POLICY IMPACT ANALYSIS OF PENALTY AND REWARD SCENARIOS TO PROMOTE FLOWER STRIPS USING A BUSINESS SIMULATION GAME

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Abstract

In germany the cultivation of silage maize has risen due to the increasing number of biogas plants and the good qualities of maize as biogas substrate. But, various reasons speak for the limitation of maize. So the policy may be promoting alternative biogas substrates. A currently much discussed biogas substrate is the use of a special floral seed blend. A business simulation game is used to investigate whether the implementation of a reward and a penalty policy will improve the uptake of flower strips in the production program of farmers. The results indicate that the implementation of these policy measures have a promoting effect on the cultivation area of flower strips. The penalty policy leads to a stronger increase in the growing area of flower strips than the reward policy, although the policies have the same income effect.

Keywords: policy impact analysis, flower strips, experimental economics, business simulation game

1. Introduction

Fossil energy sources are finite resources and contribute significantly to anthropogenic global warming by the release of CO_2 emissions. Therefore, the German government has resolved to promote the expansion of renewable energy sources with the "Act on granting priority to renewable energy sources" (Deutscher Bundestag 2011). This governs the remuneration of electricity from renewable energy sources and was last adjusted in 2012. Its goal is to realize a 35% share of renewable energy in total electricity generation by 2020 and 85% by 2050 in Germany.

Due to the increased remuneration for power derived from renewable energy sources, many farmers have invested in biogas plants. The electricity production from biomass, with a share of 26.7%, is the second most important source of renewable energy behind wind power with a share of 33.3% (Statistisches Bundesamt 2012). The importance of renewable raw materials is also reflected in the strong expansion of biogas plants. From 2001 to 2011, the number of biogas plants increased from 1,300 to 7,320 with a total installed capacity of 2,997 megawatts throughout Germany (Fachverband Biogas e.V. 2012). Because of this, the cultivation of energy crops such as maize and whole crop silage increased sharply. In 2012, energy crops for fermentation in biogas were grown on a surface of 962,000 ha. This consisted mostly of energy maize with 800,000 ha (Fachagentur Nachwachsende Rohstoffe e.V. 2012).

The expansion of energy production from biomass however is not necessarily viewed positively and is attracting increasing public criticism. "The creation of maize deserts" is a catchword which falls within this context (Bosch and Peyke 2011; Steinhäußer 2012). However, due to its high conversion of dry matter to energy, maize is the preferred crop for biogas. A conflict of interest has arisen between parts of the public that demand the cultivation of less maize, and farmers that require cultivation to be profitable (Steinhäußer 2012).

For the subsequent development of electricity production from biomass, it is essential to reconcile the interests of farmers and the public. An initial step in policy is to cap off the use of energy maize and grain, including corn-crop mix, grain maize, and ground ear maize in biogas plants to 60 mass percent, which is anchored in the "Act on granting priority to renewable energy sources" and became effective on 01.01.2012 (Deutscher Bundestag 2011). A variety of alternative biogas substrates such as cup plant, sudan grass, and sorghum are discussed. In addition, the fermentation of flower strips in biogas plants is being explored. Initial results show that flower strips are well suited. Further advantages include low input, the creation of habitats for wildlife, and also the increasing acceptance shown by the positive public response to fields that are surrounded by flower strips (Vollrath et al. 2010).

For the aforementioned reasons, a policy aim could be the integration of flower strips cultivation into the production program of farmers. But, the introduction of a new policy is accompanied by high costs. Therefore, prior to the introduction, a policy impact analysis is essential to evaluate whether a policy measure is effective or an unintended effect occurs. Human behavior can be characterized by a range of goals, such as making profit, risk aversion, traditions, recreational activities, or social recognition (Benz 2009). In addition, decision-makers act in many cases bounded rational (Selten 1990) and rely on heuristics to decide (Kahneman and Tversky 1979). Rational choice models for policy impact analysis often assume a rational behaving homo economicus (Veetil 2011). Therefore, behavior often does not correspond to the identified expectations. Because of this, rational choice models can reflect the consequences of policy implementation distorted. Experiments and in particular business simulation games offer the opportunity to address this limitation with an appropriate design. In both laboratory experiments and in business simulation game situations it is possible to set incentives to motivate participants to make "good" decisions (Hertwig and Ortmann 2001). Furthermore, the realistic design of the decision-making situation in business simulation games (Levitt and List 2007) is an important advantage compared to classical lab experiments. For these reasons, business simulation games in particular seem to be suitable for policy impact analysis.

This paper shall explicitly examine the reaction of farmers to the approach of policies for increasing the share of flower strips in the agricultural landscape. For this purpose, the developed multi-period, single-person business simulation game is arranged in a way that the farmers are in a realistic farming situation. Furthermore, they will be confronted with different policy measures. The following questions will be addressed:

1. Has the implementation of reward and penalty policies an impact on the proportion of flower strips in the production program of the farmers?
2. Is a reward or a penalty policy more effective?
3. Does the policy change leads to cultivation of flower strips as a biogas substrate?

The novelty of this paper is that the policy impact analysis is geared towards implementing flower strips in the production program of real farmers. Scientists have increasingly concerned themselves in recent years with flower strips and their environmental benefits. Primarily research has considered the nature conservation concept and impacts on biodiversity (Haenke et al. 2009; Haaland and Gyllin 2010). To our knowledge, there are no publications that address the individual effect of policies to increase the quantity of flower strips in the agricultural landscape. Furthermore, a new aspect is that a business simulation game conducted with real 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. Afterwards, the results are presented (section 5). The article ends with a summary and future prospect (section 6).

2. Hypothesis generation

Human behavior is controlled primarily through incentives or penalties. Incentive and penalty strategies lead the human behavior to comply with rules and laws and establish in this way a social order (Tyler 1990). Penalty payments pursue a strategy of deterrence to prevent that rules are broken, whereas rewards represent incentives to direct human behavior in a desired direction (Tyler and Blader 2005). Therefore, there is the assumption that a reward or penalty strategy of the policy can direct the behavior of farmers to extend the cultivation of flower strips. This yields the following hypothesis:

- H1: Regardless of whether the policy introduces a reward for growing flower strips or a penalty for not growing flower strips, the share of flower strips in the production program of farmers will increase.

In the economic literature there are hints that policy approaches which will be implemented by penalties differ with regard to policies with incentive schemes (Tyler 1990). With experiments Kahneman and Tversky (1979) and Kahneman et al. (1991) have proven "Loss Aversion" which states that people weight a monetary loss more heavily than an equally high profit. Concerning the reward and penalty policy, which have the same income effect, it means that the loss of the penalty payment is higher weighted than the reward payment. Even the "Opportunity Cost Effect" supports the assumption that reward and penalty policies differ in their effect. Out of pocket costs like penalty payments are given a higher weight than opportunity costs, which correspond to a loss of reward payments (Kahneman et al. 1991). The following hypothesis can be derived:

- H2: The penalty policy changes the cultivation behavior of farmers regarding the scope of flower strips stronger than the economic equivalent of a reward policy.

Flower strips can be cultivated as nature conservation measure (Hartmann et al. 2006) or as biogas substrate for energy production (Vollrath et al. 2010). The implementation of policy measures to increase the share of flower strips directs the assumption that the cultivation of flower strips can complement the production of a biogas substrate. Thus the following hypothesis is derived:

- H3: The establishment of reward and penalty policies would promote that flower strips are grown as a biogas substrate.

3. Design of the experiment

The experiment is divided into three sections. In the first part of the experiment, the incentive compatible, multi-period, one-person business simulation game is conducted. Subsequently, a Holt-and-Laury lottery (Holt and Laury 2002) takes place to examine the risk attitude of the participants. As a third part, socio-demographic and socio-economic information of the participants are collected.

In the following parts, the general structure of the business game will be explained and the policy measures will be described. The Holt-and-Laury lottery is not discussed further because no changes were made to the methodology presented by Holt and Laury (2002). Furthermore, this method is already established in agricultural economics (Brick et al. 2012).

3.1. Fundamental structure of the business simulation game

The structure of the business simulation game follows a "Framed Field Experiment" (Harrison and List 2004). In the business simulation game, participants put themselves in the situation of the manager of a farm. The yield and price level of production activities correspond to real conditions, where as the price developments and weather risks are reflected as uncertainties. The design is to put the participants into a realistic business situation which results in realistic decisions (Harrison und List 2004). In the business simulation game documented decision behavior is the basis for studying the effect of various policy measures.

Within the framework of the simulation the participants manage a farm with 100 hectares of arable land for twelve production periods. For all participants, the given objective is to attain the maximum profit. Each game turn is a production period and requires the following basic decisions of the participants:

1. Production program decision: The configuration of the production program for the cultivation of the farm land with the production activities wheat, silage maize, sorghum and flower strips.
2. Contract decision: Acceptance of a substrate delivery contract for an adjacent biogas plant for about 0 t, 1,500 t, 3,000 t and 4,500 t of fresh matter. For fulfillment silage maize, sorghum and flower strips can be used.

In the business simulation game (1) deterministic and (2) stochastic parameters are given.

Ad 1). The deterministic parameters apply to all participants and do not change randomly. They are communicated at the beginning of the game. When the simulation starts, each attendant has a starting capital of € 100,000. In each production period, withdrawals in the amount of € 30,000 are made to cover the costs of living. Furthermore, each participant receives after each completed period of production a transfer payment of € 300 per hectare. At the same time, they are informed that amendments may occur during the playing time. A production period is complete when the participants have set their production program and made their contract decisions. All production activities can be grown in a maximum circumference of 70 hectares. Note that the entire farm land must be cultivated with the four crops. There is no possibility to let land lie idle. Winter wheat is only used for selling on the market, while maize is for fulfilling the delivery contract, and also for marketing. The cultivation of sorghum is solely for the production of biogas substrate. Flower strips, in contrast, have two useful alternatives; they can be grown as a substrate for biogas plants or they may remain unused for ecological reasons to create habitat for animals and thus potentially increase biodiversity.

Ad 2). The stochastic parameters change randomly from production period to production period and, therefore, vary between the participants. The market prices for winter wheat and silage maize are volatile. The prices follow an arithmetic Brownian motion starting with an identical starting value for all participants. The market prices decrease or increase, starting with the current price in any production period with a probability of 50% by € 20/t for winter wheat and by € 1.50/t for maize silage. The contracted substrate delivery is remunerated at € 35/t, regardless of whether the biomass is provided with maize silage, sorghum, or flower strips. The delivery contract has to be 100% fulfilled. If this is not the case, then the missing substrate amount of maize has to be bought from the market for twice the current market price of silage maize. Weather conditions will affect yield and, therefore, gross margins. There is a distinction between above-average, average, and below-average weather conditions. The periods of good and bad weather occur each with a probability of 20%. Average weather is expected with a probability of 60%. Above-average weather has the consequence that the yield per hectare of all cultures achieves its maximum, whereas below-average weather leads to a yield drop to the minimum. Both the probabilities and the yields per hectare are communicated at the beginning of the simulation.

Since there are no storage possibilities for crops, all goods are sold at the end of each period at the current market prices. The current prices and the weather conditions of the previous period are communicated at the beginning of each new production interval. Furthermore the participants receive further information about the profit of the production program, contract decisions of the previous production periods, and the observed prices. These observed prices are the starting point for the price changes in the next production period.

3.2. Changes in the policy framework

At the beginning of the simulation, participants are randomly assigned to one of three policy scenarios. During the first six production periods of the simulation, the design is identical for the three policy scenarios. In subsequent production periods 7 to 12, the following policy changes for the three scenarios occur:

- **Scenario 1** (reference scenario): The policy framework remains unchanged over the entire duration of the simulation.
- **Scenario 2** (reward scenario): The participants are informed that the transfer payment decreases by 10% to € 270 per hectare. Simultaneously, the policy introduces an additional premium of € 300 per hectare for sustainable agriculture and promotes acceptance by growing flower strips. The state pays a maximum amount of € 3,000 per farm and in this way subsidizes a maximum cultivation of 10 hectare flower strips.
- **Scenario 3** (penalty scenario): The policy punishes all participants who use less than 10% of their farm land for the cultivation of flower strips. Each hectare lacking to fulfill the growing requirement will incur a penalty of € 300.

Scenarios 2 and 3 do not differ in their profit impact. To compare the scenarios, always three different farmers play the simulation with the same price and weather trends but operate in different policy scenarios.

3.3. Incentives

To achieve incentive compatibility, monetary incentives for "good" decisions are set. A total of two cash prizes are raffled among the planned 120 participants to four farmers. The first cash prize totaling € 1,620 is raffled to three farmers in the business simulation game. Goal for all participants is to maximize their business success. Therefore, the profit depends on the business success. With purely rational behavior, the monetary gain totals to a maximum of € 540 per cash prize. Winners receive the share of the maximum monetary gain that corresponds to their business success. The second cash prize is played in the Holt-and-Laury lottery. In this part of the experiment the participants are aware of the cash prize they could win, that depends on their own decisions. When raffle the trophy, one participant is drawn randomly, and the lottery is carried out. The participant will receive a cash prize ranging from € 10 to € 385, which conforms to his risk attitude.

4. Description of the sample

The experiment was performed at the agricultural exhibition "EuroTier" from the 13th to the 16th of November 2012 in Hanover. Nine hundred and forty-six visitors to the exhibition were contacted directly and invited to participate in the simulation. In total, 123 farmers (13% of those contacted) successfully completed the experiment, with 41 farmers playing in each policy scenario. In average 43 minutes were need to complete the experiment. The socio-demographic and socio-economic characteristics of the participants are shown in table 1.

On average, the participants were 29 years old, with the youngest participant 16 years, and the oldest 62 years old. Thirty-four percent of the farmers managed a farm of their own. The arable land of the agricultural enterprises is on average 245 ha in size. The largest farm has 3,000 ha of arable land. Fourteen percent of agricultural businesses are run as farms farmed on a parttime basis. The sample consists of 12% female participants. The average HLL-value of

5.4 indicates that the participants are slightly risk averse. With the H-test, according to Kruskal and Wallis, it can be shown that the socio-demographic and socio-economic characteristics of the participants in the three policy scenarios do not significantly differ in age (p-value = 0.140), years of education (p-value = 0.961), the HLL-value (p-value = 0.228), and the farmland (p-value = 0.759). In addition, a chi-square test, indicates that there were no significant differences between the participant groups in the percentage of female participants (p-value = 0.800), farm managers (p-value = 0.855), and parttime farms (p-value = 0.273).

Table 1. Socio-demographic and socio-economic characteristics of the participants (N = 123)

Characteristics	Policy scenario 1		Policy scenario 2		Policy scenario 3	
	mean	SD	mean	SD	mean	SD
Age	31.8	12.7	28.8	10.3	27.7	9.4
Percent of female participants	12.2%	-	14.6%	-	9.8%	-
Years of education	13.6	3.3	13.7	3.5	13.8	3.2
HLL-value (a)	5.9	2.0	5.2	2.2	5.1	1.6
Farm manager	39.0%	-	34.1%	-	29.3%	-
Farms farmed on a parttime basis	19.5%	-	7.3%	-	14.6%	-
Farmland in ha	225.5	392.3	196.9	220.4	312.5	617.4

(a) 1-3 = risk seeking, 4 = risk neutral, 5-9 = risk averse

5. Behavioral control impacts of different policy measures on farmers

In the first six production periods, all participants use the same basic conditions. On this basis, one can analyze how the cultivation area of flower strips change when the three policy scenarios appear. The average growing area of flower strips is represented in table 2 for the production periods 1 to 6 and 7 to 12 for each of the three policy scenarios.

Table 2: Growing area of flower strips in the business game (41 participants in each policy scenario)

Policy scenario	Area of flower strips periods 1-6	Area of flower strips periods 7-12
1	10.21 ha	9.88 ha
2	7.92 ha	10.01 ha
3	8.22 ha	12.73 ha
Average	8.78 ha	10.87 ha

The paired t-test shows for scenario 1 (reference scenario), that the growing area in the first six periods does not significantly differ from the growing area in periods 7 to 12 (p-value = 0.732). In contrast, the cultivation area changed significantly with the introduction of a reward (scenario 2) or penalty policy (scenario 3) (p-value = 0.080 and p-value = 0.001 respectively).

There are four initial situations: The cropping areas of flower strips for all three policy scenarios for the first six periods represent the reference situation. The policy scenarios 1 to 3, which occur at the seventh production period, reflect the policy implementation effects. They are referred to in table 3 as dummy scenario 1 to 3 and refer in to the baseline of the first six production periods in the estimated models. Model 1 reflects the effects of the independent variables on the total cropping area of flower strips. Furthermore, models 2 and 3 highlight the effects separately for the cultivation of flower strips for biogas production or nature conservation purposes.

Hypothesis H1 can be seen as being confirmed: Both in reward and in the penalty scenarios, the share of flower strips increase significantly (see Table 3, Model 1). Participants who are con-

Table 3. Pooled regression to declare the growing of flower strips (N = 1.476), robust standard errors

	Model 1 dependent variable: flower strips cumulative		Model 2 dependent variable: flower strips biogas plant		Model 3 dependent variable: flower strips nature conservation	
	Coefficient	t-statistic	Coefficient	t-statistic	Coefficient	t-statistic
constant	26.294	5.084***	10.936	4.024***	15.358	3.802***
Dummy scenario 1	1.204	0.992	0.283	0.336	0.921	1.322
Dummy scenario 2	2.230	1.701*	0.599	0.676	1.631	1.733*
Dummy scenario 3	5.276	4.326***	2.866	3.111***	2.411	2.546**
Profit differencial(b)	-1.483	-1.848*	-0.797	-1.321	-0.686	-1.074
Risk attitude(c)	0.205	0.658	0.164	0.839	0.041	0.170
Additional purchase costs(b)	0.052	2.414**	0.004	0.398	0.048	2.852***
Substrate delivery amount(b)	-1.556	-3.680***	0.123	0.488	-1.679	-4.976***
Age	-0.087	-1.337	-0.076	-2.074**	-0.010	-0.239
Gender(d)	5.485	2.886***	2.686	2.690***	2.796	1.901*
Years of education	-0.585	-2.398**	-0.279	-2.092**	-0.305	-1.897*
Earning power(e)	-7.200	-3.169***	-2.975	-2.406**	-4.225	-2.621***
Profit flower strips(f)	3.805	2.546**	1.358	1.619	2.447	2.362**
F-value	24.060 ***		9.188 ***		23.466 ***	
R^2	0.165		0.070		0.161	

(a) * = p-value < 0.1; ** = p-value < 0.05; *** = p-value < 0.01.
(b) in 1,000 € or 1,000 t.
(c) 1-3 = risk seeking, 4 = risk neutral, 5-9 = risk averse.
(d) 1 = female, 0 = male.
(e) 1 = mainstay farm, 0 = parttime farms.
(f) Do you think it is possible to earn money by growing flower strips? 1 = yes, 0 = no.

fronted with the reward policy grow on average 2.230 hectares more flower strips in comparison to the reference periods 1 to 6. Participants who are confronted with the penalty policy increase their share of flower strips on average by 5.276 hectares. No significant change occurs in the periods 7 to 12 in the reference scenario in comparison to the reference situation of periods 1 to 6. Consequently, the deterrence strategy of the penalty policy and the incentive strategy of the reward policy have effected a change in participant's behavior regarding the growing of flower strips.

Hypothesis H2 can be seen as being confirmed: The implementation of a penalty policy leads to a stronger increase in the growing area of flower strips than implementation of a reward policy (see Table 3, Model 1). A linear restriction reveals that the effects of the reward and the penalty policy differ on a significance level of 10% from each other suggesting that when estimating policy consequences, the "loss aversion" and the "Opportunity Cost Effect" have to be taken into account because these effects influence the awareness of reward and penalty scenarios.

Hypothesis H3 can partly be seen as being confirmed: A penalty policy results in an increase in cultivation of flower strips to produce biogas substrate by 2.866 ha (see Table 3, Model 2). In contrast, the introduction of a reward policy has no significant effect on the cultivation of flower strips for biogas plants. Despite having the same income effect of the policy scenarios 2 and 3, only the penalty policy (scenario 3) achieved a significant increase in the growing of flower strips to produce biogas substrate.

6. Conclusion and outlook

The German government aims the sustainable development of renewable energy. One policy goal can to promote the cultivation of alternative biogas substrates is. Business simulation games are a suitable method for policy impact analysis. The realistic design of the business situation may result in realistic decisions. Therefore, the aim of the paper is to analyze the behavior of the target group "farmers" regarding the implementation of reward and penalty policies to promote flower strips. The participants manage a fictional farm and have to determine in each of the twelve production periods cultivation and contract decisions. During the simulation, they are confronted with the policy measures, which do not differ in terms of their income effect.

The results indicate that both reward and penalty policies lead to an increase of cultivating flower strips. Furthermore, the implementation of a penalty policy affects the behavior stronger than the implementation of a reward policy. The reward policy acts on the cultivation of flower strips for nature conservation, and has no effect on flower strips used as biogas substrate. Therefore, with equal high costs of policy implementation a penalty policy should be implemented. Furthermore, the introduction of a penalty policy achieves that flower strips are used as biogas substrate.

Further research is needed to investigate the influence of socio-demographic effects on cultivation decisions. This could improve the effectiveness of policy implementations. Of interest, however, is the broader question how to design behavior-controlling policies that farmers grow increasingly flower strips as biogas substrate in order to guarantee the sustainable energy production from biogas plants. Further initial points for research could relate to contract design, which can be investigated with business simulations games.

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