Evaluating the potential contribution of spatially differentiated payments to the efficiency of Agri-Environmental Measures: A resource allocation model for Emilia Romagna (Italy)

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Summary

The European Agri-Environmental Measures (AEMs) have a relevant role in encouraging a sustainable resources use and developing environmentally-friendly farming practices. AEMs account for more than half of the rural development budget of the Common Agriculture Policy. However, despite their importance, several factors influence the effectiveness of the measures, within which the poor spatial target is still a major cause of low effectiveness. Therefore, improving the spatial targeting of these policy tools could improve their cost-effectiveness, increasing the efficiency of Agri-Environmental Schemes (AES) and support better policy design solutions. The objective of this paper is to develop an optimization model for the AEMs jointly aiming at optimal targeting and payment setting with a focus on resource and incentive compatibility differentiated by zone. Moreover the model investigates the integration of information coming from spatial analysis of participation to AEMs with mathematical programming at regional level. This is a rather new methodology which could be uses to model farmers' characteristics and compliance cost in their spatial dimension. Given that both the costs and the compensation payments are subject to spatial variation, this study simulates also the potential contribution of spatially differentiated compensation payments to efficient targeting of measure 214.1 in Emilia Romagna (Italy). Results highlight that the differentiate payment scheme gives a significant cost saving over flat rate mechanism by reducing farmers' rents and consequently the deadweight loss for cost effectiveness of the measures. The method used, which improves the acknowledgement of the spatial information, may have a potential for the design process of Agri-Environmental Schemes (AES) and support better policy design solution.

Keywords: agri-environmental policy, compensation payments, economic efficiency, spatial econometric, mathematical programming.

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1. INTRODUCTION

The EU Agri-environmental measures (AEMs) may be seen as an example of payments for environmental services (PES) in which the public administration supports farmers to provide environmental goods and eco-system services across the European Union (EU). From this perspective, this policy tool could be a mechanism to translate external non-market values of environmental services, into financial incentives for local actors to provide such services (Engel et al., 2008). Since the Common Agricultural Policy (CAP) reform in 1992, the EU has increased its support[1] to encourage sustainable resource use and to develop environmentally-friendly farming practice which resulted in the so-called "greening" of the CAP. Moreover, this major shift in EU policy has emphasized the importance of sustainable and integrated rural development which is largely based on AEMs to determine the provision of environmental goods and landscape services across the EU. These measures, based on a subsidiarity principle under Council Regulation (EC) 1698/2005, are part of voluntary schemes designed by the local administration to address specific agricultural, natural and cultural issues. Voluntarily, the farmers commit themselves for a five year period to adopt agricultural management practices that reduce environmental risk or preserve the cultivate landscape (Uthes et al., 2010). In such mechanism the payments are an incentive to participate, which is given by the administration and is established in such as way as to compensate farmers for the additional costs or loss of income. However, despite their importance, various types of inefficiency could affect these measures. Following Engel et al. (2008) it is recognized the failure to adopt practices whose benefit are smaller than their costs. In this case the payment offered could be insufficient to induce the adoption of environmentally-friendly farming practices. Engel et al. (2008) also distinguish the case of payments directed to practices that would have been adopted anyway, who generate the wasteful use of public resources. According to economic theory and observed practice, to incentive the farmer participation to these measures the payments must be set high enough to cover compliance cost but also should prevent as much as possible unneeded farmers' rents. Indeed, while the payments are usually designed as uniform between different areas and targets, the compliance costs are not uniform. Moreover, the presence of asymmetric information conditions, such as the farmer having information about compliance costs that are not disclosed to the regulator, causes a higher

[1] AEMs account for more than half of the rural development budget of the Common Agriculture Policy and are the most important examples of payments for environmental services (Uthes et al., 2010). Moreover average data published by the EU for the period 2000-2003 show that in Italy the national agri-environment spending for 2000-2003 is more than 60% of the Rural development budget.

profitability to participate for those farmers who have to cover lower compliance cost. In economic terms the difference between payments and compliance cost generate an economic surplus for those farmers and consequently a deadweight loss from the perspective of cost effectiveness of the measures. The economic literature on AES has analyzed the efficiency of flat rate compensation schemes compared with the possibility of introducing auction mechanism, to reveal farmers' compliance costs, in order to reduce information rents and increase policy cost-effectiveness. The analysis of the extent of efficiency losses with spatially uniform compensation payments emphasizes that both the cost and the benefits of measure are subject to spatial variation as differences in soil quality, opportunity cost for labour, opportunity cost for land and so different level of benefit may be due to different habitat quality (Wätzold and Drechsler, 2005). Moreover, Uthes et al. (2010) identify the poor spatial target as a major cause of low effectiveness of AEMs. The principal idea of spatial targeting is that by applying conservation measures on the most vulnerable or suitable land parcels, environmental effects are provided at lower costs than if conducted elsewhere. But several factors influence the effectiveness of the measures, such as the presence of information asymmetries between farmers and the public administration, the farm's structure and characteristics (e.g. area, age, education), private and public transaction costs, regional specificities as special habitats or vulnerable areas. Improving the spatial targeting of these measures could improve their cost-effectiveness, increasing the efficiency of Agri-Environmental Schemes (AES) and support better policy design solution.

Therefore in this paper is developed an optimization model jointly aiming at optimal targeting and payment setting with a focus on resource and incentive compatibility differentiated by zone, building on participation functions generated from a previous spatial econometric analysis. Moreover the objective is to provide a methodology that allows the integration of the information coming from spatial analysis of participation to AMEs into a mathematical programming model at regional level. This is a rather new methodology from the literature on optimization of RDP measure which could be used to model farmers' characteristics and compliance costs in their spatial dimension. Given that both the costs and the compensation payments are subject to spatial variation, this study develops a resource allocation model and simulates the potential contribution of spatially differentiated compensation payments to efficient targeting of measure 214.1 in Emilia Romagna (Italy). On one hand, this approach requires the determination of the total compliance cost of AEMs, which is known to be rather difficult to obtain. In order to avoid this problem, a function of marginal compliance cost of participation to RDP measure 214.1 is taken from a previous study, which allows us to model farmers' economic behaviour in participating to scheme 214.1. On the other hand, through this analysis it is possible to highlight the territorial consequences of differentiated payments through zoning on farmers' participation to the programme.

A cost-effective implementation of AEMs, which is relevant for the allocation of funds for rural areas, needs different ways of setting the compensation payments. Instead of a per hectare uniform flat rate payment the model establishes a spatially differentiated payment mechanism in order to better cover the local compliance and transaction cost. This also partly reflects the Emilia Romagna design process of AEMs, where each Province establishes an additional level of priorities in the selection process of applicants based on the locations, typologies of intervention, farmers' characteristics and specialisation. The model, which combines information about farmers' behaviour and participation with compliance cost taken from a previous study, also provides information about the influence of different environmental objectives, as target options, across their geographic range (E.R. Region) on the budgetary allocation and on the effectiveness of the measure 214.

The paper outline is the following: section 2 describes the background literature about targeting, payments setting and spatial issues of participation on AEMs. Section 3 describe the methodology adopted, followed in section 4 by the results of a case study and in section 5 with a discussion. The paper ends in section 6 with some concluding remarks.

2. TARGETING, PAYMENT SETTING AND PARTICIPATION ISSUE OF AEMS

The decentralized design of RDP implies that each local administration is in charge of setting and identifying target and zoning policies, in order to better design the measures with focus on the main local concerns. Often this process entails higher public transaction costs and lead to greater administration efforts. A reasonable improvement has to be evaluated comparing the transaction costs associated with factors such as additional data needs and changes in administrative procedures (Wünsher et al., 2006). The RD literature of targeting issues concerns a set of different priority or eligibility criteria applying to the measures mainly based on population density or the amount of inhabitants of the municipalities. Uthes et al. (2012) distinguish different approaches to targeting mechanism, which range from relatively simple approaches based on benefit, cost targeting, eligibility criteria only, to more complex and selective targeting mechanism based on zoning policies, or scoring systems. For instance the local administration of Emilia Romagna (ER) has set a mechanism of priority to incentive the participation to the measure 121 based on locations (e.g. LFA zone, plain, hill and mountain zone), the farm specialization and the farmers' age. The expected effect of this zoning is to prioritize the access to measure 121 to some farm sectors which are considered relevant for the area. Moreover, across the entire RDP of ER an identification of less favourable areas (LFA) is realized. This is a kind of zoning that follows the application of EU directives (NATURA 2000, WFD, NITRATE DIRECTIVE; etc.). Additional identification of the LFA are realized including to the above other areas with specific handicap, for example mountain areas in ER.

Many factors could influence the choice for a particular targeting approach, such as administration costs, budget availability, spatial variability in terms of benefits and costs, but once identified the target areas, the regulation must be accompanied with the provision of an adequate system of incentives since the purpose is to encourage farmers' participation to the RDP. For example, measure 214 of RDP Emilia Romagna, introduces compensatory payments targeting to farms in areas affected to nitrogen pollution to achieve the environmental objective of encouraging organic production and reduce nitrogen pollution. By this way farmers commit themselves to adopting organic farming or less resource-intensive farming practices. In return, they receive payments that compensate them for additional costs and loss of income (DG Agriculture and rural development, 2005). However it is also possible that the regulator uses the targeting mechanism to exclude some participant to the application. This case happens when the number of applications to participate exceeds the available budget, so the regulator uses the targeting to select among applicant sites to maximize the program's financial efficiency (Engel et al., 2008).

As it is mentioned in the introduction of this work, to incentive the farmer to adopt agri-environmental measures, the payments must be high enough to cover compliance cost but also should prevent farmers' rents and consequently the deadweight loss of effectiveness for the measures. The literature from AE payments recognizes the possibility to introduce a differentiated payment policy in order to reduce the farmer's surplus. Wätzold and Drechsler (2005) discuss the possibility of spatially heterogeneous compensation payments for biodiversity-enhancing land-use measures. Their results show that the cost-effectiveness of uniform payments may be low and depending on the assumption on the variability of cost and benefit function and on the correlation between them. The costs of agri-environmental measures such as biodiversity-enhancing land-use measures clearly differ because of the variations in soil quality, the opportunity cost for land, and the availability of equipment to carry out such measures, while different levels of benefit may due to different habitat quality (Wätzold and Drechsler, 2005). Other works have studied the issue of spatial differentiation of environmental policy instruments by analyzing the efficiency losses with spatial uniform regulation (see e.g. Kolstad, 1987; Babcock et al., 1997; Ferraro, 2003; Johst et al., 2002). These studies that focus on biodiversity conservation, try to incorporate the ecological and economic knowledge into the evaluation of conservation instruments. Overall, the literature seems to converge on the opinion that efficiency losses depending on spatial uniform payments are determined by the level of information that is available to the regulator about costs and benefits of the measures. Assuming an heterogeneous (varying in the spatial dimension) farmers' cost function, from a theoretical point of view, in order to reduce the farmers' surplus and deadweight loss of efficiency for the measure, the regulator must set up a differentiate payment policy instead of a flat rate payment mechanism. In this case, the payment must be equal to each marginal farmer's compliance costs functions to reduce individual rents. As consequence, the payment gives both the incentive to participate (the payment covers the cost to participate) and the optimal and desired quantity of agri-environmental goods. In the other case (flat rate payments option) the uniform payment does not coincide necessarily with each marginal cost function and as a result, where there is a cost lower than the given payment, there is a surplus for the farmers. The sum of each individual surplus gives the deadweight loss and hence affects for the cost-effectiveness of the measure. Normally it is very difficult for the administration to know the different compliance costs, but various alternative payment mechanisms can be applied with the aim of reducing information asymmetries leading to overcompensation and increasing the efficiency of the measures in terms of participation/expenditure ratios (Viaggi et al., 2008).

A more cost-effective policy design requires a consistent combination of policy instruments, connected payments levels and differentiation, as well as monitoring (Bazzani and Viaggi, 2004). Indeed alternative ways of setting the payments could be closer to the actual compliance costs of heterogeneous farmers differentiated by zone thus the payments should be able to provide incentives to participate, while reducing as much as possible farmers' rents. With the objective of maximize participation in these specific zones, measured by the degree of uptake, the whole effect of this kind of policy instrument would be a screening, restricting participants to only those having cost below the resulting payment. More precise instruments imply a greater degree of information about compliance costs on the part of public decision maker. This is not completely unrealistic if measures are targeted to some specific area (e.g. ER LFA areas, mountain, hill, plain) that is also characterised by compliance costs different from the average (Viaggi et al., 2008). Alternatively mechanism allowing the self revelation of farmers' compliance costs could be adopted, such as auctions, as already mentioned.

An improvement of the knowledge about spatial issues of local RDP could help the regulator to increase the AEMs efficiency. For example, the spatial analysis could help the RDP design process to provide information on the context variable with higher effect on the spatial participation and on the uptake. Results from a previous econometric analysis[2] of participation on AEMs (measures 121 farm modernization, 311 farm diversification, 214 agri-environment) of the Rural Development Program (RDP) of Emilia Romagna for the programming period 2007-2013 show a relevant ability of the model to explain participation; within these models the spatial component was highly significant and important. The

[2] The reference study is the deliverable 5.2 of the SPARD EU FP7 (SPARD: Spatial Analysis of Rural Development Measures - Providing a tool for better policy targeting).

explanatory variables[3] are sharply differentiated by sub-measures. This study highlights that the regional priorities affect the results probably as a mixed effect of environmental characterization and of priority in awarding of the funding, hence revealing an explicit role of policy target though priority scoring. Moreover, the socio-economic indicators appear as less often significant and less stable across models. The information about participation to RDP and for land based measure (e.g. 214) about payments was delivered by the Regional administration (Agricultural directorate). Data concerning participation are then aggregated at municipality level in order to match with information related to the dependent variables. Such level allows having enough information to conduct the spatial analysis on the regional scale. In the case of Emilia Romagna the measure 214 covers a substantial part of the RDP budget and it is organized in several sub-measures which target different environmental objectives and areas. The distribution of the participation (percent of participating farms per municipality) is mainly differentiated in the plain area and in the hill-mountain area and it is different between the aggregate, the specific sub-measures and across municipalities. The distribution of participation of the whole measure 214 also differs across municipalities with some spatial agglomeration in areas where a zoning system is applied. For example, the sub-measure 1 (integrated production) is mainly located in the plain areas of Emilia Romagna, characterised by large share of fruit production (eastern part of the region). This is largely connected to a deliberate strategy of valorisation and targeting to the sector.

3. METHODOLOGY

This paper provides a methodology that allows the integration of the information coming from spatial analysis of participation to AEMs into a mathematical programming model focused on incentive compatibility at regional level. The methodology is based on mathematical programming through the maximisation of participation rate on AEMs (focusing on area-related measures, such as measure 214.1 "Integrated Production") under resource and participation constraints. Also the output of the model can be, at last, aggregated by the target zone of Plain, Hill and Mountain to reflect the spatial approach on targeting of the PSR Emilia Romagna on which is based the case study described in the next section.

Participation rate is measured by the degree of uptake (DU) in UAA. The model also combines information about farmers' behaviour and participation with compliance cost taken from a previous study. The type of instrument considered is spatial econometric analysis (following LeSage and Pace 2009), that could be seen as a spatial extension of the standard linear regression model (see e.g. Breustedt and Habermann, 2011) and Spatial lag model.

Moreover, it is assumed that the area targeted by the measures has different characteristics in term of farmers' compliance costs. As a consequence, we suppose the need for different payments levels differentiated by zoning. We define three hypothetical areas (mountain, hill, plain), where payments change taking into consideration the different compliance costs. It is also assumed that the regulator knows of the existence and the characteristics of the different types of farmers, as compliance costs of each type, and the

[3] According to literature (LeSage and Pace, 2009) on spatial analysis, the explanatory variables for participation are: a territorial proxy for plain, hill and mountain, the density of inhabitants, the percentage of farms that are conducted directly by the farmer, the percentage of farms which use only household labor, the percentage of farms with arable crops, with fruit crops, with forest, with pigs and with livestock, the percentage of farmers with age less than forty and more than sixty-five, the percentage of part-time farmers and five variables related to different preferential areas.

proportion of each type in the population, but cannot identify individual compliance costs (Bartolini et al., 2007).

As a reference, however, we also consider the possibility that the regulator is informed about which type each individual famer belongs to. By this way we build the theoretical reference point of first best solution. Moreover it is assumed that the Public Administration objective is to maximize participation, measured by the degree of uptake (DU), without consideration, for example, to the value of different environmental services produced by different farmers. The type of instrument considered is the classical rationality incentive constraint given by the comparison between the payments level offered to farmers for participating to the RDP programme and the compliance costs.

With these hypotheses we set up a nonlinear programming model that allows an optimal allocation of the participation on measure 214, focusing into the scheme 1 “Integrated production”.

Let $i = 1, 2, \dots, I$ denote an index for various area type ($i = 1$ Mountain, $i = 2$ Hil, $i = 3$ Plain) and let $j = 1, 2, \dots, J$ denote an index for various agri-environmental measure (j=1 measure 214.1, j=2 measure 214.2 etc.), while it is also assumed that farmers participating just to one agri-environmental measure (214.1 “integrated production” on RDP E.R.) in various municipality of Emilia Romagna, so j=1.

Let $k = 1, 2, \dots, K$ denote an index for various variables representing farm characteristics and features included in the regression model (model 1 and 2) $r_{k,i}$ discussed in the previous section. Since measure 214.1 provides to farms an annual premium per hectare of cultivated area, it is indicated in the model as “ρ_i” the marginal payments per hectare in each area type. Given a fixed value of the available budget (B), the public administration will maximize the area under contrac tx_i.

Max

$$DU = \sum_{i=1}^{I} x_i$$

Subject to:

$$\sum_{i=1}^{I} \rho_i x_i \leq B \qquad \text{Budget constraints}$$

$$\rho_i - \theta_i \geq 0 \qquad \text{Rationality Constraints}$$

$$\theta_i = C(x_i)(1 - \sum_{k=1}^{K} r_{k,i}) \qquad Marginal\ Cost\ function\ \theta(i)$$

$$x_i \leq S_i \qquad \text{Area constraints}$$

$x_i \geq 0$, $\rho_i \geq 0$, $\theta_i \geq 0$

Where S_i is the total surface per area zone i (ha), ρ_i the marginal payments for measure on area i (euro/ha) and B the total amount of Public funds available as budget for measure 214.1 (euro).

θ_i is the marginal cost function (euro/ha) which is composed by a component of marginal cost $C(x_i)$ calculated in a previous study (see Viaggi et al., 2008) and a parameter calculated based on the coefficients of the regression model $r_{k,i}$ derived from Viaggi et al. (2012).

The variable $r_{k,i}$ introduces the spatial regression model $r_{k,i} = \rho W_1 r + X_{k,i}\beta_k + \varepsilon$ with $\varepsilon = \lambda W_2 \varepsilon + \mu$ (k = 1, 2 , ..., K) under several assumptions about of the ρ and λ the equation 1 could yield:with $\rho = 0 ; \lambda = 0$ the equations return a standard linear regression model (model 1);

with $\lambda = 0$; the equations return a spatial lag model (model 2);

The $X_{k,i}$ denote a vector of variables representing farm characteristics and features related to farm location (i) such as geographical, socio-economic (age, UAA, level of instructions) and institutional factors. In θ_i $\beta_1, \beta_2, \ldots, \beta_k$ are the estimated coefficients of the regression model come from Viaggi et al. (2012).

Using this approach the marginal cost function constrains the model to maximize the uptake in those areas where there are factors that influences the participation and where the corresponding payments cover such costs. This is the equality between the payments and the marginal compliance cost function, that minimizing the farmers' rents and allows the model to select the surface of measure under area j where the compliance cost function achieves the maximum. By this way the model selects only those areas where farmers' surpluses (the deadweight loss as previously explained) is minimized.

4. CASE STUDY AND RESULTS

The methodology described in the previous section has been implemented through a simulation exercise of the participation to AEMs. The model is built in GAMS.

This exercise is carried out for measure 214.1 (Integrated Production) in Emilia Romagna. The data for this problem are taken from Viaggi et al. (2012).

The marginal cost function $C(x_i)$ (euro/ha) used is:

$$C(x_i) = 1415.2x_i^3 - 1670x_i^2 + 701.9x_i \qquad \textit{Marginal Cost function } C(i)$$

Moreover, the analysis was conducted at municipality level (i.e. considering the 341 municipality of E.R. as the units) and then the results were aggregate considering the target zoning of plain, hill and mountain.

The total UAA considered in the analysis is 1,111,997.52 (ha) which can be divided into 649,047.53 (ha) for plain, 218,617.47 (ha) for hill and 244,332.52 (ha) for mountain. It is also supposed that the amount of Public funds to invest in measure 214.1 varies in the range from 0 to27,500,000.00 (euro), which is in the order of magnitude of the regional annual commitments for this measure.

The results are summarized in the four tables below considering the two hypothesis about the regression model (model 1, the linear regression and model 2, the spatial lag model). Table 1 shows the results considering model 1 (linear regression model) as the econometrically-derived component of the cost function. As expected, an increase in the available budget reflects a growth in the degree of uptake. Also the share of UAA on the different zones is growing, but at different ratios depending on marginal costs and payment in combination with the variables which influence more the participation from the regression model. In other words, the different degree of participation in the measure for the target areas indicate a different profitability/attitude of farmer to participate beyond a certain level of budget depending on the different compliance cost and characteristic of farms of each zone.

Table 1. Results of Participation Model 1

Budget (euro)	Marginal cost (euro/ha)			Average Marginal payment (euro/ha)	Plain (ha)	Hill (ha)	Mountain (ha)	DU total (ha)	DU/UAA (%)
	Plain	Hill	Mountain						
0	0	0	0	0	0	0	0	0	0
1,000,000.00	38.82	38.00	37.99	38.60	24803.13	178.34	144.71	25126.2	2.2
5,000,000.00	83.18	74.03	73.99	77.17	59329.38	348.07	282.22	59959.68	5.3
10,000,000.00	111.51	92.10	92.05	98.55	89022.56	433.47	351.33	89807.38	8.0
15,000,000.00	129.83	100.29	100.22	110.11	114868.55	472.17	382.63	115723.37	10.3
27,500,000.00	155.84	102.13	102.06	120.01	175890.07	480.90	389.69	176760.67	15.8

Source: own elaboration

The results of Table 1 also allow carrying out a careful comparison with the prediction of Ex-Ante evaluation report of RDP Emilia Romagna on the allocation of financial resources for measure 214.1 and the related area involved (see Regione Emilia-Romagna, 2007). The Ex-Ante evaluation report shows with a budget level of 8,000,000 (euro) an average flat rate payments for measure 214.1 of 164 (euro/ha) and an expected commitment area of 49,246 (ha) while, with regard to the model 1, the average payment for the reference level of budget of 8,000,000 (euro) is 90 (euro) and the involve area is 78,600 (ha). Therefore the comparison may indicate the potential financial saving which the differentiated payment system offers.

Table 2 shows the results using model 2 (spatial lag model) as the econometrically-derived component of the cost function. Also in this case is highlighted the concentration of participation to the plain area which has the main share on the total of DU (ha) for each budget level. Moreover the marginal costs (and consequently the payments) are higher than the value of marginal costs obtained from the previous model and therefore the share of uptake is lower.

Table 2. Results of Participation Model 2

Budget (euro)

	Marginal cost (euro/ha)			Average Marginal payment (euro/ha)	Plain (ha)	Hill (ha)	Mountain (ha)	DU total (ha)	DU/UAA (%)
	Plain	Hill	Mountain						
0	0	0	0	0	0	0	0	0	0
1,000,000.00	174.08	173.34	173.32	173.58	4327.93	681.38	741.09	5750.43	0.5
5,000,000.00	386.42	382.58	382.49	383.83	9803.13	1517.7	1650.06	12970.91	1.1
10,000,000.00	543.43	535.56	535.38	538.12	14002.85	2139.04	2324.92	18466.81	1.6
15,000,000.00	662.67	650.62	650.36	654.55	17295.27	2612.11	2838.45	22735.84	2.0
27,500,000.00	889.57	866.61	866.12	874.10	23774.36	3513.90	3816.67	31104.95	2.7

Source: own elaboration

In table 3 and 4 below, the differences (surplus) between the total cost function and the total payment for the two models for the three areas (plain, hill, mountain) are reported. The estimation of the total cost function for measure 214.1 is achieved by calculating the integral of the marginal cost function, which is a 3rd degree cost function derived from a previous study, combined with the regression model.

Table 3. Deadweight loss (surplus) in Model 1

Budget (euro)	Plain			Hill			Mountain		
	Total Payment	Total Cost	Surplus	Total Payment	Total Cost	Surplus	Total Payment	Total Cost	Surplus
0	0	0	0	0	0	0	0	0	0
1,000,000.00	987,723	509,476	478,247	6,777	3,391	3,386	5,498	2,750	2,748
5,000,000.00	4,953,349	2,675,191	2,278,158	25,768	12,900	12,868	20,882	10,450	10,432
10,000,000.00	9,927,732	5,590,376	4,337,356	39,927	19,995	19,932	32,340	16,188	16,152
15,000,000.00	14,914,296	8,720,588	6,193,708	47,355	23,718	23,637	38,348	19,197	19,151
27,500,000.00	27,411,110	17,542,132	9,868,978	49,116	24,601	24,515	39,772	19,911	19,861

Source: own elaboration

The differences in the costs level between the three areas are reflected in a different weight of the surplus. In both Hill and Mountain areas the ratio between the surplus and the payment is about the 50% while in the plain area is slightly lower, it is about the third part (33%) of the surplus. Table 4 below show the same results for model 2 with a surplus which is approximately equal to the costs.

Table 4. Deadweight loss (surplus) in Model 2.

Budget (euro)	Plain			Hill			Mountain		
	Total Payment	Total Cost	Surplus	Total Payment	Total Cost	Surplus	Total Payment	Total Cost	Surplus
0	0	0	0	0	0	0	0	0	0
1,000,000.00	753,434	378,724	374,710	118,114	59,203	58,911	128,451	64,380	64,071
5,000,000.00	3,788,197	1,917,170	1,871,027	580,652	291,937	288,715	631,150	317,280	313,870
10,000,000.00	7,609,679	3,871,516	3,738,163	1,145,589	577,287	568,302	1,244,731	627,112	617,619
15,000,000.00	11,454,472	5,851,823	5,602,649	1,699,506	857,912	841,594	1,846,020	931,624	914,396
27,500,000.00	21,149,059	10,894,435	10,254,624	3,045,203	1,542,360	1,502,843	3,305,736	1,673,702	1,632,034

Source: own elaboration

5. DISCUSSION

This paper provides an exploratory attempt to use econometric estimated information within an optimal targeting model. The model shows the possibility to improve the targeting of AEMs by modelling farmers' economic behaviour in participating to scheme 214.1 and it offers an alternative approach to the design of payment mechanism, based on differentiated payments instead of the classical flat rate payments. The results from the optimization problem also confirm/exploits the hypothesis of heterogeneity in cost and payment functions which could depend on location, type and farmers' characteristics. This also confirms the findings of Drechsler and Wätzold (2005) and Viaggi et al. (2008) about the efficiency losses for AEMs associated with the uniform payment mechanism. In this way, the model which consider both the costs and payments spatially heterogeneous may lead to a more efficient allocation of funds for agri-environmental measures. Moreover the additional information given by the econometric analysis allows the model to explain with some neighborhood effects the different influence in the uptake ratio between zone.

The model used in this paper, while reflects a number of plausible assumptions, also remains rather simplified and could be improved in the further research. The main weakness of the approach rests in the fact that the econometric information was particularly poor in terms of effect of policy design parameters (in particular payments), due to the limited range of payment observation. Also prioritisation was only tentatively modelled. Due to this, a participation cost function, the ideal input one would expected for this type of model, was not available. Hence, in this paper we used an approximate coefficient derived from spatial econometrics to correct an exogenously derived cost function.

In addition, while the spatial correlation term was used in the econometric analysis, it was not in the optimisation model, which hence used a somehow more limited information than potentially available from the models. Another point was that a meaningful empirical functional form for compliance costs in the area was not "well behaving" in terms of sought economic properties for a cost function, which yielded difficulties in managing the model from a numerical point of view.

The model can be improved on several other grounds, particularly considering the complexity of factors which affect participation and the difficulties to model hidden transaction cost.

However the results confirm the relevance of a Policy design related to connected payments or in the case of the Emilia Romagna Region to explicit policy priorities (targeting and zoning system). Also the factors related to farmers' characteristics, features and institutional factors, included in the model with the regression term, play a role in encouraging participation and stressing the different structure of compliance cost which depends to the location and to those spatial characteristic. The study highlighted the importance of spatial differentiation to explain the determinants of farmers' participation to AEMs schemes and the relevance of considering this differentiation in optimisation tools searching for optimal incentive-compatible targeting.

6. CONCLUDING REMARKS

This paper focused on the use of spatial econometric information within mathematical programming methods to test the feasibility of using the data coming from spatial analysis to support the design of AEMs policies, in particular concerning spatial targeting and payment differentiation.

Based on the importance of spatial differentiation to explain the determinants of farmers' participation to AEMs schemes, the paper highlights the relevance of considering such differentiation in optimisation tools searching for optimal incentive-compatible targeting. The overall message goes in the direction that further improvements are possible in efficiency of AEMs. Such improvements would require a consistent development of implementation data collection, data analysis and ex-ante policy design and evaluation.

The discussion also showed the weaknesses of this approach in the current form. Despite this limitation, due mainly to data availability, the analysis showed the potential in contributing to the design process of an alternative incentive scheme based on different farmers' compliance cost through space instead of the classical flat rate payments. Future research may attempt to improve the integration between spatial approach and optimisation methods to explain the determinants of farmers participation to AEMs schemes.

By this way it could be possible to identify better policy design option that could help the definition of appropriate RDMs and a larger involvement of farmers, hence a better delivery of environmental goods.

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