CAP post-2013: alternative greening designs in Tuscany (Italy)

Gava O.[1] , Andreoli M.[1] Bartolini F., Brunori G.[1]

[1] Department of Agriculture Food and Environment, University of Pisa, Pisa, Italy (Times New Roman, 10)
oriana.gava@for.unipi.it

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Summary

The provision of public goods is at the heart of agriculture's multifunctionality. Since 1992s, the Common Agricultural Policy has addressed the environmental challenge by designing and implementing a set of environmental instruments, among which the most important are cross-compliance and agri-environmental schemes, respectively under Pillar I and Pillar II. The CAP has faced a reform where one of the main novelty beside to a new payment mechanism is the greening. This paper aims at assessing the ex-ante impact of alternative designs of the greening measure, within the framework of introduction of the new basic payment system. The design of the alternative scenarios encompasses the design of the optimal greening prescription: to increase the cost-effectiveness of the measure. The empirical analysis relies on Tuscany's micro-data *from the Italian agricultural Census 2010. We focus on the province of Grosseto, due to its high concentration of intensive farms. We apply a mathematical programming model at the farm level, which allows simulating the behaviour of farmers facing alternative greening designs under the new payment system. Data about farmers' cost are derived from the Farm Accountancy Data Network. We assess the cost-effectiveness of alternative greening designs, by upscaling farm-level model's results about the crop diversification index and the intensity of management.*

Keywords: ex-ante analysis, cost-effectiveness, hnv, mathematical programming, cap's greening

JEL Classification codes: Q18 – Agricultural Policy; Q10 General

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INTRODUCTION

The provision of public goods is at the heart of agriculture's multifunctionality. Since McSharry's reform (1992), the Common Agricultural Policy (CAP) of the European Union (EU) has addressed the environmental challenge by designing and implementing a set of environmental instruments, with cross-compliance and agri-environmental schemes having the highest relevance within CAP's Pillar I and Pillar II, respectively. From an economic perspective, the externalities of agriculture on the environment have motivated CAP's supplementation with environmental regulations (Pretty et al., 2001). Given the extent of externalities, the market cannot meet society requirements in terms of environmental goods' provision, with both positive and negative externalities of agriculture being cases of market failure. The objective of aligning the agricultural provision of environmental goods with society demand has shaped the policy design (Van Tongeren, 2008).

The cross-compliance sets the threshold between positive and negative externalities, thus allowing a clear-cut distinction, that helps the agricultural provision of environmental services. This results in the application of the "polluter pays principle", i.e. the free input to farming is priced and treated as if it was similar to other costs (Pretty et al., 2001). Differently, agri-environmental schemes enforce the "provider gets principle", with farmers being financially rewarded for improving the environmental performance of their farming systems.

Moving to the new basic payment scheme under CAP 2014 – 2020's Pillar I (Reg.(EU)1307/2013), major changes involve the shift from a "historical" to a "regionalised" system and the launch of the green direct payment (Matthews, 2013). With respect to the regionalized system, Italy opted for the partial convergence to an average basic payment (flat rate) by 2019 (Irish model). According to recent simulations, the average basic payment approaches to 179 € per hectare (ha) (Frascarelli, 2014). Safeguard clauses under the partial convergence mechanism can lead farmers' unitary payments to significantly diverge between them (Frascarelli, 2014). The greening is a compulsory policy instrument aimed at remunerating farmers for the provision of public goods and ecological services, accounting for 30% of direct payments' envelope at the member state level. Regardless of the existing differences in terms of basic payment per hectare, farmers must comply each year with the same three agricultural practices beneficial for the climate and the environment, i.e. (i) crop diversification, (ii) permanent grassland maintenance, and (iii) ecological focus areas (EFA). The three commitments refer to the whole farmland. Major exemptions to greening requirements are as follows: (i) farms with less than 15 ha arable land benefit from EFA requirement exemption, (ii) farms with less than 10 ha are exonerated from crop diversification, (iii) certified organic farms are dispensed from all three commitments. Here, we provide an ex-ante impact assessment and an economic evaluation of alternative CAP's greening designs. Essentially, the economic evaluation of policies moves from the comparison of the related costs and effects and relies on three main methodologies, notably cost-benefit Analysis (CBA), cost-effectiveness analysis (CEA), and multi-criteria analysis (MCA) (Drummond, 2005; Pearce, 2005). Taking the province of Grosseto (NUTS 3 level) as an empirical case study, we attempted to assess the prospective costs-effectiveness of new CAP's greening at the farm level, with statistically significant clusters of farms being the units of analysis.

We proceed as follows. The next section introduces the greening measure followed by CEA and modelling approaches, after which we report the results of the statistical analysis and discuss our findings. Alternative policy scenarios are modelled to increase greening's cost-effectiveness. The empirical analysis relies on Tuscany's (NUTS 2) micro-data from the Italian agricultural Census 2010, taking the province of Grosseto (NUTS 3) as example, due to the high concentration of intensive farms. We apply a mathematical programming model at the farm level, which allows simulating the behaviour of farmers facing alternative greening designs under the new payment system. Data about farmers' costs are from the Farm Accountancy

Data Network (FADN). We assess of the cost-effectiveness of alternative greening designs, by upscaling farm-level model's results with respect to crop diversification index and management intensity (Desjeux et al., 2015).

Preliminary results support previous research. Particularly, model outcomes suggest that the "crop diversification" requirement can barely affect crop mixes' composition. In terms of EFAs, the equivalence mechanism has a significant impact on the profitability of different arable crops. Overall, farm level CEA highlights that there is room for improvement in the current design of the greening measures.

THE GREEN DIRECT PAYMENT (GREENING)

Three policy targets informed CAP post 2013 reform, i.e. helping the competitiveness of the agricultural sector, boosting sustainable agricultural systems, and improving policy efficiency and effectiveness. The new CAP is structured towards four basic regulations, all published on the Official Journal of the EU on 20 December 2013: (i) Reg(EU) 1305/2013, about rural development (Pillar II policy); (ii) Reg(EU) 1306/2013, covering "horizontal" issues such as funding and controls; (iii) Reg(EU) 1307/2013, about direct payments for farmers (Pillar I policy)1; (iv) Reg(EU) 1308/2013, encompassing market measures. A fifth regulation, Reg(EU) 1310/2013, relates transitional provisions about basic regulations' application in 2014. Here, we focus on new features of the direct support scheme under Pillar I in Italy.

The new Pillar I design entails the shift from the "historical" to the "regional" allocation of entitlements, with one entitlement being awarded for each hectare (ha) of land, and the partial convergence to a flat payment rate by 2019 (so-called "Irish model"). Some important features of the new payment model are as follows (Frascarelli, 2014): (i) all cultivations are eligible (e.g., SRC, energy crops); (ii) 2015 is the reference year for the basic payment (BP); (iii) BPs should reach at least 60% of the national average by 2019; (vi) farmers' would face no more than 30% payment reduction compared to 2015 levels; (v) BPs ranging from 60% to 90% of the national average would be raised with one third of the difference between the payment level and the national average. Farmers meaning to apply for Pillar I support have to keep unchanged the existing permanent pasture and are subject to statutory management requirements and minimum requirements to maintain land in good agricultural and environmental conditions (cross-compliance). The direct support scheme relies on a multi-purpose payment system, with seven components, i.e. (i) BP, 58% national ceiling, (ii) green direct payment, 30% national ceiling, (iii) payment to young farmers, 1% top up for the first five years of installation, (iv) redistributive payment, granting additional support for the first ha of farmland, (v) support to areas with specific natural constraints[3], (vi) coupled payment, 11% national ceiling, and (vii) simplified small farmers scheme.

The green direct payment, commonly referred to as "greening", is first pillar's main new measure (Allen et al., 2012; Matthews, 2013). The primary purposes of that measure are boosting crops diversification and maintaining natural and semi-natural crop systems in Europe's rural landscapes (Zeijts et al., 2011). The greening component is financed with 30% national ceiling for direct support to farmers (Table 1).

Table 1 Italian ceiling for direct payments to farmers and share of ceiling (30%) allocated to the greening component for years 2015-2020.

Year	Italian ceiling (€)	Greening component (€)
2015	3,902,039,000	1,170,611,700
2016	3,850,805,000	1,155,241,500
2017	3,799,540,000	1,139,862,000
2018	3,751,937,000	1,125,581,100
2019	3,704,337,000	1,111,301,100
2020	3,704,337,000	1,111,301,100

Source: Own elaboration from Reg(EU) 1307/2013, Annex II

The amount of the greening component at the farm level is calculated and paid annually per eligible ha of land. To benefit from the greening component, farmers have to receive the BP and to implement jointly

[1] Reg(EU) 1307/2013 had a follow-up in march 2014, Reg(EU) 639/2014, which encompasses some integrations to the original regulation and a revised Annex X.

[3] In order to benefit from the simplified scheme, overall small farm payments do not have to exceed €1,250. Redistributive payment and support to areas with specific natural constraints are not implemented in Italy

three agricultural practices beneficial for the climate and the environment on their eligible land5, i.e. (i) crop diversification, (ii) permanent grassland maintenance, and (iii) ecological focus area (EFA) on farm arable land. Farms specialized in permanent cultivations (e.g. meadows, olive trees, vineyards) are exempted from the compliance with those three commitments.

Direct payment regulation encompasses greening equivalencies[6] for a series of environmentally beneficial practices that are deemed to be substitutes for the three requirements above.

Administrative penalties for beneficiaries who do not meet all three greening requirements consist of a payment reduction, that is proportional and graduated according to the severity, extent, permanence and reoccurrence of incompliance. Incompliances during years 2015 and 2016 (transition period) would not be monetary fined. Repeat offenders during 2017 would suffer 20% greening component reduction. From 2018, the fine would reach 25% cut in the green payment (Reg(EU) 1306/2013).

EX-ANTE ANALYSIS OF GREENING'S IMPACT

Assessing policies' effectiveness is common among agricultural economists and several papers used econometrics and mathematical programming approaches to model CAP's impact on environmental sustainability. Both methods allow impact estimation by modifying relevant conditions of exogenous parameters. Econometric models are rarely applied for ex-ante purposes, being less suited to simulate radical changes in relevant parameters, e.g. new payment mechanisms or new commitments.

Concerning the CAP post 2013, some early empirical studies suggest an overall low, or negligible, impact of the greening measure. For example, using positive mathematical programming, Was et al. (2014) proposed that greening's major outcome would be a reduction in the surface of arable land, as higher shares of farmland would be left fallow to meet "permanent grassland maintenance" and EFA prescriptions. The ex-ante analysis of greening impact by Westhoek et al. (2012) shows that the great majority of EU's arable land already complies with the "crop diversification" prescription, with the greening driving land use changes over just 2% share of EU's arable land. An investigation of data from the Italian cadaster concerning Tuscany, lead Landi et al. (2014) to a similar conclusion, with 97% Tuscan farms already complying with the greening commitments. However, the same Authors pinpointed some rural areas where the majority of farmers do not comply with any of the greening requirements; these areas are the ones where the productivity and profitability of agriculture are the highest of Tuscany (i.e. the province of Grosseto1). Other research findings showed that the greening could somewhat increase the demand for land; thus all-encompassing assessments should include the greening (see, e.g., Puddu et al., 2014). Other strains of literature concentrates on different aspects of the recent CAP reform. While some papers pinpoint prospective positive outcomes of all measures on small farmers, in terms of both simplification and increased payments (see, e.g., Dwyer, 2014), other studies stress the advantages of sharing common basic prescription among all Member States. These benefits include having larger shares of land subject to responsible management and reducing the chance for countries to opt for very low levels of environmental standards, as had been the case for matters that are regulated at State or Region level, such as Pillar II measures (see, e.g., Hart and Baldock, 2011). Some researches focus on the need for more "tailored" and "targeted" approaches, that can account for different pedoclimatic conditions in different parts of the EU. Matthews (2013), for example, compares "competitive" environmental protection measures under both Pillar 1and Pillar 2. Many papers deal with the challenge of evaluating CAP's effects at the State or Region level, in order to understand who is gaining and who is losing from the CAP reform as well as to deliver practical highlights to farmers, especially in its first implementation (for example, Was et al., 2014). Finally, a number of contributions (see, e.g., Hart and Little, 2012; Hauck et al., 2014; Matthews, 2014) discuss the effectiveness and the efficiency of the both the CAP and CAP's measures, notably the greening, even comparing alternative greening scenarios. Particularly, the emphasis is on the apparent incapacity of the greening to cover farm costs associated to policy measure implementation, as well as on the trade-offs between the provision of ecosystem services and the sum of public and private policy costs.

Some other Authors, such as e.g., Heinrich (2012), provide quantitative estimates of costs borne by farmers, based on the integration of data from the European Farm Accounting Data Network with nation or sub-region-wide information (as we did here).

[5] Reg(EU) 1307/2013, Art. 32, paragraphs 2 to 5, sets land eligibility criteria.
[6] Annex IX to Reg(EU) 1307/2013 lists the equivalent practices.

Qualitative approaches to the problem of costs borne by farmers are worth mentioning. Those studies have analyzed the willingness of farmers to enter the new CAP scheme (see, e.g. Shulz et al., 2014 for a case study in Germany), hypothesising that farmers could opt out the new CAP when their prospective direct payments cannot cover their costs in terms of added valued, higher risk of volatile revenue, higher direct and indirect costs for complying with bureaucratic requirements, and risk of sanction for involuntary breaking of rules. Among the others, we mention a study made in Finland by Liesivaara, et al. (2012), reporting different stakeholders' positive and negative opinions about a range of issues associated to the CAP reform. The research highlights that both the Central Union of Agricultural Producers and Forest Owners and the Central Union of Swedish-speaking agricultural producers in Finland (i.e. all the interviewed stakeholders involved in agricultural production) have a negative opinion about the greening, that contrast with the positive one of the rest of the stakeholders, i.e. governmental institutions and environmental organizations. Undoubtedly, the crop diversification requirement would diversely impact on different member states, depending on to the range of crops that can be grown on their territories; for example, the sugar regime reform has hardened the Finnish agriculture.

Despite its unavoidable incompleteness, our literature survey helped define some of the obstacles to plausible ex-ante evaluations of greening's impact on farm costs; we schematically depict those barriers as follows:

- Rules are too complex for economic models to be all-encompassing[7]. However, simplifications are embedded in modelingThe direct payments regulation entails a long list of equivalent practices for each of the three greening requirement. The greening equivalencies could partly integrate or substitute model rules, e.g. the minimum number of different crops according to farm acreage, the minimum share of farm acreage to be left fallow or to be dedicated to land uses that deliver environmental benefits. As a result, the reviewed models, as well as the one we propose, start from a set of over simplified hypotheses.
- Greening and cross-compliance partly overlap. To some extent, buffer zones compatible with EFA prescriptions had been covered by cross-compliance requirements. In addition, the pre-existing compliance with the "crop diversification" commitment could originate from the former support coupled to crop rotation. Having observed that some farms are already complying with "crop diversification" before the actual enforcement of the direct payment regulation could be due to payments coupled to crop rotation, which encouraged farmers towards crop diversification. If that were the case, the greening payment for diversification could not be evaluated under the flag of a deadweight policy, but rather the measure impact should be assessed in terms of better-worse performances with respect to the pre-reform situation.
- Hypothesising that present production mixes will affect greening payment levels and farm costs is only partly true. Under the reformed CAP, both the BP and the greening components of the direct payment scheme still depend on historical payments and thus on past choices about productive mixes. However, greening costs borne by farmers depend on current or future choices about farm productive mixes. Since productive choices have changed after the decoupling set by 2003 CAP reform, there is no guarantee that the cost of greening (associated to present productive mixes) will be related to the loss of related payments, which in turn depends on historical productive choices, except when choices endure (as many Authors seem to imply).
- The partial convergence mechanism makes it difficult to estimate the final unit value per ha by 2019 at the territorial level. Farm distribution of unitary value per ha is relevant because the partial convergence avoids farmers' payment to be cut with more than 30% unit value per ha.
- EFA and diversification costs borne by farmers would be higher in more fertile rather than in less fertile land (Shulz et al., 2014). On one hand, the higher the firm productivity the higher the opportunity cost of production diversification; this is especially relevant when EFA prescription is supposed to be met by leaving fallow a quote land. On the other hand, even firms located in less fertile agricultural areas would face high opportunity cost of production diversification when the specific pedo-climatic features narrow the range of suitable crops and leaving land fallow is not an acceptable option.

[7] Of course, models are simplifications by definition.

- Farm structure affects greening's acceptance by farmers. Usually, larger scale farms that owns all the technical equipment they need for running their activity diversify the pool of cultivated crops to lower market and weather related risks and to flatten labour peaks. In contrast, smaller farms that rely on contractor services could reject the diversification to reach a minimum scale for a single crop. However, setting a mandatory requirement for diversification, beside the voluntary crop rotation, could help the economic return for farms with heterogeneous pedo-climatic features. Those farms may cultivate the fertile areas with the same high return crop over time, while allocating less fertile areas to more easy-fitting, but less remunerative crops. Being crop rotation not mandatory, the extent to which the diversification requirement would benefit the environment is questionable.
- Different times and places under study harden the comparison among research studies. In recent years, many studies have assessed the impact of PAC reforms on farm revenue and costs. While comparisons are possible across the applied methodologies, research results depend on the time of the analysis. The same logic applies to the evolution of the CAP reform from the early proposal back in 2010 to the enforcement in 2015. Specific features (e.g., climate, water availability, height AMSL, soil depth and richness) of the country or the area under study are also barely comparable among different papers.
- Paperwork costs are uncertain. Information about real costs would not be available before CAP's reform implementation. In Italy, bureaucracy is usually costly, as well as time consuming. Thus, the financial burden of the new payment system could be unbearable for both farmers and public administrations.

METHODOLOGY

This paper aims at assessing the ex-ante impact of alternative designs of the greening measure, within the framework of introduction of the new basic payment system. Alternative design concerns the implementation of several level of payment (both share of greening payment and the amount of basic payment) and changes in commitments (minimum amount of crops each years).

The design encompasses the identification of the optimal greening prescription: to increase the measure cost-effectiveness. The empirical analysis relies on Tuscany's micro-data from the Italian agricultural Census 2010. We focus on the province of Grosseto, due the high concentration of intensive farms. Data about farmers' cost are derived from the Farm Accountancy Data Network. We assess of the cost-effectiveness of alternative greening designs, by up-scaling farm-level model's results about the crop diversification index and the intensity of management (Desjeux et al., 2015).

4.1 THEORETICAL MODEL

The greening is the most relevant novelty introduced by the CAP post-2013 reform and the only measure that explicitly aims at improving the environmental performance of the agricultural systems. To date, a wide literature has debated the extent to which different measures of the new CAP would be effective in increasing the environmental quality. Some Authors assess the environmental impact of the policy based on prescriptions' tailoring and targeting, as well as on the levels of both participation and compliance (Finn et al., 2009). Other Authors face policy measures' effectiveness investigating the spatial distribution and the agglomeration effects of farmers participation (Bartolini and Brunori, 2014; Signorotti et al., 2015). According to Juntti (2014), the cross compliance is better suited than other agri-environmental measures for driving environmental benefits, with the latter being affected by piecemeal implementation and uneven distribution of participation. Additionally, voluntary measures lead to sub-optimal environmental benefits, particularly in case of not proper enforcement and/or implementation (Bartolini et al., 2012). Hence, designing measures in order to maximise the level of environmental quality while minimizing the associated costs, i.e. in a cost-effective way, should be is policy makers' concern.

Let π be farm's profit. Once a prescription has been implemented, farmer's decision can be simulated by a discrete choice among a set of alternatives aimed at profit maximisation. Here, farmer's decisions are opting out the CAP (superscript *0*), participating to cross-compliance (superscript *cc*) and receiving just the BP component of the direct payment, and complying with all three greening prescriptions (superscript *g*) and fully benefiting from the direct payment; formally:

$$\pi_i = \left(\pi_i^0; \pi_i^{cc}; \pi_i^{cc+g}\right)$$

Then, the profit function associated to the farming activity is as follows:

$$\pi_i^0 = \sum_{j=1}^{J} p_i f_i(l,t,k,i,j) - k_j(l,t,k,i,j) - c_j$$

Particularly, when $\pi_i^{cc} > 0$ farmers would opt for cross-compliance and when $\pi_i^{cc+g} > 0$ they would decide to fully implement the greening; thus:

$$\pi_i^{cc} = \left[\pi_i^0 - CC_i(e_{cc})\right] + (1-\alpha)BP_i * l_i$$

and

$$\pi_i^{cc+g} = \left[\pi_i^0 - CC_i(e_{cc}) - CG_i(e_g)\right] + BP_i * l_i \ .$$

4.2 COST-EFFECTIVENESS ANALYSIS

The assessment of policy effectiveness do not represent a novelty in economic literature and several papers already address CAP impact on the environment. Cost-effectiveness analysis (CEA) is a tool for the socio-economic evaluation of policies that contrasts the costs of alternative policy settings with their relative capacity to achieve the desired objectives (i.e. effectiveness), measured in physical terms. Given a set of measures to choose from, CEA can pinpoint the alternative that either maximises the output level (i.e. the benefits) for a given cost or the one that minimises the actual value of costs for a given output level.

Both the European Commission (2013) and the Organization for Economic Co-operation and Development (OECD, 2005) propose consider CEA to allocate public funds efficiently when precise monetary measurement of benefits would be impossible, tricky or open to considerable dispute and recommend such an evaluation in case of mandatory policy commitments. Following Pearce (2005) and Schader et al. (2013), the cost-effectiveness (CE) of a policy measure can be depicted as the ratio between measure's outputs (E) and public expenditure (C) allocated to policy's implementation:

$$CE_{ij} = \frac{E_{ij}}{C_i} CE_{ij} = \frac{E_{ij}}{C_i}$$

$$CE_{ij} = \frac{E_{ij}}{C_i}$$

The subscripts *i* and *j* respectively state for potential policies and their relative effects; E_{ij} is an indicator of *i*-th policy's effectiveness in terms of *j*-th effect; C_i is the monetary cost of *i*-th policy's implementation, provided the available budget ($\bar{C}$). Alternative policies are ranked based on their performance in terms of a measurable indicator of the *j*-th effect:

$$Rank\ by\ CE_{ij} \ \ | \sum_i C_i = \bar{C}$$

CAP's greening is a mandatory agri-environmental measure that allocates public funds to farmers in return for income forgone and additional costs due to the compliance with practices beneficial for the climate and the environment. The ultimate purpose of agri-enviromental measures is to minimise the negative externalities of agriculture on the environment while maximising the positive ones (Antle, 2007). In this context, *E* is the physical measure of the *j*-th environmental benefit, which is calculated via an indicator of environmental performance, e.g. Shannon index (biodiversity) or hectares of land conserved (land use), and *C* is measured as the sum of greening payments:

$$GAI_j = BG_j + CP_j = 100\%$$

$$minPE = \sum_i PL_i \, PS_i$$

$$CP_j = \sum_i PS_i \, ET_{ij} \geq 0$$

4.3 Selection of representative farm

We tested the model on representative farms of the Italian province of Grosseto (NUTS 3 level), a sub-region of Tuscany (NUTS 2), that we chose by a cluster analysis on official data from the Italian Census 2010 about the farming systems in Tuscany. We applied the cluster analysis on a subsample of Italian farms made of 7856 farms of the province of Grosseto. We selected that study area as previous studies highlighted the high relevance of greening's introduction (Landi et al., 2014). Due to the straightaway involvement in the greening, we applied the cluster analysis to arable and vegetable farming systems only and obtained 32 representative farm clusters, i.e. 21 arable and 11 vegetable farms. Due to the importance of both farmland's height AMSL and slope, we clustered for plain, hill, or mountain farmland and assigned to each of those "altitude" clusters the associated representative farm per farming system. The clusters were then classified using the following criteria: (i) farmland surface area; (ii) amount of household and/or off-farm labour employed; (iii) amount of payments (Annex 1).

4.4 Environmental impact measures

We assess the environmental benefits of the greening by means of the "HNV drivers" set of indicator. The indicator framework have been developed by Paracchini et al., (2008) and Paracchini and Britz (2010) with the aim of pinpointing the policy impacts that are able to drive high nature value (HNV) farmland. Recently, Desjeux et al. (2014) and Bartolini and Brunori (2014) have applied that set of indicator. HNV drivers are measured using three indicators; specifically: the diversity crop index (DCI) takes into account crop diversity in non-grassland areas; the management intensity index (MII) is intended for considering the management intensity in non-grassland areas; (iii) the livestock intensity index (LII) considers the livestock pressure over grassland areas and the provision of EFAs. Formally:

$$E_i = 100\left(\sqrt{DCI_i * MII_i}\left(\frac{\sum_{s \notin G} x_s}{\sum_s x_s}\right) + LII_i \frac{\sum_{s \in G} x_s}{\sum_s x_s}\right)$$

$$DCI_i = \min\left(1, -\sum_{c \forall s \geq 0.1}^{S} a_n * \log a_s\right)$$

$$MII_i = 2.25 - 0.97(\log_{10} n_i)$$

$$LII_i = \max\left(0,\ 1 - 0.708\sqrt{d_i}\right)$$

Where,

$$\sum_s x_s = \text{utilised agricultural area (UAA)}$$

$$\sum_{s \in G} x_s = \text{share of UAA allocated to grassland or fodder crops (G)}$$

$$\sum_{s \notin G} x_s = \text{share of UAA not allocated to G}$$

$$a_s = \text{share of UAA allocated to n crops}$$

$$n_i = \text{nitrogen used}$$

$$d_i = \text{livestock units per ha of grassland}$$

The proxy for DCI is the Shannon Index, an indicator that returns a non-linear score ranging between zero and one. MII is estimated by the intensity of agricultural nitrogen inputs and calculated via a non-linear transformation. The values of this indicator approach to zero for nitrogen inputs below 20 kg/ha, while they get closer to one when nitrogen loads exceed 190 kg/ha. *LII* is intended for quantifying the extent of the impacts of livestock farming on biodiversity. Provided the above study boundaries, livestock's consistency is assumed fixed, thus *LII* is a measure of the changes in grassland due to greening. The functions used for MII and LII entail the mandatory commitments of the nitrates directive (Bartolini et al., 2007).

CASE STUDY

Tables 2 and 3 provide basic information about the agricultural sector of the Grosseto province compared the other administrative sub-regions (i.e. provinces) of Tuscany.

Table 2 Main utilisation of agricultural land in Tuscany at 2010; data are expressed in hectares by administrative province.

			UAA per farm specification				
	TAA	UAA	Arable	Permanent cultivations (non-grassland)	Vineyards	Family Orchards	Pasture and permanent grasslands
Massa Carrara	25,451	10,254	951	3,501	763	120	5,682
Lucca	47,201	24,344	7,988	7,903	1,058	251	8,202
Pistoia	46,121	21,270	5,978	12,448	786	184	2,661
Firenze	197,687	107,518	42,845	47,160	18.393	391	17,122
Livorno	51,451	33,391	23,565	7,909	2,445	179	1,737
Pisa	158,576	95,754	75,324	12,038	3,187	304	8,089
Arezzo	193,519	96,740	59,958	21,991	7,047	470	14,321
Siena	275,240	169,284	119,879	33,554	18.330	224	15,627
Grosseto	**285,029**	**188,578**	**139,874**	**27,843**	**7.471**	**329**	**20,531**
Prato	14,846	7,211	3,525	2,722	512	39	926
Toscana	1,295,120	754,345	479.888	177,069	59,993	2,490	94,899

TAA: total agricultural area; UAA: utilised agricultural area
Source: own elaboration based on the Italian Census of Agriculture 2010

Table 3 Main utilisation of Agricultural Land in Tuscany at 2010; data are expressed as % by administrative province.

				UAA per farm specification			
	UAA/TAA	Arable/TAA	Arable/UAA	Permanent cultivations (non-grassland) /UAA	Vineyards/UAA	Family Orchards/ UAA	Pasture and permanent grasslands/ UAA
Massa Carrara	40,3%	3,7%	9,3%	34,1%	7,4%	1,2%	55,4%
Lucca	51,6%	16,9%	32,8%	32,5%	4,3%	1,0%	33,7%
Pistoia	46,1%	13,0%	28,1%	58,5%	3,7%	0,9%	12,5%
Firenze	54,4%	21,7%	39,8%	43,9%	17,1%	0,4%	15,9%
Livorno	64,9%	45,8%	70,6%	23,7%	7,3%	0,5%	5,2%
Pisa	60,4%	47,5%	78,7%	12,6%	3,3%	0,3%	8,4%
Arezzo	50,0%	31,0%	62,0%	22,7%	7,3%	0,5%	14,8%

Siena	61,5%	43,6%	70,8%	19,8%	10,8%	0,1%	9,2%
Grosseto	***66,2%***	***49,1%***	***74,2%***	***14,8%***	***4,0%***	***0,2%***	***10,9%***
Prato	48,6%	23,7%	48,9%	37,7%	7,1%	0,5%	12,8%
Toscana	58,2%	37,1%	63,6%	23,5%	8,0%	0,3%	12,6%

TAA: total agricultural area; UAA: utilised agricultural area

Source: own elaboration based on the Italian Census of Agriculture 2010

Among the ten provinces of Tuscany, Grosseto has the highest share of arable land over both the total agricultural area (TAA) and the utilized agricultural area (UAA); in contrast, shares of agricultural land below Tuscan averages are devoted to pasture and permanent grasslands. Among arable specializations, durum wheat production has generally a high relevance for farms located in hilly areas. For example, when considered together, Grosseto and Siena provinces account for about half the surface involved in durum wheat production in Tuscany. Western lowlands, instead, are cultivated with are more intensive cropping systems. In 2000, durum wheat cropping in Grosseto accounted for about 15% UAA (52.000 ha); ten years later, the same cereal was cultivated on roughly half the surface (29.000 ha), while fodder crops and grasslands (previously not associated with coupled payments) had increased, thus confirming the weak relation between historical choices on cropping and present direct payments.

RESULTS AND DISCUSSION

Tables 4 and 5 and Figure 1 displays the study results.

Table 4 shows the share of farms and UAA involved in the greening. The rows display the share of payments conditioned to the compliance with greening's prescriptions. The columns display the hypothesised alternative levels of payments expressed as shares of the.

Table 4 Share of farms and utilised agricultural area involved in greening measure.

	No payment		**-50% BP**		**Current payment**		**+50% BP**	
	Farms	**UAA**	**Farms**	**UAA**	**Farms**	**UAA**	**Farms**	**UAA**
0	-	-	-	-	-	-	-	-
0.1	-	-	0.1892	0.2311	0.6446	0.6141	0.6942	0.6714
0.2	-	-	0.6446	0.6141	0.6942	0.6714	0.7028	0.6944
0.3	-	-	0.6942	0.6714	0.7028	0.6944	0.7061	0.7230
0.4	-	-	0.6942	0.6714	0.7061	0.7230	0.7130	0.7624
0.5	-	-	0.6942	0.6714	0.7130	0.7624	0.7130	0.7624
0.6	-	-	0.7028	0.6944	0.7130	0.7624	0.7130	0.7624
0.7	-	-	0.7028	0.6944	0.7130	0.7624	0.7130	0.7624
0.8	-	-	0.7061	0.7230	0.7130	0.7624	0.7130	0.7624
0.9	-	-	0.7061	0.7230	0.7130	0.7624	0.7130	0.7624
1	-	-	0.7130	0.7624	0.7130	0.7624	0.7130	0.7624

UAA: utilised agricultural area; BP: basic payment

Source: own elaboration

Results highlight that both policy parameters positively affect farmers' uptakes as well the area of the operated agricultural land. The share of farms under the current design of greening design (Current payment) approaches to two thirds, thus supporting previous literature. Despite the increased payments or the higher share of greening payment, the effects on uptakes are weak. Increasing greening's payment level seems to affect more farmers, due to the higher participation costs compared to those of farmers that operates small farmlands. Even when the greening payment raises to 50% direct payment, 30% of the farms do not choose to involve in the greening.

Table 5 provides the measures of the environmental benefits delivered by three alternative BP schemes.

Table 5 Value of the environmental indicator associated at the drivers of HNV.

	No payment	-50% BP	Current payment	+50% BP
0	0.263	0.288	0.284	0.282
0.1	0.263	0.364	0.370	0.377
0.2	0.263	0.372	0.382	0.384
0.3	0.263	0.377	0.384	0.404
0.4	0.263	0.376	0.393	0.409
0.5	0.263	0.386	0.409	0.409
0.6	0.263	0.386	0.409	0.409
0.7	0.263	0.385	0.409	0.409
0.8	0.263	0.393	0.409	0.409
0.9	0.263	0.404	0.409	0.409
1	0.263	0.409	0.409	0.409

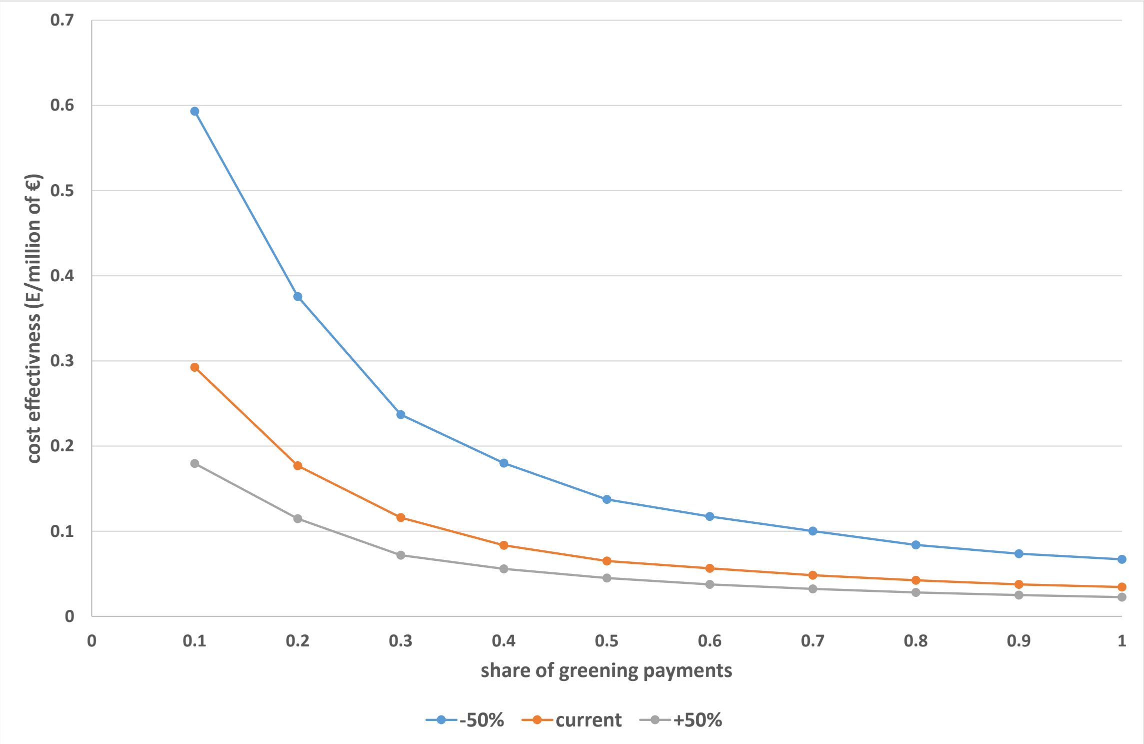
BP: basic payment

Source: own elaboration

Results show that the values associated to the environmental performance rise as the payment level rises or as the level of greening payment rises. With no BPs, the model returns lower environmental benefits. Similarly, a gradual introduction of BP lead to better environmental performances. These outcomes are determined by the introduction of the greening measure, which entails constrains over the maximum amount of nitrogen used as agricultural input. Moving from the “no payment” to the lower level of greening payment raises the vale of the indicator by one third. This is mainly attributable to the positive effects of cultivating a higher number of crops to comply with the diversification requirement. Raising the payment above the current level allow only very small environmental improvements.

Figure 1 illustrates the cost-effectiveness of the alternative greening designs.

Figure 1 Cost effectiveness of the alternative greening designs.



Source: own elaboration

Results highlight that the effects of the greening are small, thus confirming previous literature. Greening's cost-effectiveness can be obtained by reducing the level of basic payments or reducing the share of direct payments allocated to greening. Increasing the payment level without making the commitments more restrictive would lead to a very low cost-effectiveness of the measure. The model returns a very high cost-effectiveness when 50% reduction of the BP is associated with low share of greening.

CONCLUSIONS

We analysed the cost-effectiveness of new cap's greening by considering farmers' strategies when facing the decision of whether to apply or not for the greening payment. We simulated the environmental impacts of the measure by means of an indicator framework (i.e. HNV drivers) that has been explicitly designed for assessing the environmental benefits delivered by high nature value (HNV) farmland. Our findings confirm previous literature highlighting that the impact of the current policy design would be low. The greening has resulted from a negotiation that has emphasised the measure itself, which in turn has few ambitions. Despite the large amount of CAP budget allocated to the measure, a few farm have not complied with the prescriptions yet. In addition, our simulation points out that 30% farms would find profitable not to opt for the measure. A proper implementation sanctions and controls, is of course a basic requirement.

The model is affected by several limitations. Specifically, our approach relies on representative farm obtained by cluster analysis rather than on real farms, thus no cases of real farms are simulated, but once a farm has been modelled it is possible to up-scale the impacts at territorial levels. The model relies on arable and vegetable farms. Our results confirm the exploratory study of Landi et al. (2014). The literature highlights that those farms are facing the highest participation costs, due to higher profitability of the crop mixes. In addition, a relatively high number of farms choose not to complying with the commitments.

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ANNEX 1: RESULTS OF THE CLUSTER ANALYSIS

Cluster	Specialization	Topography	Operated UAA (ha)	Rented-in UAA (ha)	DP (€/year)	DP per ha (€/year)
CL1	arable	plain	112.24	14.38	50,245.88	447.68
CL2	arable	plain	16.09	-	6,030.14	374.78
CL3	arable	plain	5.90	-	1,138.75	193.01
CL4	arable	plain	31.02	20.31	16,540.45	533.30
CL5	arable	hill	13.14	-	3,445.21	262.19
CL6	arable	hill	5.71	-	1,079.18	189.00
CL7	arable	hill	44.50	-	12,477.74	280.40
CL8	arable	hill	640.18	-	-	-
CL9	arable	hill	19.50	-	5,294.43	271.51
CL10	arable	hill	6.60	-	-	-
CL11	arable	hill	87.50	44.00	30,780.58	351.78
CL12	arable	hill	65.76	0.60	19,821.88	301.43
CL13	arable	hill	28.34	-	8,047.40	284.01
CL14	arable	hill	8.85	-	2,113.65	238.83
CL15	arable	mountain	29.82	-	6,319.50	211.92
CL16	arable	mountain	9.60	-	-	-
CL17	arable	mountain	20.16	-	4,380.28	217.33
CL18	arable	mountain	42.55	12.46	10,979.32	258.03
CL19	arable	mountain	18.22	-	1,780.81	97.74
CL20	arable	mountain	12.76	-	2,977.35	233.33
CL21	arable	mountain	7.00	-	981.67	140.24
CL22	vegetable	plain	3.17	-	509.19	160.63
CL23	vegetable	plain	3.00	-	-	-
CL24	vegetable	plain	8.60	-	3,134.02	364.42
CL25	vegetable	plain	8.10	-	11,935.79	1,473.55
CL26	vegetable	plain	5.71	-	1,702.16	298.10
CL27	vegetable	hill	14.62	2.00	4,495.23	307.47
CL28	vegetable	hill	5.50	-	1,732.42	314.99
CL29	vegetable	hill	2.50	-	-	-
CL30	vegetable	hill	2.90	-	601.66	207.47
CL31	vegetable	mountain	52.75	41.00	17,463.57	331.06
CL32	vegetable	mountain	6.68	-	1,670.43	250.06

DP: direct payment; UAA: utilized agricultural area
Source: own elaboration