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Analysis

# Ex-ante evaluation of policy measures to enhance carbon sequestration in agricultural soils

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ABSTRACT

In the course of climate change, sequestration of soil organic carbon (SOC) has gained importance as a compensation for carbon emissions. Moreover, the promotion of SOC is increasingly advocated as a measure to sustainably increase crop yields and reduce agricultural production risks. Applying an incentivized extra-laboratory experiment, we evaluate the factors and policy measures that affect the decision to promote SOC using a sample of German farmers. Our results reveal that farmers were highly motivated to promote SOC. Political fostering through subsidy payments increased farmers' efforts to build SOC. Efforts remained constant if economically equal payments were designated as certificates rather than subsidies. Surprisingly, certificates with uncertain payments increased farmers' efforts to enhance SOC to a similar degree as subsidy and certificate scenarios, which provided fixed and therefore certain payments. Thus, these results contribute valuable information regarding the effectiveness of market-based policy measures which aim to include farmers in climate protection strategies.



## 1. Introduction

It is commonly agreed that the climate is changing due to anthropogenic greenhouse gas (GHG) emissions. Carbon dioxide ($CO_2$) plays a particularly important role since it accounts for 78% of total GHG emissions between the years 1970 and 2010 (IPCC, 2014). In the last three decades, the goal of bringing a halt to global warming emerged. However, the prospect of a warming "hiatus" was rebutted in a recent article by Karl et al. (2015), indicating that global warming is still increasing. Surface warming and climate change are associated with negative consequences for life on earth, such as species extinctions and disruptions to ecosystems (Thomas et al., 2004; Orr et al., 2005). Furthermore, extreme weather events, such as droughts and floods, cause yield losses for agricultural production, which worsens hunger throughout the world (Rosenzweig and Parry, 1994; Piao et al., 2010).

In order to mitigate climate change and its consequences, the European Union (EU) signed the Kyoto Protocol and committed itself to a 20% reduction in GHG emissions by 2020 compared to levels in 1990 (Eurostat, 2016; UBA, 2016). One relevant sector for GHG emissions is agriculture, which accounted for approximately 9.9% of the EU's total GHG emissions in the year 2014 (Eurostat, 2016). However, to date, the EU has no binding quantitative GHG emission reduction targets for the agricultural sector, nor for emissions from agricultural soils (Lünenbürger, 2013; BMUB, 2014).

Most recently, the Paris Agreement, a global climate policy agreement aiming to achieve a sustainable future with low carbon emissions, went into force (UNFCCC, 2016, 2017). One section (Art. 5) of the agreement deals with *sinks and reservoirs* for GHGs, encouraging countries "to conserve and enhance, as appropriate, sinks and reservoirs of GHGs" (UNFCCC, 2016). Currently, the Paris Agreement has been ratified by 132 countries, including the EU (UNFCCC, 2017). Regarding the latest developments in climate policy, literature provides evidence that in recent years, the scientific focus on climate protection and GHG emission has also extended to agricultural soils, as these are an important resource for carbon mitigation (Smith et al., 2000). Furthermore, agricultural soils have a huge carbon sequestration capacity (Freibauer et al., 2004; Lal, 2004). Freibauer et al. (2004) indicated that agricultural soils in the EU have the capability to sequestrate 2% of anthropogenic carbon emissions, while Lal (2004) suggested a worldwide sequestration potential for agricultural soils ranging from 5% to 15% of anthropocentric carbon emissions.

However, estimations of the soil's carbon sequestration potential as well as estimations of carbon losses vary greatly (Lal, 2004; Smith et al., 2008). There are several reasons for this, such as different scientifically acknowledged methods to measure carbon pools and fluxes (Stockmann et al., 2013), or the high spatial variability of soil organic carbon (SOC) (Conant and Paustian, 2002). Apart from these analytical limitations, the sequestration potential is subject to further limitations, such as the non-linearity and finite nature of the accumulation capacity (Freibauer et al., 2004; Lal, 2004; Desjardins et al., 2005). After the implementation of SOC increasing practices (e.g. conservation tillage,

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cover crops, mulching), sequestration is highest in the first 5 to 20 years and then decreases until a saturation point is attained after a period of 20 to 100 years (Freibauer et al., 2004; Lal, 2004; Desjardins et al., 2005). Thus, the potential to balance carbon emissions with carbon sequestration is bound to a specific window of time. Furthermore, carbon sequestration processes generally "depend on soil texture and structure, rainfall, temperature, farming system, and soil management" (Lal, 2004: 1623), and are of a non-permanent nature, since the soil represents an open system with dynamic gains and losses (Freibauer et al., 2004). Nevertheless, Lal (2004): 1624/25 describes carbon sequestration as "a natural, cost-effective and environment-friendly process" that "buys us time until the alternatives to fossil fuels take effect". In this context, farming practices that mitigate carbon losses from soil and promote $CO_2$ sequestration can be described as "carbon farming" (Australian Government, 2012).

This presents an opportunity for policy interventions to promote agricultural techniques to increase soil carbon sequestration. Market-based instruments (MBIs) are of great importance since these policy measures could either be used to increase carbon sequestration or to penalize those whose land use strategies do not actively stop carbon losses (Djanibekov and Villamor, 2017). The latter could be realized through the implementation of a punitive carbon tax "as it would oblige $CO_2$ emitters to pay for the alleged damage to the climate" (Pirard, 2012: 60). If farmers are sanctioned by a tax for emitting $CO_2$, this could be a promising approach to reduce emissions (Djanibekov and Villamor, 2017). However, conversely, it might not be the best possible tool to enhance farmers' carbon sequestration efforts.

To increase carbon sequestration on farms, Pirard and Lapeyre (2014: 113) propose "incentive mechanisms that aim at orienting agents towards environmentally-friendly behaviours" such as subsidies or certificates. Agri-environmental Measures (AEM) within the Common Agricultural Policy (CAP) are a descriptive example for subsidies, as the EU provides payments for farmers based on their ecosystem services (Pirard, 2012). Comparable mechanisms have also been developed in the US (Claassen et al., 2008). An advantage of subsidies is that farmers are familiar with this kind of policy measure. Furthermore, subsidies might also be promising in terms of voluntary adoption of carbon sequestration practices, as farmers are rewarded for additional effort, without being obliged to participate (Pirard and Lapeyre, 2014). In a broader definition, many financial incentives, including the aforementioned subsidies, could also be understood as payments for environmental services (Wunder, 2005; Pirard, 2012).

Tradable permits for pollution, such as certificates, are also a commonly used MBI (Pirard, 2012), mainly established for the electricity generating sector and industry to enhance an overall reduction of GHG emissions (Ellerman and Buchner, 2007). In Europe, the Emission Trading Scheme (ETS) is a prominent example of certificate trading within the first multinational cap-and-trade system to limit GHG emissions (Zhang and Wei, 2010). Agricultural GHGs are not considered in the ETS, whereas Australia's *Carbon Farming Initiative* allows farmers to earn carbon credits by adopting techniques that reduce carbon losses from the soil and promote carbon sequestration. These credits can then be sold to parties wishing to balance their emissions (Australian Government, 2012). Some scholars argue that in terms of $CO_2$ reduction, political preference should be given to such MBIs as first best solutions (Rogge and Hoffmann, 2010; Rogge et al., 2011). However, Pirard (2012) indicated that the markets of tradeable permits are very dependent on the current political will, and thus often only provide voluntary agreements which are not credible.

In the context of evaluating potential MBIs to mitigate GHG emissions, Metcalf (2009) discussed a carbon tax and a cap-and-trade-system of marketable permits for emissions to reduce GHGs in the US. However, his study does not focus on a specific sector. In the context of carbon sequestration in agricultural soils, MBIs have been investigated by Pautsch et al. (2001), who highlighted potential costs of different subsidy programs that promote conservation tillage as a tool to sequester carbon in Iowa. Kurkalova et al. (2004) also assessed the costs of a subsidy program that enhances the adoption of conservation tillage in Iowa. Furthermore, the authors estimated the benefits of a practice-based policy compared to a performance-based policy. Glenk and Colombo (2011) designed different policies to mitigate the agricultural contribution to climate change and thereby focused on soil-based carbon sequestration and its co-benefits. However, this study did not include MBIs in the estimation process. The farmers' perspective on the adoption of carbon farming activities was most recently investigated by Dumbrell et al. (2016). By applying the best-worst scaling method among 43 farmers, they found a high preference in Australian farmers for farming activities which are easy to implement and reduce soil carbon losses, such as stubble retention and no-till cropping. Adoption was also influenced by the co-benefits each activity provided, e.g. less soil erosion and higher soil fertility due to reduced tillage. However, the authors did not evaluate the influence of MBIs on adoption rates.

As the literature reveals, there are currently only a few studies that focus on MBIs from the farmer's perspective (e.g. Cacho et al., 2014; Povellato et al., 2007). However, to our knowledge studies did not focus on effects of various MBIs on SOC in the European context. Europe has not yet been in the focus of investigations on MBIs that support carbon sequestration as a measure to mitigate climate change. Since the EU aspires to take a leading role and has set ambitious targets in international climate protection (Oberthür and Kelly, 2008; Parker and Karlsson, 2010; Eurostat, 2016), it is therefore interesting to gain more information about policy measures which encourage the use of cost-efficient and easily applicable methods to store carbon in agricultural soils (Dumbrell et al., 2016). Germany, as the greatest GHG emitter in Europe and as a country with even more ambitious climate protection goals than those of the EU, serves as an example in this study (BMUB, 2014; UBA, 2016). In a recently published study, experts from China, India, Russia, and the US describe Germany as a role model for environmental protection, as well as for economic and technological reasons (KAF, 2016). Therefore, it is of importance that MBIs for carbon sequestration practices are investigated by and for a country whose policy makers aim to achieve exceptional climate protection. Such an investigation may contribute to achieving these goals and serve as an orientation for other countries that also aspire to halt the progress of climate change (BMUB, 2014).

Regarding the data collection, confronting farmers with potential policy scenarios that do not yet exist, requires the development of an experimental design. This study is the first to conduct an extra-laboratory experiment evaluating the willingness of farmers to promote SOC under three different policy scenarios: subsidies with fixed payments, certificates with fixed payments and certificates with uncertain payments.

With the exception of insights provided by Australia's *Carbon Farming Initiative* (Australian Government, 2012), it is unknown which policy measures are likely to effectively encourage increases in soil organic carbon levels on farms. Based on the great potential of agriculture for climate protection, it is critical to determine which kind of political intervention can best integrate agriculture into climate policy. Thus, we seek to close the research gap regarding policy measures that could increase adoption rates of SOC-promoting techniques. Since the EU, and Germany in particular, have ambitious GHG reduction targets but no binding carbon storage policy for agriculture, we pursue the following three objectives: (1) we examine whether the designation of a policy measure as a "subsidy" or "certificate" affects the willingness of farmers to apply SOC-promoting techniques, even if the same income effects are expected for both measures. (2) Furthermore, we investigate whether uncertainty in the payment structure has an influence on the success of a policy measure. (3) Finally, we evaluate the effect of further personal and farm-specific characteristics on the promotion of SOC.

In doing so, this study gives policy makers important information about farmers' perceptions and therefore enables future adoption of different policy measures based on their designation and degree of