Payments for Carbon Sequestration in Agricultural Soils:
Incentives for the Future and Rewards for the Past

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Abstract


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Agricultural carbon sequestration could be a relatively low cost opportunity to mitigate GHG concentration and a promising means that could be institutionalised (McCarl and Schneider, 2000). While comparing different countries, the position given to carbon sequestration in their strategy to reduce GHG emissions has been very diverse. As stressed by Young

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et al. (2007), the US has not ratified the Kyoto Protocol but has been encouraging the use of agricultural and forestry carbon sequestration, whereas the EU has ratified the Protocol as soon as 2002 but without using agricultural soil carbon sequestration in its strategy. Sperow et al. (2003) estimated that agricultural carbon sequestration could account for 40% of the US reduction of GHG emissions needed to abate US emissions at the level of 1990. In Europe, Freibauer et al. (2004) estimated that carbon soil sequestration could have provided 9% of the reductions required in 2005. Schulze et al. (2009) show that Europe should consider the development of land management policies which aim at reducing GHG emissions as a priority. Within the preparation of the next European Common Agricultural Policy (CAP) for the 2014-2020 period, the design of financial supports to promote environmental services is currently under review. The main objective of our article is therefore to analyse and provide theoretical justification to design incentive mechanisms to enhance carbon sequestration in agricultural soils.

Additional carbon quantities in agricultural soils are gained by the implementation of new crops or new management practices. According to Feng et al. (2002) (referring to Lal et al., 1998), the potential for carbon sequestration of US cropland through improved management could be set to 75–208 MMTC/year. Significant illustrations of these practices are conservation tillage and mineral fertilization. However, farmers do not switch spontaneously to costly practices that increase social benefits and the adoption rate is likely to be lower than the socially optimal one. They indeed assess their private costs whilst ignoring the positive externality through higher sequestration that enhances social benefits. Schneider (2002) states these costs as adjustment costs, opportunity costs, stickiness, market changes, and environmental and international co-effects. The great heterogeneity that can be observed between countries regarding the use of different management practices reflect the heterogeneity of sequestration costs. For instance, Weersink et al. (2005) state that the profitability of reduced tillage is not significantly different compared to the profitability of conventional practices, that is consistent with the observed common use of both tillage methods in Canada. Kurkalova et al. (2006) notice that switching to conservation practices does not always imply
a monetary sacrifice for farmers; they indeed observe that even without any subsidy, on average more than one third of the US acres are in conservation tillage. Nevertheless, in Europe the practices that have the highest sequestration rates are also the less profitable (Pendell et al., 2007) as well as in many developing countries, such as in West Africa, according to Gonzalez-Estrada (2008). As a consequence, policymakers usually have to counteract direct costs while inducing sustainable sequestering practices to increase carbon sequestration in soils. To this end, they have the opportunity to propose monetary transfers as subsidies to bring about suitable practices. Two kinds of subsidies are mainly available for a policymaker: a per-tonne subsidy and a per-hectare or lump-sum subsidy.

In the literature, some studies have shown that the role of history (past crops and practices) and the nature of agricultural soils lead indeed to a great spatial heterogeneity about the potentials of additional carbon sequestration which prevents from implementing standard regulation policies. This heterogeneity involves high monitoring costs if the regulator is concerned about rewarding farmers accordingly to their results. Kurkalova et al. (2004) point out the difficulties encountered by a regulator willing to differentiate payments between farmers in the absence of field-scale measurement technologies. Moreover, one important effect of switches toward more sequestering practices is that they generally bring about other external effects. Plantinga and Wu (2003) point out the important environmental co-benefits provided by an afforestation program in Wisconsin. Nevertheless, this is a still ongoing debate to assess if the positive externalities are greater than the negative ones. Another encompassing view of this range of issues consists in considering agriculture as a provider of various ecological services (Dale and Polasky, 2007), such as preservation of landscape that should be paid as Payments for Environmental Services (PES). Antle and Diagana (2003) have already mentioned the need to consider co-benefits of carbon sequestration.

The research question we challenge is the following one: how could the policymaker induce more carbon sequestration in agricultural land whilst taking into account heterogeneity in potential for additional carbon sequestration? We bear in mind that the regulator cannot observe without prohibitive costs this heterogeneity among plots of land, even in the same
region (or even among plots belonging to the same farmer). This asymmetric information through private information on the farmers side depicts a so-called hidden information or adverse selection setting. Furthermore, picking sequestering practices could imply changes in the use of fertilizers and pesticides and could generate positive or negative externalities such as variation in the groundwater pollution. This generates another kind of failure and requires a more sophisticated regulation policy whilst taking into account the positive externality of sequestering carbon as well as the joint co-effects. Asymmetric information indeed prevents a regulator from using first-best economic instruments as long as farmers get information rents. In this paper, we set incentive mechanisms to enhance carbon sequestration as a principal-agent relationship between a regulator and agricultural firms. The originality in our paper is that we build a model on two different streams of the theoretical literature: on the one hand, optimal exploitation of the exhaustible resource represented by the potential of additional carbon sequestration (Dasgupta and Heal, 1974, 1979) under the assumption that the sequestration costs increases with the amount of carbon already stored\(^1\), and on the other hand mechanism design (Myerson, 1979; Baron and Myerson, 1982; Baron, 1989; Laffont and Martimort, 2002). Our contribution is to specify differentiated contracts in order to induce truthful revelation by the firms regarding their intrinsic characteristics towards carbon sequestration (following Wu and Babcock (1996) or Canton et al. (2009) except that spatial targeting of our measures would be impossible due to the monitoring costs), and we analytically characterize the optimal path to sequester carbon.

From our theoretical framework, a few important results emerge. Firstly, we show that incomplete information slows the sequestration process, advances the end of the sequestration activities and increases the unexploited potential of carbon sequestration (or equivalently decreases the quantity of carbon stored at the end of the contract). Secondly, the proposed

\(^1\) Most empirical studies (INRA, 2002) demonstrate that the sequestration process is essentially non linear. After a move toward more sequestering management practices, carbon sequestration increases rapidly, then slows down to reach a maximum level depending on the nature of the soil, of the crops and on the practices themselves. Insights show that it is not possible to sequester an infinite quantity of carbon on a given plot of land. The adoption of particular practices for a given crop enables to sequester a finite quantity of carbon that is an absolute potential for carbon sequestration associated to these crop and practices. Our cost function allows us to represent this specific sequestration path.
contract has the advantage to avoid the inefficiency of the per-hectare subsidy as well as
the excess cost of the uniform per-tonne subsidy; in addition, it overcomes the unfairness
of the incentive mechanism mentioned by Kurkalova et al. (2004) by not penalizing pre-
cocious adopters of more sequestering practices. We introduce a participation constraint
type-dependent in order to acknowledge the previous effort of the farmers who have accepted
before the policy to incur some sequestration costs, and to prevent them to decide to switch
back to less sequestering practices. This amount stands for the opportunity cost for not
releasing all the carbon already sequestered before the policy implementation. After the end
of the sequestration process, the contract must entail a non decreasing subsidy in order to
deter any moral hazard and induce conservation. Thirdly, we take into account the further
co-benefits or the potential negative externalities due to carbon sequestering practices and we
spotlight the need to slow down or to accelerate sequestration depending on the paramount
externality in a given geographical area.

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