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# Farmland Use Transitions After the CAP Greening: a Preliminary Analysis Using Markov Chains Approach

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ABSTRACT

This paper represents a preliminary attempt to evaluate ex-post impact of the CAP greening payment on farmland use changes, testing by a Markov Chain approach whether farmland use transitions dynamics changed after the introduction of this new policy instrument. Unlike previous contributions, relying on ex-ante simulations, this analysis is based on the actual behaviour of farmers over the period immediately after the last CAP reform. Such ex-post assessment was based on real georeferenced data on farmland allocation, collected in the Lombardy Region, in Northern Italy, over the period 2011-2016. As the current CAP has recently entered in force (in 2015), the present analysis covers the first two years of implementation of the new rules along with the previous four years. Results are in line with previous ex-ante simulations in the same region, detecting a deep discontinuity for those farmland uses characterised by monoculture before the introduction of the greening. They show a significant discontinuity of farmland use transitions in the reference area after the introduction of greening rules, pointing to a decrease in maize monoculture, in favour of other cereals and legume crops like soybean and alfalfa. Unlike some critical opinions that see current greening rules as a "low profile" compromise, the present analysis points to a strong effect of such rules on regions with high-intensity agriculture.

## 1. INTRODUCTION

Common Agricultural Policy (CAP) is currently structured in two pillars: the first one, that adsorbs the main part of the CAP financial resources, provides direct payments to farmers, while the second one covers rural development policies. The recent last reform has redesigned CAP contents over the programming period 2014-2020, introducing important changes, mainly in the first pillar. In particular, single farm payment (SFP), that represented the main direct payment in the first pillar, has been unpacked in different payments, targeted to different goals and partly tailored to farm specific characteristics. According to European Regulations, Member States (MS) are obliged to set some of such payments (base payment, greening payment and payment for young farmers), while setting of other kinds of payment (coupled, for less favoured areas, for small farms) is not mandatory for MS.

Among mandatory payments, the so called "greening" represents one of the main novelties of the current CAP programming period, providing an horizontal payment for farmers, conditioned to the compliance with some "agricultural practices beneficial for the climate and the environment (Regulation EU 1307/2013), namely i) arable crops diversification, ii) maintenance of permanent grassland and iii) ecological focus areas (EFA). As a consequence of these rules, such farm practices pertain, and potentially influence, farmland allocation, particularly arable land and grassland.

The introduction of the greening payment within the "package" of direct payments in new CAP 2014-2020 reflects the EU legislators intention to provide a more consistent social and political justification to CAP policy instruments, emphasizing in particular their role in pursuing environmental sustainability (Erjavec and Erjavec, 2015;European Commission, 2010a,b). In fact, the implementation of such new instrument aims to plug in Pillar I a reward for the provision of public goods and ecosystem services by agricultural activities (Matthews, 2013a; Cimino et al., 2015). Given the novelty of this political tool, a large debate around greening has arisen after the publication of the initial Commission legislative proposals for the new CAP (Hart and Little, 2012), and even more, after the final political agreement among EU Commission, EU Council and EU Parliament in 2013, often seen as a watered-down compromise on environmental ambitions (Matthews, 2013b). Such a debate mainly focused on some issues related to: *i)* the

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decision-making process behind greening setting up and the genuineness of its objectives (Erjavec and Erjavec, 2015; Knops et al., 2014; Bureau et al., 2012; Hart and Little, 2012; Mahé, 2012); *ii)* the policy design, particularly referring to its targeting and farm/territorial application level (Buckwell et al., 2012; Hart and Baldock, 2011); *iii)* the weight of technical and economic burdens for farmers and national authorities due to the implementation and monitoring of greening practices (COPA-COGECA, 2012; Roza and Selnes, 2012), *iv*) the degree of substitutability between greening practices and national equivalent practices (Bureau, 2013), and overall, *v)* the potential effectiveness of greening measures in ensuring environmental effects (Hart and Baldock, 2011; Matthews, 2012, 2013a; Westhoek et al., 2013).

The latter point of the debate around greening has been addressed by various analyses and researches. Many Authors have attempted to forecast from a quantitative point of view possible effects of greening, mainly recurring to ex-ante simulations. The most popular tool for such kind of simulations is mathematical programming and, in particular, PMP (Van Zeijts et al., 2011; Czekaj et al., 2014; Solazzo et al., 2014; Ahmadi et al., 2015;Cortignani and Dono, 2015 Solazzo et al., 2015; Solazzo et al., 2016; Solazzo and Pierangeli, 2016; Cortignani et al., 2017; Gocht et al., 2017; Louhichi et al., 2017; Cortignani and Dono, 2018). The main output of these simulations pertains the land use change effect induced by the greening. Based on such estimations, some Authors have then derived economic and/or environmental impacts of greening (Louhichi et al., 2017; Gocht et al., 2017; Solazzo and Pierangeli, 2016; Cortignani and Dono, 2018). These simulations have been set to different territorial scale: at European level (Gocht et al., 2017; Louhichi et al., 2017), at country level (Czekaj et al., 2014; Cortignani and Dono, 2019) or at a regional scale (Solazzo and Pierangeli, 2016;Cortignani and Dono, 2015 Cortignani and Dono, 2018). Some of the analysis covered only some crops or some type of farming (Solazzo et al., 2014, for tomato farms in Italy, Cortignani et al., 2017, for specialized arable farms in Italy).

In these regards the present contribution is framed within the literature aimed at estimating the effect induced by greening rules, firstly in terms of land use change, even if with some differences with respect to previous contributions. First of all, unlike similar studies (all based on ex-ante assessment), the evaluation consists in an ex-post analysis based on actual land allocation choices of farms, after the first two years of greening implementation (2015 and 2016). Furthermore, while previous contributions are grounded on farm-level sample data, this analysis is more detailed (parcel-level) and covers almost the whole universe (from 93% to 96% depending on the year) of regional farmland affected by the CAP. Such level of accuracy confines the analysis to Lombardy region, in Northern Italy. A further contribution of the present approach is to translate to a territorial scale the effects (discontinuities in farmland use transitions) of a policy targeted at farm level.

Given its vocation for high-intensity agricultural production, and in particular for maize monoculture (in some sub-areas), Lombardy region represents an interesting case to examine the interaction between CAP greening and land use transition. As some areas of the Region examined are characterized by monoculture, they may be a target for greening, whose aim is to increase diversity in land use and crop allocation. Maybe for this reason, many earlier analyses on greening covered this Region (Solazzo and Pierangeli, 2016; Solazzo et al.; 2016, Cortignani et al., 2017)

For the above mentioned reasons, this paper aims at analysing to a very detailed (parcel) level the temporal and spatial dynamics of farmland use transitions before and after the introduction of greening commitments. Being the first step in a wider research aimed to estimate the net effect of the greening payment on farmland use, the specific contribution aims to highlight whether discontinuities in agricultural land use emerged after the last CAP Reform. To do that a spatial statistical model based on Markov Chains has been developed in order to analyse farmland use changes in the Lombardy Region over the last years.

More specifically, the data in this paper represent the entire population of the region of study, in subsequent years. Thus, for each year, one can explain the past evolution and explore the future developments of farmers' choices of cultivations, to check if and when there has been a significant change. The Markov theory (Norris, 1997) is used to model randomly changing systems, and it is widely applied in recent studies on land-use changes, (see Brown et al., 2000; de Souza Ferreira Filho and Horridge, 2014; Guan et al., 2008; Piet, 2011). In this literature, the Markov theory is often used to model the evolution of a system of parcels. When the emphasis of the evolution is given by the spatial interaction with the neighbourhoods' states, then the system is said to be made by cellular automata (see Ghosh et al., 2017; Fu et al., 2018; Halmy et al., 2015;Palmate, 2017 Sang et al., 2011).

A Markov model assumes that future evolutions depend only on the current state of the system, and not on the events that occurred in the past (that is, it assumes the Markov property). Such assumption makes the model computationally tractable, and easy to be interpreted. This aspect is very important due to the big amount of data that are here used and to their spatial geometrical structure (see Aletti, 2018; Aletti and Micheletti, 2017; Micheletti et al., 2016; Micheletti et al., 2010, for examples in other areas of applications).

The prediction of land use changes from year $t$ to $t + 1$ is explained by the transition matrix $P(t)$, having elements $p_{ij}(t)$, with the following equation

$$S_j(t+1) = \sum_i S_i(t) \bullet p_{ij}(t);$$

where $S_i(t)$ denotes the amount of type-$i$ crops at time $t$, and the summation is made on all the possible land uses $i$. Each element $p_{ij}(t)$ is called transition probability, and explains the conditional probability of adopting the cultivation $j$ at time $t + 1$, conditioned on the fact that one has used the type-$i$ crop at time $t$. A Markov process with transition probabilities that do not depend on $t$ is called stationary, and it models a system whose land-use change does not vary with time. Within this framework, with a suitable model, it is intended to show here that there was a strong discontinuity in the transition matrix just after the introduction of the greening (Table 1).

## 2. GREENING: NORMATIVE ASPECTS AND PREVIOUS EVIDENCE

### 2.1. Greening legislative framework

The adoption of environmentally targeted tools is not new in CAP (see Matthews, 2013a; and Erjavec and Erjavec, 2015 for a review). Since 2000, an important part of CAP second pillar, has been represented by a set of voluntary measures (agri-environmental measures) intended for farmers willing to uptake environmentally friendly practices beyond the baseline established by law. More recently, also payments provided within CAP first pillar have been bonded to environmental contents. An example is represented by cross-compliance, that, since the Mid Term Review of CAP (2003) requires a minimum threshold of environmental friendly behaviours in order to receive first pillar payments. Such standards are represented by Statutory Management Requirements (SMRs), set by previous EU Regulations and Directives, and by Good Agricultural and Environmental Conditions (GAECs), established by each MS. Notably, as both SMGs and a fair part of GAECs are represented by pre-existing compulsory laws, binding the perception of direct payments by farms to their respect, has generated a certain ambiguity. In fact, vesting direct payments as a reward for environmental services, when these are mandatory standards, has become increasingly difficult, in face of societal concerns for public support to European agriculture and increased environmental awareness. (Meyer et al., 2014).

As greening practices represent a step forward with respect to cross-compliance, they are used to justify part of CAP direct payments,