Self-selection as a problem in evaluating agri-environmental programs

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Abstract

Since participation in agri-environmental programmes is voluntary, associated with opportunity costs (most of these programmes aim at reducing output), and financial compensation for participation is typically a fixed amount per hectare, a tendency is likely to arise for some sort of self selection: farms in favourable regions which face high opportunity costs from foregone output are less likely to participate than other, more disadvantaged farms. When trying to estimate the effects of such programmes on agricultural output, this self-selection bias can pose severe problems, as a direct comparison of participants with non-participants is likely to lead to erroneous results. This paper tries to highlight the effects of this self-selection process in the context of the Austrian OEPUL programme and its effects on grain yields. After identifying various sources of this problem, some possible remedies are presented and discussed.

The empirical analysis is based on farm-level accounting data linked with the official agricultural support data (INVEKOS) for a sample of 1327 Austrian grain farms. Two years of data before (1993 and 1994) and one year (1997) after EU accession are utilized to estimate programme effects on grain yields.

Keywords: evaluation, agri-environmental programmes, self selection

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1 Introduction

Since participation in agri-environmental programmes under EU Regulation 1257/99 (and 2078/92 before) is voluntary, a major problem in evaluating their effects is the so called self-selection bias. Farmers are participating only in those programmes for which additional economics benefits (mainly direct payments) exceed additional costs (often forgone profits through lower output). In the extreme case, a farmer may participate in a programme, but doesn't change his farming practices compared to what he would do without the programme being in place. As an example, think of a farmer who would farm organically, either because of higher market prices or because of personal conviction, no matter if she receives direct payment or not. This problem of self-selection is especially severe since most programmes pay a fixed amount per hectare not considering differences in participation costs. As an example one might compare the costs of participation in organic farming between a farmer in the mountainside and a farmer in a favoured area; opportunity costs, especially foregone yields, might be much higher for the second one.

The aim of this study is to reveal and to some extent quantify this self-selection bias in regard to the output show that effects of agri-environmental programmes. In particular, we try to divide the observed differences in yields between participants and non-participants into a part caused by programme participation and a part that would also exist with no programme in place, caused by economic and natural differences between these two groups. To do so, we look at ten agri-environmental programmes in connection with cereal production in Austria in 1997. Although this focus might seem somewhat restrictive, these ten programmes however account for about 12% of all EU expenditures for agri-environmental programmes.

To look at output effects is interesting for two reasons: first, being part of the so-called Accompanying Measures of the 1992 Reform, programmes launched under the Regulation 2078/92 are supposed to support the overall goal of the 1992 Reform: output reduction. In fact "reducing or stabilizing production levels" was beside "safeguarding farm income" and "improving environmental quality" an explicitly stated goal of this regulation. Therefore, many programmes have tried to reach all three goals by compensating farmers for practicing less intensive production methods. In addition, in the context of the GATT-Uruguay Agreement agri-environmental programmes are policies under the Green box, i.e. are supposed to 'have no, or at least minimal trade distorting effects or effects on production' (Annex 2 of the Agreement of Agriculture, signed in Marrakech).

The rest of this study is organized as follows: We first shortly described the ten agri-environmental programmes analysed. In Section 3 we lay the theoretical basis for the empirical analysis in section 4. We finish in section 5 with a discussion of our results.

2 Austrian Agri-environmental programme

The Austrian agri-environmental OEPUL-programmes (*Austrian programme for the promotion of extensive farming methods compatible with requirements of environmental protection and the maintenance of the countryside*) were introduced in 1995, the year after EU-accession consisting of 25 individual measures (Groier and Loibl, 2000). Here we concentrate our analysis on ten programmes relevant for grain production:

1.) Elementary support: very general conditions including compliance with good farming practice and limitation of animal units per hectare.

2.) Organic farming: in accordance with EU Regulation 2092/91 on organic farming. In addition, restricted to 2 animal units per hectare

3.) Non-application of agro-chemicals, whole farm: Same regulations for crop production as for organic farming. No restriction to animal production except a restriction to 2.5 animal units per hectare.

4.) Crop rotation scheme: a maximum of 75% of arable land may be used to produce cereals and maize; a winter cover crop covering at least 15% of arable land must be planted before November 1 an may not be ploughed under before December 1.

5.) Extensive cereal cultivation: cultivation limited to low-yield varieties; non-application of growth regulators or fungicides; non-application of sewage sludge; maintaining the grassland area.

6.) Non-application of growth regulators

7.) Non-application of easily soluble commercial fertilizers and growth regulators

8.) Non-application of easily soluble commercial fertilizers and synthetic chemical crop protection agents

9.) Non-application of fungicides

10.) Non-application of synthetic chemical crop protection agents

The first four programmes require the farm as a whole to participate, while the rest allows for partial participation (e.g., that only 15% of a farm's tilled acreage are managed according to a programme's stipulations).

In 1997 these ten programmes accounted for about 68% of the total expenditures for agri-environmental programmes (Groier and Hofer, 2002) in Austria. Since in 1997 Austria accounted for about 21% auf the total EU budget for agri-environmental programmes, these ten programmes accounted for about 12% of all EU expenditures for agri-environmental programmes.

Farmers can participate in more than one programme at the same time and do so as illustrated in Table 1.

Table 1: Distribution of farmers with regard to the number of participations

participation in	Number of farms
no programme	45
1 programme	50
2 programmes	199
3 programmes	629
4 programmes	431
5 programmes	31
6 programmes	1

As depicted in Table 2 participation rates were highly unequal between programmes, ranging from a high of almost 94% for elementary support (#1) to a low of under 1% for non-application of synthetic chemical crop protection agents (#10).

A straightforward procedure to investigate the effects of the agri-environmental programmes on output (and therefore indirectly on the environment) would be to compare the yields between participants and non-participants. However, this would ignore the self-selection bias, i.e. the fact that participants and non-participants might have different yields even without the programmes in place. In other words, there is a bias towards farms with low yields (and therefore lower opportunity costs in restricting an input) participating in agri-environmental programmes.

For all programmes participants exhibit significantly different relative yields as compared to non-participants. A relative yield of 103 for non-participants in organic farming means that their yields are 3% above the yield of the whole sample, while a value of 77 for organic farmers implies yields which are 23% lower than for the whole sample. However, participants also exhibit significant different farm characteristics. For example, farms which have

participated in programmes organic farming (#2) and non-application of agro-chemicals (#3) are much smaller (14 and 8 ha of tilled area vs. an average of 24 ha for all farms), are less specialized (with a share of tilled area of less than 50%, compared with almost 70% for all farms), and face less favourable production possibilities (as captured by area unit values which are less than 2/3 of average unit values) as the average farm. This is a first indication of the possibility of a severe self-selection bias. Therefore, to estimate the influence of participation on yields, one has to account for other influences, originating from economic and natural conditions.

Two of these ten programmes already existed in Austria before EU accession: organic farming and the crop rotation scheme. The first imposed the same regulations on participants, but direct payments were considerably lower. The average support per hectare in 1994 was € 96, while it was € 246 in 1997 (BMLF, 1995, Hofer and Groier, 2002). The crop rotation scheme before accession was basically the same as OEPUL programme #4.

Table 2: Average farm characteristics for participants and non-participants

		all farms		#1	#2	#3	#4	#5	#6	#7	#8	#19	#10
# of farms in programme		1327	abs.	1244	154	33	1141	511	823	35	24	83	12
			[%]	93.7	11.6	2.5	86.0	38.5	62.0	2.6	1.8	6.3	0.9
relative yield	[%]	100.0	non-part.	96.7	103.0	100.5	94.1	97.4	95.9	100.1	100.1	99.7	100.1
			participants	100.2	77.3	82.2	101.0	104.2	102.5	96.1	96.0	103.8	92.3
tilled area	[ha]	23.7	non-part.	18.1	25.0	24.1	11.0	15.6	22.1	23.9	23.9	22.8	23.8
			participants	24.1	14.1	7.8	25.8	36.6	24.7	16.4	13.1	37.5	19.3
share of tilled area	[%]	69	non-part.	68	72	70	52	57	63	70	70	68	69
			participants	69	49	35	72	88	73	55	47	80	73
area unit value	[1000 ATS]	11.3	non-part.	10.5	11.8	11.4	9.1	9.9	10.4	11.3	11.4	11.3	11.3
			participants	11.4	7.3	6.1	11.7	13.5	11.9	10.4	7.8	11.8	7.8
animal units per ha	[AU/ha]	0.9	non-part.	1.2	.9	.9	1.2	1.1	.9	.9	.9	.9	.9
			participants	.9	.8	1.0	.8	.5	.9	1.1	1.1	.8	1.0
machinery stock	[ATS/ha]	552	non-part.	599	510	501	1131	749	794	534	551	566	551
			participants	548	865	2528	457	237	403	1181	596	341	561

#1: Elementary support,
#2: Organic farming,
#3: Non-application of agro-chemicals, whole farm,
#4: Crop rotation scheme,
#:5 Extensive cereal cultivation,
#6: Non-application of growth regulators,
#7: Non-application of easily soluble commercial fertilizers and growth regulators,
#8: Non-application of easily soluble commercial fertilizers and synthetic chemical crop protection agents, ,
#9: Non-application of fungicides, #10: Non-application of synthetic chemical crop protection agents.

3 Method

To reveal to what extent observed differences in yield between participants and non-participants of agri-environmental programmes are due to programme participation and to what extent they are due to structural difference we proceed as follows: In order to be able to compare yields of different kinds of grain (we looked at wheat, rye, oats, barley), but also because of a better interpretation of parameter values estimated later on, we constructed an index of relative yields for every farm in the following way: the relative yield of farm *i* for grain *j* (v_i^j) is given by

(1) $v_i^j = \frac{V_i^j}{\bar{V}^j}$, *i = 1, . . . , n* farms, and *j = wheat, rye, barley, oats*,

where V_i^j is the absolute yield of farm *i* for grain *j* and $\bar{V}^j$ is the average yield for grain *j* over all *n* farms. The relative yield of farm *i* over all *j* grains (v_i) is given by

(2) $v_i = \frac{\sum_j \left(v_i^j F_i^j \right)}{\sum_j F_i^j}$, *i = 1, . . . , n* farms, and *j = wheat, rye, barley, oats*,

where F_i^j is the area farm *i* allocates to grain *j*. Hence, v_i is the weighted average of the relative yields of all grains.

Observed relative yields of farm ***i*** in 1997 ($v_{i,1997}$) can be explained by a vector ***X*** of environmental (soil, climate, weather, …) and economic factors (farm size, specialisation, management, …) and by a dummy vector ***D*** of programme participation:

(3) $v_{i,1997} = \alpha + \beta \boldsymbol{X}_{i,1997} + \delta \boldsymbol{D}_{i,1997} + \varepsilon_i$,

For programmes including the whole farm ***D*** is set to 1 for participation and 0 for non-participation. For programmes including only specific crop areas ***D*** is set to the ration between participating and total crop area. If vector ***X*** represents the true model, i.e. includes all important natural and economic factors, parameter vector δ directly estimates the average effect of participation. For example, a parameter value of δ_1 = -0.07 would imply a 7% lower yield for participants on average.

To reveal self selection we compare equation (3) to a naive specification where

(4) $v_{i,1997} = \alpha + \delta'' \boldsymbol{D}_{i,1997} + \varepsilon_i$.

Hence, in contrast to Table 2 equation (4) considers that farmers may participate in more than one programme at the same time. However, it does not consider that there are economic and natural difference between different areas, while equation (3) does.

Finally, we also look at the marginal effect of introducing these ten ÖPUL programmes in utilizing a difference-in differences approach for the average of 1993/94 and 1997. Starting from equation (3) and assuming a similar relationship for 1993/94 (but of course no participation dummies, we derive

(5) $(v_{i,1997}\ v_{i,1993/94}) = \alpha' + \beta'(\boldsymbol{X}_{i,1997} - \boldsymbol{X}_{i,1993/94}) + \delta' \boldsymbol{D}_{i,1997} + \varepsilon_i$.

Parameter vector **δ'** gives us the additional (marginal) effect of introducing these ten OEPUL programmes, while δ might be interpreted as an "average" effect. A good example to explain the difference between marginal and average effect might be organic production. Since some of the farmers participating in the organic farming programme in 1997 already did organic farming in 1994 the difference-in-differences estimation (5) can only include the effect on yields of those farmers who switched to organic production between 1994 and 1997, but

distribute their decrease in yields over all participants in 1997 – thus, the difference-in-differences approach is likely to under-estimate the full effect due to organic farming.

4 Results

The utilized data consist of farm accounting data linked with the official agricultural support data (INVEKOS) for a sample of 2053 (approximately 1 % of all) Austrian farms. Two years of data before OEPUL programme was in place (1993/1994) and one year of data with OEPUL being in place (1997) are available. Of these 2053 farms, 1327 farms produced grain in all three years of observation.

Table 3 gives the results for the naive specification in equation (4). As mentioned dummies are set to one if a farm participates in one of the four programmes including the whole farm and are between 0 and 1 for participation in all other programmes depending on the share of the acreage in the programme to total area under tillage.

Table 3: Differences in yield between participants and non-participants

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.98	0.02	42.95	0.00
Elementary support	0.08	0.02	3.14	0.00
Organic farming	-0.37	0.02	-16.55	0.00
Non-application agro-chemicals	-0.32	0.04	-8.48	0.00
Crop rotation scheme	0.09	0.02	5.41	0.00
Extensive cereal cultivation	-0.11	0.02	-5.23	0.00
Non-appl. growth regulators	-0.12	0.02	-6.46	0.00
Non-appl. fertilizers & growth reg.	-0.20	0.05	-3.73	0.00
Non-appl. fertilizers & pesticides	-0.28	0.12	-2.31	0.02
Non-application fungicides	-0.21	0.07	-3.10	0.00
Non-application pesicides	-0.36	0.12	-2.92	0.00
Adjusted R-squared	0.21			

This naive specification estimates the difference in yields between participants and non-participants including both, differences implied by the programmes and differences that would exist even without the programme. Participants in eight programmes have significant lower yields between –37% for organic and –9% for extensive cereal cultivation. For two programmes, elementary support and the crop rotation scheme, the yields of participants are significantly higher than those of non-participants.

To get an idea to what extent these measured differences would also exist even if no programme were in place, we try to capture the economic and natural conditions of farmers in equation (3) by vector (*X*) of economic and natural variables which are:

AREA: tilled area as a proxy for economies of scale; expected sign: + .

RATIO: the ratio of tilled to total farm area as a proxy for specialization; expected sign: +.

UVH: unit value per hectare: this is a variable compiled for tax purposes; it includes soil characteristics, climate etc.; expected sign: +.

AUH: animal-units per hectare to somehow account for the unrecorded amount of manure, which is typically disposed on the field; expected sign: + .

In addition, to better account for natural differences as well as specific weather conditions in specific areas in 1997 we add dummies for the 89 different production areas (Kleinproduktionsgebiete) as defined in Schwackhöfer (1996) and Wagner (1990a, 1990b) to account for regional differences not covered in the variables a) – d).

DREGION1 - DREGION88: production region 1 to 88.

Results in Table 4 reveal that the coefficients for variables a) to d) are significant and have the expected sign (Results for the production region dummies are not reproduced here because of space limitations, but are available upon request. Jointly, they are highly significant). The two programmes organic farming and non-application of agro-chemicals are grouped to one explanatory dummy since they basically ask for the same requirements in regard to cereal production and quantitative results were not significant different between these two. The adjusted R^2 of 0.43 is reasonable for a cross-section estimation.

Table 4: Differences in 1997-yields from participation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.43	0.17	2.50	0.01
Elementary support	0.09	0.02	3.81	0.00
Organ. farm. & non-appl. agro-chem.	-0.23	0.02	-10.90	0.00
Crop rotation scheme	0.04	0.02	2.45	0.01
Extensive cereal cultivation	-0.04	0.03	-1.76	0.08
Non-appl. growth regulators	-0.07	0.02	-4.14	0.00
Non-appl. fertilizers & growth reg.	-0.13	0.05	-2.69	0.01
Non-appl. fertilizers & pesticides	-0.12	0.11	-1.12	0.26
Non-application fungicides	-0.08	0.06	-1.25	0.21
Non-application pesicides	-0.19	0.11	-1.70	0.09
AREA_97	0.00	0.00	3.03	0.00
RATIO_97	0.09	0.03	2.57	0.01
UVH_97	0.01	0.00	7.65	0.00
AUH_97	0.08	0.01	7.02	0.00
DREGION1-88				0.00
Adjusted R-squared	0.40			

It is obvious and expected that compared to the naive specification in Table 3 the parameter values of participation dummies are lower since variables a) – d) explain some of the differences observed in Table 3. If variables a) - d) are able to explain all existing structural differences, parameters values of dummy variables reveal the average effect of programme participation. For example, the average effect on yields in participating in the programmes organic farming or non-application of agro-chemicals is 23%. Being aware that maybe not all economic and natural conditions are covered by our model, this result can be interpreted as the average difference between participants and non-participants to be 23% or less. Two programmes have no significant effect on yields (non-application of growth regulators, non-application of easily soluble commercial fertilizers and growth regulators) and two have a positive effect (elementary support and crop rotation scheme).

To test how good our model is to account for economic and natural differences we estimate the same model as described in equation (3) for the average data of 1993/1994. If the model accounts for all relevant differences, the dummy variables for programme participation in 1997 should be not significant if applied to 1993/1994 data. Table 5 reveals that six out of nine dummies are not significant. In addition, that the dummy for organic farming and non-application of agro-chemicals is significant is expected, since a similar programme already existed in 1993/1994.

Table 5: Test if the differences in yield implied from economic and natural differences are captured by the model (average 1993/94-yields)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.44	0.16	2.77	0.01
Elementary support	0.05	0.02	2.29	0.02
Organ. farm. & non-appl. agro-chem.	-0.15	0.02	-7.76	0.00
Crop rotation scheme	0.02	0.02	1.36	0.18
Extensive cereal cultivation	-0.01	0.02	-0.55	0.58
Non-appl. growth regulators	-0.05	0.02	-2.84	0.00
Non-appl. fertilizers & growth reg.	-0.07	0.05	-1.41	0.16
Non-appl. fertilizers & pesticides	-0.01	0.10	-0.07	0.94
Non-application fungicides	-0.01	0.06	-0.22	0.83
Non-application pesicides	-0.09	0.10	-0.91	0.36
AREA_9394	0.00	0.00	4.20	0.00
RATIO_9394	0.11	0.03	3.27	0.00
UVH_9394	0.11	0.02	6.77	0.00
AUH_9394	0.06	0.01	5.99	0.00
DREGION1-88				0.00
Adjusted R-squared	0.44			

Finally, Table 6 illustrates the results for the difference-in-differences estimation (again, the – jointly highly significant - coefficients for the production region dummies are not reported in table 5). As mentioned the results show the additional impact of the introduction of the OEPUL Programme. A significant additional effect is only confirmed for organic farming and non-application of agro-chemicals. It is estimated to be 7%. The big difference to the average effect of 23% can be explained by the fact, that only about 2/5 of farms being in these two programmes used conventional farming methods in 1994[3].

Table 6: Difference-in-differences estimation (1997 – 1993/94)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.03	0.18	0.17	0.86
Elementary support	0.03	0.02	1.37	0.17
Organ. farm. & non-appl. agro-chem.	-0.07	0.02	-3.30	0.00
Crop rotation scheme	0.02	0.02	1.13	0.26
Extensive cereal cultivation	-0.04	0.03	-1.34	0.18
Non-appl. growth regulators	-0.02	0.02	-1.04	0.30
Non-appl. fertilizers & growth reg.	-0.06	0.05	-1.16	0.25
Non-appl. fertilizers & pesticides	-0.09	0.11	-0.81	0.42
Non-application fungicides	-0.06	0.06	-0.95	0.34
Non-application pesicides	-0.08	0.12	-0.70	0.48
(AUH_97 – AUH_9394)	0.07	0.02	3.07	0.00
DREGION1-88				0.00
Adjusted R-squared	0.44			

[3] As participation data on pre-OEPUL-programmes was not available, this share was estimated by looking at data on purchases of plant-protective agents. The application of most of these is banned for participants in programmes 2 and 3. Therefore, farms which in 1993/94 did not show „significant" amounts of such purchases were thought to have already used comparable (i.e., organic) farming practices. When defining this „insignificant amount" of agri-chemicals as per-hectare-purchases which are less than 10% of the amount used by typical farms, 109 (or about 60%) of the 187 participants in programmes #2 and 3 seem to belong to this group.t

(Remark: assuming that about 60% of participants in programmes 2 & 3 already used similar farming practices in 1993/94, and that consequently these farms do not show a "marginal effect" in their yield, the full treatment effect of programmes 2 & 3 might roughly be calculated as some 2.5 (=1/0.4) times the estimated effect as shown in table 6. The effect thus calculated, 2.5 x (-0.07 %) ~ -18 %, approaches the cross-section difference between participants and non-participants, estimated at about –23 % (cf. table 4). This tendency, though not the absolute level, can be reproduced in a difference-indifferences regression when including "farms in programmes 2&3 which exhibit change in farming practices" (78 farms) and "farms in programmes 2&3 which exhibit no change in farming practices" (109 farms) as separate dummies. In this regression, the yield difference of no-change farms is estimated at (insignificant) –3 %, whereas the yield difference of farms which did change their farming practices is estimated at (highly significant) –13 %).

5 Discussion

Output effects of agri-environmental programmes, but also of other direct payment policies become more and more important in the political debate, especially in the WTO. To what extent these direct payments are decoupled will determine if they are accepted as legitimate national policies or condemned as trade distorting policies. To what extent agri-environmental programmes really decrease output is hard to evaluate. Because participation in these programmes is voluntary, critics might argue that there is a large self-selection bias, i.e only those farmers participate in extensification programmes which are not producing very intensively anyway.

An important political question is, if agri-environmental programmes are expected to decrease output or if it is enough to give farmers an incentive to not intensify further. While most of the programmes analysed seem to have a significant negative impact on yields on average, an additional effect of the introduction of these ten programmes can only be verified for organic farming and non-application of agro-chemicals. For all other programmes it seems that participating farmers do not change their behaviour much with participation. This supports the view of a strong self-selection bias.

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