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Policy impact analysis of penalty and reward scenarios to promote flowering cover crops using a business simulation game

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ABSTRACT

Due to an increasing number of biogas plants and the positive qualities of maize as a biogas substrate, the cultivation of silage maize has risen in Germany. However, there are still various reasons for the limitation of the cultivation area of silage maize. Hence, policymakers are currently discussing various alternative biogas substrates and ways to promote their cultivation. One possible alternative is the use of special flowering cover crops with additional ecological benefits. Using a business simulation game conducted with farmers, the present study investigates whether the implementation of a reward and penalty policy will improve the uptake of flowering cover crops in the production programs of farmers. The results indicate that the implementation of these policy measures was followed by a significant increase in the cultivation area of flowering cover crops. The penalty policy leads to a stronger increase in the size of the cultivation area of flowering cover crops than the reward policy, even though the policies have the same income effect for farmers. Furthermore, the results reveal that the cultivation of flowering cover crops is influenced by various socio-demographic variables.

1. Introduction

Fossil energy sources are finite resources that contribute significantly to anthropogenic global warming through the release of CO_2 emissions. Therefore, the German government has decided to promote the expansion of renewable energy sources with the 'Act on granting priority to renewable energy sources' [1]. This act determines the remuneration for electricity generated from renewable energy sources and aims to realize a 35% and 85% share of renewable energy in total electricity generation by 2020 and by 2050, respectively.

Due to the profitability and possible income stabilization, many farmers have invested in renewable energies [2]. In Germany, the number of biogas plants increased between 2002 and 2012 from 1600 to 7515 with a total installed capacity of 3.352 GWh [3]. Moreover, the total electricity production from biomass is the second most important source of renewable energy with a share of 27.7%, after wind power with a share of 35.3% [4]. Thus, the cultivation of energy crops,

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such as maize and whole crop silage, has increased sharply. In 2013, energy crops for fermentation in biogas plants were grown on a total surface area of 11,570 km^2 [5]. The cultivation of energy maize accounts for 8000 km^2 of the aforementioned surface area [6].

Due to its high yield of dry matter and its energy content, maize is the preferred crop for biogas production [7]. The expansion of energy production from biomass, however, is not necessarily considered to be positive as it can lead to serious environmental problems, such as the pollution of ground water by nutrients or the loss of organic matter in farmland [7]. For the future development of electricity production from biomass, it is essential to reconcile the production of biogas substrate and nature conservation. An initial step for policymakers in Germany is to restrict the use of silage maize and grain, including corn-crop mix, grain maize, and ground ear maize in biogas plants to 60 mass fraction, which is anchored in the 'Act on granting priority to renewable energy sources' and became effective on 01.01.2012 [1].

A variety of alternative biogas substrates, such as cup plant, Sudan grass and sorghum, have been discussed [8–10]. In addition, the fermentation use of silage produced from flowering cover crops in biogas plants is being explored. Initial results show that flowering cover crops are well suited for fermentation in biogas plants [11,12]. Further advantages include low input, the creation of habitats for wildlife, as well as the increasing acceptance shown by the positive public response to fields that are used for, or surrounded by, flowering cover crops. Bees and other insects use the flowering crops as a food source and wildlife offer these crops cover along with a secure place to deliver. The harvest takes place in October when most flowers are withered and the animals and insects have left the field [11,12].

For the aforementioned reasons, a political goal could be the integration of flowering cover crop cultivation into the production programs of farmers. However, the introduction of a new policy is accompanied by high costs [13]. Prior to the introduction of a policy, a policy impact analysis is essential in evaluating whether a policy measure is effective. The development of models which simulate the consequences of a policy implementation may be an opportunity [14,15]. Frequently used models for policy impact analysis assume a perfect rationally behaving profit maximizer [16]. However, it is often discussed that assuming profit maximizing behavior is not appropriate [17–19]. Explanatory approaches regarding the concept of utility maximization suppose that people maximize their utility and, therefore, various objectives, such as making profits, risk aversion, traditions, recreational activities, or social recognition are pursued [20]. Another explanatory approach is the bounded rationality [21]. Thus, models assuming rational decision makers could reflect the distorted consequences of policy implementation. These limitations can be addressed by experiments which are not based on decisions given through exogenously predetermined theories. Instead, we observe the real decisions of real people. In both laboratory experiments and in business simulation games, it is possible to set incentives for motivating participants to make well-conceived decisions [22]. Business simulation games make it possible to design a realistic decision-making situation, resulting in a significant advantage compared to classical laboratory experiments [23]. Thus, they seem to be especially suitable for policy impact analysis.

This study explicitly examines the farmers' reaction to the implementation of policies in order to promote the share of flowering cover crops in the agricultural landscape. For this purpose, the multi-period, single-person business simulation game is developed. Additionally, the participant farmers will be confronted with different policy measures. The following questions will be addressed in the business simulation game:

1. Does the implementation of reward and penalty policies have an impact on the proportion of flowering cover crops in the production programs of the farmers?
2. Is either a reward or a penalty policy with the same income effect more effective?
3. Does the policy change lead to the cultivation of flowering cover crops as a biogas substrate?

The novelty of this paper lies in the policy impact analysis that is geared towards implementing flowering cover crops in the production programs of farmers. In recent years, studies have dealt with flowering crops and their environmental benefits, with primary research focusing on the nature conservation concept and the impacts on biodiversity [24,25]. Vollrath et al. [11] and Vollrath and Werner [12] investigated the benefits of flowering cover crops as a biogas substrate. To our knowledge, there are no publications that address the individual effect of policies to increase the quantity of flowering cover crops in the agricultural landscape. Furthermore, a new aspect to this research is that a business simulation game conducted with real decision makers – in our case farmers – is used for the policy impact analysis.

The article is structured as follows: First, the behavioral theoretical hypotheses are derived (Section 2). Sections 3 and 4 explain the experimental design and sample characteristics. The results are presented in Section 5 and the article concludes with a summary and a discussion of future opportunities (Section 6).

2. Hypothesis generation

Reward and penalty strategies encourage human compliance through the use of rules and laws and, in this way, establish a social order [26]. Penalty payments pursue a strategy of deterrence in order to prevent rules being broken, whereas rewards present an incentive to direct human behavior in a desired direction [27]. Accordingly, it is assumed that a reward and a penalty policy strategy can direct the behavior of farmers, so that the cultivation of flowering cover crops is extended. Thus, the following hypothesis can be derived:

H1. Regardless of whether the policymakers introduce a reward for growing flowering cover crops or a penalty with the same income effect for not growing flowering cover crops, the share of flowering cover crops in the production program of farmers will increase.

In the economic literature, it has been hinted that the effects of penalty policies differ from reward policies [26]. Kahneman and Tversky [28], as well as Kahneman et al. [29] found