y = 3$ €/Ha. Assuming that European Union does not behave as a free rider for the financing of global public good (EU pays its share), we do have $y = 42$€/Ha.

preferences, we have to define two areas defined by two average distances d_1 and d_2. Assuming $d_1 = 2$ and $d_2 = 5$, we deduce that $v = 857$€/Ha[12].

These two areas are managed by two groups of identical farmers F_1 and F_2. We assume that these farmers have the same levels of abandoned wetlands in both areas in the actual financing rules (i.e. the decentralization case): i.e. 900 Ha of abandoned wetlands located at d_1 and 900 Ha of abandoned wetlands located at d_2. The two groups of farmers face the same profit function (relation (1)) with $c = 0.2778$. The marginal cost is thus defined in both areas by: $C_{m,i} = 0.2778 * X_i$.

ii. Comparative statistics

Based on this set of parameters, we can compute the landscape structure, the set of subsidies and the welfare on the three types of governance.

Full-centralization

In the case of full centralization (this is the actual case), we have thanks to relation (8):

$$X_1^{*\,full\_centralisation} = X_2^{*\,full\_centralisation} = 540\text{Ha}$$

Given that, in each area, 900 Ha of wetlands are currently abandoned and 540 Ha are managed, the two groups of farmers would have 1440 Ha of abandoned wetlands in case of null budget, i.e. $\overline{X}_1 = \overline{X}_2 = 1{,}440\text{Ha}$. In case of full-decentralization, 37.5% of the wetlands have been managed (37.5% in both areas). We also have that the actual level of AEM for wetland management is 150 €/Ha (we do find this value using $c = 0.2778$ and relation (7)), like what we observe in reality.

Based on this landscape, we can compute the welfare of the economy. We have:

$$W^{full\_centralization} 446{,}526€$$

The welfare of the economy can be decomposed in detail as:

$$\Pi_1^{*\,full\_centralization} = \Pi_2^{*\,full\_centralization} = 40{,}500€$$

[12] We do have $\frac{1}{2}\left(\frac{857}{d_1} + \frac{857}{d_2}\right) = 300$.

We have also:

$$U_{city}^{full\_centralization} = 320{,}166€$$

And :

$$U_{rest\_of\_the\_economy}^{full\_centralization} = 45{,}360€$$

Even if the policy is designed by the central government, the benefits of the policy are mainly captured by the city, followed by the farmers. These figures are the benchmark figures.

Full-decentralization

In the case of a full-decentralized government with no deadweight losses, we have:

$$X_1^{*\,full\_decentralization} = 709 \text{ Ha}$$

$$X_2^{*\,full\_decentralization} = 283.6 \text{ Ha}$$

In the case of full-decentralization, the city would increase the amount of funds dedicated to the closest abandoned wetlands. About 50% of the wetlands of the closest area would be managed (contrary to 37.5% in the previous case). On the opposite, only about 20% of the wetlands of the farthest area would be managed, 80% remaining abandoned. In total, the number of wetlands decreases by 8%. The amount of X_1^* increases compared to the full-decentralization until the deadweight loss rate is lower than $\bar{\tau}$ (cf. relation (21)), i.e. when τ is lower than:

$$\bar{\tau} = 0.31$$

Based on this theoretical landscape, we can compute the profits and welfare that would appear with the full-decentralization. We have:

$$W^{full\_decentralization} = 471{,}007€$$

The total welfare increases within full-centralization compared to full-decentralization.

With details, we have:

$$\Pi_1^{*\,full\_decentralization} = 69{,}828€$$

$$\Pi_2^{*\,full\_decentralization} = 11{,}172€$$

But also:

$$U_{city}^{full\_decentralization} = 348{,}316€$$

And :

$$U_{rest\_of\_the\_economy}^{full\_centralization} = 41{,}690€$$

Compared to the full-centralization case, we do have the utility of the city that increases (by 9%) and the utility of the rest of the economy that decreases (by 8%, like the total amount of financed wetlands). In total, the welfare of the whole economy increases by 5.5%. The differences are much more pronounced for the supply side: F_1 increase their profit by 72% whereas F_2 decrease their profit by 72%. In case of no deadweight losses, the full-decentralization case increases the total welfare of the economy.

Mix-decentralization-centralization

In the case of mix-decentralization-centralization (with null deadweight loss), we find:

$$X_1^{*mic\_centralization\_decentralization} = 695.3 \text{ Ha}$$

$$X_2^{*mix\_centralization\_decentralization} = 315.7 \text{ Ha}$$

In the case of *mix-centralization-decentralization*, we do find that:

$$\begin{cases} X_1^{*\_centralization} < X_1^{*\_mix} < X_1^{*\_decentralization} \\ X_2^{*\_centralization} > X_2^{*\_mix} > X_2^{*\_decentralization} \end{cases}$$

In total, the number of wetlands decreases by 6% in comparison with the actual case (decentralized one). Based on this theoretical landscape, we can compute the profits and welfare that would appear with the *mix-centralization-decentralization*. We have:

$$W^{mix\_centralization\_decentralization} = 471{,}416€$$

The total welfare increases by 0.1% in the *mix-centralization-decentralization* compared to the full-decentralization case. However, it increases by 5.6% compared to the full-centralized case. In the case where we do not have any deadweight loss, the centralized government has no real incentives to keep a share of the budget dedicated to environmental good provision.

With details, we have:

$$\Pi_1^{*mix\_centralization\_decentralization} = 67{,}151€$$

$$\Pi_2^{*mix\_centralization\_decentralization} = 13{,}849€$$

But also:

$$U_{city}^{mix\_centralization\_decentralization} = 347{,}951€$$

And :

$$U_{rest\_of\_the\_economy}^{mix\_centralization\_decentralization} = 47{,}416€$$

The utility of the city decreases by 0.1% compared to the full-decentralization case. In contrast, the utility of the rest of the economy increases by 2%. The profits of the farmers are closer from each other in the mix-centralization-decentralization compared to the full-centralization even if F_1 has still a much larger profit than F_2.

4. Discussion

Our analysis provides some theoretical background for a potential -and partial- decentralization of the design of agricultural policies aimed at public good provision. The provision of public goods from agriculture is a complex process that entails the joint production of local and global public goods, whose valuation is further complicated by spatial issues and conflicting preferences. The result of our model, albeit relatively simple, seems to show that indeed a partial delegation of decisions to local regional government could improve the total welfare. However, the inclusion of deadweight losses due to transaction costs related the transfers from the central to the local government would increase the ambiguity of the results. Consider also that the results depend on the relative valuation of the global and local public goods, and that the central government provides a higher absolute extent of land allocated to public good provision. This result is in line with Tiebout & Houston (1962), who suggested to proceed to the integration of jurisdictions in order to create a multi-level government where provision of some public goods would be in charge to the national scale, other ones to federal scales and others to lower levels of government.

Some limitations of the model point out at the potential extensions.

First, we assume that the budget in exogenously determined. While this is a reasonable and functional assumption for the current analysis, the budget and its distribution across EU regions is endogenously chosen. The endogenization of the budget (and the related tax rate) in the different cases would certainly increase the comprehensiveness of the model results. We have computed the resulting landscape, welfare and subsidies in the case of an endogenous budget. The conclusions of our work remain, but the amount of total wetland is much higher in this case (the subsidy is equal to the (eventually expected) marginal utility derived from global and local public goods)[13]. Anyway, it is unlikely that the budget for environmental good provision will be endogenized. As stressed by the intention letter[14] of the European Commission on the public consultation about the future CAP reform: “The EU is committed to respecting its WTO obligations, whatever form the new CAP might take.”

Second, we have assumed the homogeneity of the EU regions. Obviously, the inclusion of the heterogeneity that entail the potential complementarity and substitutability across EU in the provision of local and global public good that would enrich the analysis. Heterogeneous regions are also interesting for the introduction of strategic behavior between regions, in agreement with the literature on fiscal federalism. Mobility of inhabitants (or public good providers) between regions are however required to explore these interactions (Bougherara & Gaigné, 2008).

Third, in relation with the second point, we have assumed that the benefits of local public goods were all captured within the jurisdiction (i.e. inside the watershed in our empirical example). Although the benefits of water quality (or the benefits of flood control) are captured inside the watershed, there are other local public goods whom benefits overlap to other jurisdictions (i.e. watersheds). In particular, agricultural wetlands do support local public good provision with spillover characteristics. This is notably the case of recreational activities. Indeed, wetlands are crucial for salmon and trout reproduction because they act like nursery for juvenile fishes. The Odet watershed is a third biggest watershed for salmon fishing in France. In 2016, fishermen were authorized to fish 61 salmons and 553 juvenile salmons. Several anglers come from outside the watershed (even from abroad) to benefits from these fishing conditions (Salanié, 2006). We can thus consider that the angler association can pay farmers to manage some wetlands. Local angler associations and French authorities manage the access to the rivers jointly. They notably provide national or departmental fishing cards and the employment of fishing guards. The fishing rights are thus managed as a club good. The introduction of an

[13] Our conclusions remain also the same with a marginally decreasing utility function.

[14] https://ec.europa.eu/agriculture/sites/agriculture/files/consultations/qa-cap-modernising.pdf [consulted the 09/12/2017]

intermediate scale of government can change our results because it introduces competition to finance wetland conservation. Here, we have not considered these local public goods with spillover characteristics.

Fourth, related to the first point, the environmental economics literature has often advocated the use of Payment for Environmental Service (PES) type of mechanisms to increase effectiveness of Agri-Environmental Payments. PES, in most of the definitions, entail the direct formulation of contracts between users and providers of environmental services (Engel et al., 2008; Wunder, 2005, 2015). An interesting extension could be the assessment of the effect of CAP (given an endogenous budget) on the extent of the emergence of PES mechanisms. It is thus important to integrate totally the effect of deadweight losses. According to Ferraro and Simpson (2002), transaction costs of PES represent from 5% to 25% of the overall budget[15]. They are higher than AEM, notably because of the heterogeneity of consumers (Peterson et al., 2015). In our opinion, an interest of our framework is to model specifically the difference between AEM (payment based on average opportunity costs inside the region) and PES (payment based on supply and demand sides). Even if there is a growing literature on PES[16], there has been no many attempts to model this governance mechanism. We believe that one interest of the distance-decay literature is to provide a theoretical justification to model PES as a real alternative to AEM.

5. Conclusion and future researches

Based on a simple model with explicit representation of preferences for local public good (depending on distance between provision and "consumption" according to the "distance-decay" literature) and the definition of two public good provision areas, we have stressed that the decentralization of agri-environmental design would result in a drastically change of landscape structure. Whereas current environmental subsidies focus on opportunity costs (i.e. on the supply side), the decentralization would allow a better target of environmental subsidies around the main cities of the EU regions. This would lead to a better match between supply and demand for local public goods provided by agriculture, even with an exogenous budget. This

[15] With this reference for τ, we still have that $X_1^{*-centralization} < X_1^{*-decentralization}$

[16] Either to examine their effectiveness (Ferraro & Simpson, 2002; Muradian, Corbera, Pascual, Kosoy, & May, 2010; Pascual, Muradian, Rodríguez, & Duraiappah, 2010; Pattanayak, Wunder, & Ferraro, 2010), their equity (Pascual et al., 2010), the institutional context of their application (Hausknost, Grima, & Singh, 2017; Vatn, 2010), information theory issues (Engel, Pagiola, & Wunder, 2008; Ferraro, 2008) or the social norm issues (Gong, Bull, & Baylis, 2010).

result could contribute to the reflections around the future CAP reform. This intermediate work still needs some improvements.

Indeed, our initial question is to find the optimal allocation of the actual budget dedicated to environmental PG provision between the EU and the decentralized authorities. Here, because we have not considered yet strategic interactions between central and local governments, we are only able to determine the optimal landscape structure, but not to determine which government should pay for what. The strategic interaction should play a deep role on the allocation of the budget, notably in the presence of risk aversion and/or incertitude. We will also pay a deeper attention to the role of transaction costs (influencing total deadweight losses), notably due to their importance inside PES mechanisms. Finally, we have been only able to present the trade-offs analytically within a landscape composed of two provision areas (located at d_1 and d_2). Our aim is to develop a spatially explicit Agent Based Model (ABM) on the real landscape of the Odet watershed. We will notably integrate the relationship found by Pate and Loomis (1997) between the WTP and the distance between the wetland and the public good "consumer" to integrate the preferences for local public goods. The results of the ABM should underline the trade-offs of financed wetland inside a continuous landscape, and not only inside a two-area landscape.

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