Farmers' participation in agri-environmental programs and impact on farm performance: an empirical analysis applied to Swedish agriculture

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Abstract

Compensatory payments for agri-environmental measures related to arable and pasture land management constitute a significant share of the total direct payments to farmers' in many countries today. In Sweden, 25% of the direct payments to farmers are in form of agri-environmental payments. In this study, farmers' decision to participate in the programs, the level of participation (measured in hectares) and impact from participation on farm performance (measures by profitability) is analysed using data from Swedish farms for the years 1998-1999. Heterogeneity among farms/farmers, in terms of different levels of fixed inputs (such as land) and farm/farmer characteristics (such as managerial characteristics, location, type of farming etc), imply that the acreage devoted to agri-environmental programs differ among farms. The average impact from program participation on farm performance is, as expected, positive and the results moreover suggest that the impact on profitability varies with the location of the farm.

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1. Introduction

The main objective of most agri-environmental programs, including the one in Sweden/EU, is to reduce the environmental damage from agriculture and to maintain open landscapes and cultural environments. However, these payments may also serve as income support to the farmers. The total agri-environmental subsidies paid to Swedish farmers in 2003 were 2, 211 million SEK, which corresponds to 25% of all direct payments to Swedish farms (Statistics Sweden, 2004). The three largest progams, that together constitute approximately 80% of the total agri-environmental payments in Sweden today, are measures related to preservation of grazing lands, management of open landscapes and organic production.

A farmer's required compensation for participating in an agri-environmental program is likely to be determined by factors that affects the cost of participation but also by non-economic factors such as attitude and awereness. The costs associated with participation include both foregone revenues from agricultural production (because some program practices implies lower expected yields since they do not allow the use of certain inputs) and costs associated with adopting and maintaining program practices (such as the cost of maintaining grazing lands or constructing wetlands). The participants in an agri-environmental payment program also make a decision about the extent, the level, of participation, i.e. how many hectares that will be devoted to the program and how many hectares that will be kept in conventional production. Under the very simplifying assumption that a farmer maximizes profits and is risk-neutral, he/she will choose to participate in an agri-environmental program only if the profit is equal to or larger than otherwise and the acreage devoted to the program will be choosen where the subsidy level equals the marginal value of land in conventional production (opportunity cost of land)[2]. Thus, factors that determine the opportunity cost of land should also explain the participation/level of participation in agri-environmental programs.

From a policy maker's perspective, the objective is cost-effectiviness of the program. Cost-effectiveness requires that the objective the program is achieved at the lowest possible cost for society. Thus, the objective of the payment program must first of all be determined. Another consideration is whether the payment program is constrained by a budget, which in practice always is the case. Cost-effectiviness subject to a budget constraint requires that the farmer receive his/her minimum required compensation form participation in the program.

[2] There are studies that suggest that some agri-evironmental measures, such as organic farming, are considered as more risky compared to conventional farming (see for example Kuminoff and Wossink, 2005). If this is the case, the farmers required compensation will also include a risk premium.

Knowledge about what factors that determines the farmer's choice of participating in an agri-environmental payment programs for different groups of producers is thus interesting from a policy point of view. Moreover, an estimate of farmer's "minimum required compensation" for the provision of an environmental service is desirable to obtain.

The objective of this study is to analyze the determinants of participation, the level of participation (measured in land) as well as the impact on farm performance (and ultimately the farmers minimum required compensation for program participation) from participation in agri-environmental programs. By analysing the effects of the present subsidy programs, some conclusions is possible to make concerning for efficincy of the present program.

There is an extensive amount of literature dealing farmers participation in agri-environmental programs. Two recent examples are Damianos and Giannakopoulos (2002) who analyze farmers' participation in agri-environmental schemes in Greece and Boisvert and Chang (2005) who looks at farmers' participation in the Consvervation Reserve Program (in the US) and impact on farm productivity and efficiency.

The outline of the paper is the following. First, the agri-environmental programs in Sweden and the objective of each program are described. Thereafter, the empirical models are presented followed by a description of the data used in the empirical application. Finally, the results are discussed.

2. Agri-environmental programs in Sweden

The agri-environmental program in the CAP (Common Agricultural Policy), that applies to all member countries of the European Union (including Sweden) and is co-financed by EU and the member country, aims to reduce the environmental damage from agriculture and to preserve open landscapes and cultural environment (European Commission, 2005). Swedish farms can receive compensatory payments for between nine and eleven different agri-environmental measures (depending on where the farm is located), of which the three largest are compensatory payments for preservation of grazing lands, open landscapes and organic production.

Agri-environmental programs in Sweden can be divided into two main groups; programs related to arable land management and programs related to pasture land. The programs related to arable land management compensate farms for agri-environmental measures undertaken on arable land, and includes input reduction measures, organic farming, conversion of arable land to grazing land and hay fields and preservation of natural or cultural elements on, or in connection to, arable land. The second type of program compensates farmers for preservation of grazing land hay fields on pastureland. The arable land management programs are further decompesed into programs where the farmer is compensated for agricultural production on arable land while following the program regulations (for example organic farming and input reduction measures), programs that compensate maintainance of arable that is not used in crop production (for example open landscapes) and compensation for natural and cultural elements on, or in connection to arable land.

The agri-environmental payment program was revised in 2000, why we distinguish between the “old program”, before 2000, and the “current program”, that is valid until 2006 (see Table 1). The duration of the commitments is five years in both the current and the old program (an exception is the 20 year commitment for wetlands). Therefore, some of the payments in the old program were still paid after 2000 and it was possible to receive payments from both programs at the same time. The compensations are uniform for some programs and differentiated for others (by region or crops/animals). For example, the payment for organic production depends on which crop and/or livestock that are produced wheraes the payment for grazing land and hay field is the same for all farms. The payment for open landscape is differentiated for five production regions and additional requirements to receive the payments are imposed for some of the regions. An overview of the agri-environmental payment programs, the objectives of the programs and type of compensation for each program can be found in Table 2 (for the current program). Figure 1 shows the size of total agri-environmental payments to Swedish farms during the time period 1997-2003.

Table 1. The largest agri-environmental programs in Sweden (the new and the current program).

Old program (before 2000)	**Current program (2000-2006)**
Open landscape	Open and diversified landscape
Organic cultivation	Organic production
Catch crops	Reduced nitrogen leakage
Wetlands	Wetlands
Protection areas	Protection areas
Pasture ground, many years	Nature and culture environments
Cultural Environment	
Preservation of grazing lands	Preservation of grazing lands and hay fields
Preservation of hay fields	

Table 2. The main agri-environmental payment programs and to farmers in Sweden (the new programs) divided by type (The Swedish Board of Agriculture, Statistics Sweden, own construction).

Agri-environmental program	Objective of program	Type of compensation
Open and diversified landscape	Preserve and prevent retirement of arable land by compensating farmers for maintainance of grazing ground and hay fields on arable land.	Differentiated by region
Organic production	Increase crop and livestock production with organic production methods	Differentiated by type of crop/animals
Reduced nitrogen leakage	Compensate farmers for measures undertaken to reduce nitrogen leaching (through catch crops and/or spring cultivation).	Uniform
Wetlands	Construction and maintainance of wetlands in order to reduce the nitrogen leaching and improve the biological variety.	Uniform compensation for maintaince. Compensation for construction differ by region.
Protection areas	Compensate farmers for construction of protection areas in order to reduce leakage from agricultural land.	Uniform
Nature and culture environments	Compensate farmers for maintainance of certain landscape elements that preferably origins from the time before 1940 in, or in connection to, arable land.	Uniform base payment. Differentiated by element.
Preservation of grazing lands and hay fields	Preserve and enhance natural and cultural values.	Uniform

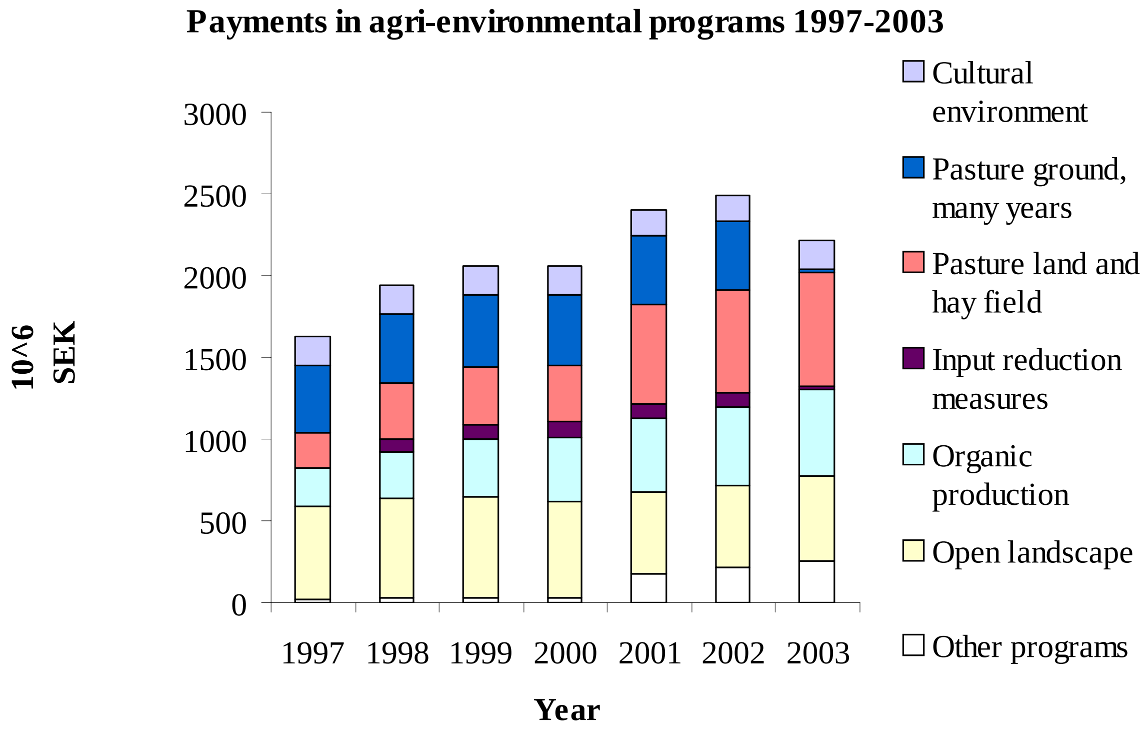

Figure 1. Payments for agri-environmental measures for the period 1997-2003 divided by program (Statistics Sweden, own construction).

The nature of the agri-envisonmental measures differs and we can distinguish between three different types of measures in agri-environmental programs:

- *Type 1:* Programs that compensate the farmer for agri-environmental measures on arable land that is used in the production of agricultural products. Organic farming may serve as an example. Input reduction measures (the old program) may serve as another example.
- *Type 2:* Programs that compensate the farmer for agri-environmental measures on arable land that is not used for crop production. Open landscape may serve as an example since the objective of this program is to prevent retirement of arable land by compensating farmers for maintainance of grazing and meadows on arable land.
- *Type 3:* Program that compensate farmers for preservation agri-environmental measures on pasture land (for example the preservation of grazing lands on pasture land).

An empirical observation is that the level of participation (the number of hectares/animal units devoted to the program) varies among participants in an agri-enviroinmental program (see Table 3 in section 5).

4. Empirical analysis

The empirical analysis is divided in two parts. In the first part, factors that influence the farmer's decision to participate in an agri-environmental program are analyzed. Participation decisions are often analyzed using a binary choice model such as the logit or probit (where in our case the dependent variable could be 1 if the farm is a participant in the agri-environmental subsidy program and 0 otherwise). However, because the farmer makes two choices - whether or not to participate in the agri-environmental subsidy program and the level of participation given participation - both the participation decision as well as the level of participation may be of interest to analyse. A so-called "hurdle" or "threshold-crossing" model, originally suggested by Cragg (1971), can be used for this purpose. These types of models involve both an analysis of the participation decision as well as of the level of participation.

In the second part of the analysis, the effect on farm performance of participation in the agri-environmental program on farm performance is analyzed. Profitability, calculated as Return on Assets (ROA) is used as a measure of profitability. In order obtain unbiased estimates of program participation on farm performance, potential endogeneity of the participation choices is accounted for by using instrumental variables.

Thus, the empirical analysis is conducted in the following two steps:

1. Determinants of the farm's participation in the agri-environmental subsidy program as well as determinants of the level (acreage and animal units) of participation are analyzed.

2. The effect of participation on farm performance (profitability) is analyzed.

4.1. Determinants of participation and level of participation agri-environmental programs

Farmer *i*´s choice to participate in agri-environmental program *m* is described by the following equation where I_{im}^* is an underlying latent variable:

$$I_{im}^* = \alpha_m ' Z_{im} + e_{im} \quad (1)$$

where

$I_{im} =$ 1 if $e_{im} > -Z_{im}\alpha_m \quad i = 1,..., N;$ (farm *i* is a participant of program *m*)

0 otherwise (farm *i* is a non-participant of program *m*)

Given that a farm participates in the agri-environmental program *m*, the amount produced is analyzed by estimating equation (18).

$$LP_{Eim}^* = \beta_m ' X_{im} + u_{im} \quad (2)$$

where

$LP_{Eim} =$ LP_{Eim}^* if $u_{im} > -Z_{im}\beta_m \quad i = 1,..., N;$ (participant)

0 otherwise (non-participant)

As argued earlier, the participation choice will be determined by factors that affects the farm's cost of participation (opportunity cost of land). Thus, the explanatory variables (the vectors Z_{it} and X_{it}) include variables that explaines the productivity/profitability of a farm. The explanatory variables will be discussed in more detail in next section.

The model described above is a so-called double-hurdle model and estimation of this model was originally discussed by Cragg (1971). The log-likelihood function of the model can be found in Jones (1989). This log-likelihood function can however be decomposed if restrictions on the joint distribution of the error terms, *u* and *e*, are imposed. If *u* and *e* are independent, the model reduces to the so-called "Cragg model". If it is assumed that the participation decision dominates the consumption decision, so called "first hurdle dominance", the log-likelihood function reduces to Heckman's generalized Tobit (the sample selection model). In this case, the decision to be a non-participant is considered as a separate discrete choice rather than a standard corner solution. When independence and dominance can be assumed at the same time ("Complete dominance"), the model reduces to a probit part and an OLS part (Jones, 1989).

4.2. The effect of program participation on farm performance

In the second part of the empirical analysis, the impact of program participation on farm performance is analyzed. An interesting objective of such an analysis would be to obtain an estimate of the farmer's "minimum required compensation" for the provision of an agri-environmental service (preferably also for different groups of farmers in order to analyze weather payments should be differentiated or not). Since the choice of method for this type of analysis is not obvious, we will begin by an overview of potential methods. Two groups of methods when the participation choice is treated as binary are the following:

1. Comparsion performance measures among participants and non-participants. This can be done by, for example, using a switching regression framework where determinants of farm performance are analyzed for the two groups separately. Potential endogeneity of the participation choice[3] can be accounted for when using this method by including error correction terms (inverse Mill's ratio) as an explanatory variable in the estimations[4] (see for example Heckman 1979 and Lee 1978). Alternatively, determinants of farm performance could be analyzed for the whole sample simultutaneusly while including a dummy variable to indicate participation (instrumental variable estimation could be employed to correct for potential endogeneity of the participation dummy). An overview of these types of methods is provided in Maddala (1993).
2. Calculation of compensation required by the farmer based on option value theory (see for example Kuminoff and Wossink, 2005). An appealing feature of this approach is that an estimate of the required compensation can be obtained that includes a risk premium.

It should be noted that the methods to evaluate the effect on farm performance from program participation that treats the participation decision as binary may not be appropiarate because of the following reasons: i) Farmers receive compensation for several different types of agri-environmental measures and nature of these are substantially different (see previous). ii) The level of participation (measured in hectares) in a given agri-environmental programs differ substantially among participants and non-participants (see Table 3).

[3] There are reasons to believe that a farmer's choice to participate in an agri-environmental program is not random. Assuming that farmers act as profit maximizers, a farmer with high productivity in conventional farming would require a higher compensation than a farmer with low productivity in conventional farming (since the opportunity cost of land is higher for the more productive farmer).
[4] A related approach is the so-called propensity score, originally suggested by Rosenbaum and Rubin (1983). The idea of propensity scores is to match participants and non-participants who have the same or similar predicted probabilities to obtain an unbiased estimate of the treatment effect.

However, the impact of participation on farm performance will here be analysed by estimating model (3) were the coefficient of the participation dummy (*D*), γ, is a measure of the average impact of participation on farm performance.

$$FarmPerformance = \alpha + \beta X + \gamma D + \varepsilon \qquad (3)$$

where

FarmPerfomance	is measured by **ROA (Return on Assets),** i.e. net returns over total farm assets**;**
D	is a dummy indicator for participation in agri-environmental program (***D=1*** if the farm is a participant ***0*** if non-participant);
X	is a vector of other explanatory variables such as farm/farmer characteristics.

The dependent variable, Return on Assets (ROA), is calculated as

ROA = (Total revenues **-** Total costs + Net cost of interest **-** Depriciation) / (Total farm assets)

There are a few things one should note when using ROA as a measure of farm performance. For example, the value of land and buildings is generally lower in the northern part of Sweden which will reduce the value of Total farm assets and thus increase the value of ROA. However, ROA should still be an accurate measure of the net return on invested capital. It might also be accurate to substract the value of the families labour since this is not included as a cost (this was not done here however).

A second think to note is the potential endogeneity of the participation dummy variable. It is reasonable to expect that farms that have a higher performance when they participate in the agri-environmental programs are more likely to participate. Therefore, the dummy variable for farm performance might be endogenous. If the potential endogeneity of the participation dummy is not considered for, the parameter estimates might be biased. Therefore, the above model is estimated using 2SLS where potential endogeneity for the particpation dummy is considered. The number of animal units is used as an instrument (as many of the programs directly or indirectly require that there are animals on the farm). A test for the validity of animal units as an instrument could not reject that it is a valid instrument[5].

[5] The cofficient of the variable “animal units” was significant at a 5%-level when used as a regressor in the participation choice equation.

5. Data

The data utilized in the empirical application consists of FADN-variables for the time period 1998-1999 combined with information about the farms participation and level of participation (measured in hectares) in the various agri-environmental programs. The information about the farms participation in agri-environmental programs was provided by the Swedish Board of Agriculture. FADN (Farm Accountanct Data Network) consists of accountancy data from a sample of agricultural holdings that are representative with respect to region, economic size and type of farming. In Sweden, the FADN-variables are available for about 1000 farms each year and about 100 of the farms are replaced each year. The total number of observations for the period 1998-1999 is 1926. 1598 of the sample farms (83%) participate in at least one agri-environmental program. On avarge, the participating farms are larger (the value of total output is signicicantely higher for this group as well as the level of all inputs).

In Table 2, the average value of total output, aggregate mesures of inputs and farm/farmer characteristics are presented for all farms in the sample as well as separately for participants (those farms that participate in at least one agri-environmental program) and non-participants. “Value of total output” consists of total revenues from crop and livestock production. “Capital” is the user cost of capital (machinery and buildings). The labor input is measured in hours and consider both paid and unpaid labor. “Other expenses” includes expenses for other inputs such as seed, feed and fertilizer. Farm charactersics such as age of farmer, rented land and share of hired labor are also presented. Dummy variables for production regions are available (Sweden is divided into eight production regions, see Appendix) and the share of sample farms located in each region is displayed in Table 2. Specialized crop farming is indicated with a dummy variable.

Table 2. Description of data (year 1998 monetary values).

Variable	Unit	All sample farms (N=1926)		Participants in agri-environmental program (N=1598)		Non-participants (N=328)	
		Mean	St.dev	Mean	St.dev.	Mean	St.dev.
Value of total output	thousand SEK[†]	814.5	971.1	879.4	1,000.6	498.5	728.9
Production factors							
Capital	thousand SEK	373.2	313.7	386.6	319.7	308.8	275.3
Arable Land	Ha	74.2	78.5	78.0	81.0	55.7	61.7
Pasture Land	Ha	19.8	49.5	22.5	53.0	6,5	21.2
Labor	Hours	3460	2387	3606	2457	2357	1612
Energy	thousand SEK	35.4	48.1	36.2	45.4	31.7	59.7
Other expenses	thousand SEK	376.4	467.0	387	479	325	397
Farm/farmer characteristics							
Age of farmer	Years	49.0	10.0	48.6	9.8	50.6	10.8
Rented land	Share	0.41	0.38	0.42	0.37	0.36	0.40
Hired labor	Share	0.070	0.17	0.072	0.17	0.06	0.17
Production area*	Share						
Area 1 - Nö		0.15		0.12		0.25	
Area 2 - Nn		0.14		0.14		0.12	
Area 3 - Ssk		0.15		0.14		0.18	
Area 4 - Ss		0.15		0.13		0.25	
Area 5 - Gns		0.26		0.28		0.15	
Area 6 - Gsk		0.05		0.05		0.03	
Area 7 - Gmb		0.06		0.07		0.006	
Area 8 – Gss		0.05		0.06		0.015	
Production specialization	Share						
Crop		0.29		0.23		0.57	

[†] SEK = Swedish Kronor

* The production regions used are the ones used in Agriwise (2005) and are shown on a map in Appendix. I.

In Table 3, the average environmental subsidies paid to the farms in the sample as well as the average amount of hectares for which subsidies are received are presented (along with standard deviations) for the three largest programs. For all three programs, there are large variations in the level of participation (number of hectares devoted to the programs) as well as the compensatory payments share of total farm income.

Table 3. Descriptive statistics of subsidy paid to farmers in the sample and hectares of land that subsidies are received for (for some programs).

		Average for participants in agri-envoronmental program (Standard deviation)	
Agri-environmental program	Share of farms that participate in the program	Hectares in program	(Payment received)/(total revenues)
Open landscape	0,44	36,2 (31,0)	0,06 (0,07)
Organic cultivation	0,17	39,8 (59,5)	0,09 (0,1)
Conservation of pasture land	0,27	18.5 (29.6)	0,05 (0,08)

6. Results

The results of the estimation of the participation and level equations, for participation in any agri-environmental program and for each program separately, are presented for the three largest programs in Table 4. The double-hurdle model was estimated assuming "first hurdle dominance" which implies that the farmer's decision to participate in an agri-environmental program is considered as a discrete choice and not as a marginal adjustment (Jones, 1989). It should be noted that the parameter estimates cannot be interpreted as marginal effects on the participation- and level decisions in these types of models. However, the sign of the parameters should be the same as the marginal effects.

For all programs, the probability for a farm to be a participant increases as the size of the farm (in terms of land) increases. As can be expected, the level of participation increases as the size of the farm increases. The results furthermore suggest that the localisation of the farm has a significant impact on the probability of being a participant in an agri-environmental program. However, given that the farm is a participant, the localisation has no significant impact on the level of participation. Age of the farmer has, in most cases, no significant impact on the participation choice or the level of participation. Production specialization has in most cases an impact on the participation decisions, but not always on the level of participation.

Table 4. Determinants of participation and level equations (standard deviations within brackets). N=1928

Variable	*Any agri-environmental program*		*Conservation of grazing lands*		*Organic production.*		*Open landscapes*	
	Part. Equation	Level Equation	Part. Equation	Level Equation	Part. Equation	Level Equation	Part. Equation	Level Equation
Constant	0.50*	-121***	-2.2***	38***	-1.09***	-151	0.34	13
	(0.27)	(43)	(0.26)	(18)	(0.24)	(113)	(0.26)	(10)
Share of	-0.64**	11	0.019	-15**	0.58**	17	-0.58**	13
hired labor	(0.25)	(34)	(0.24)	(7.5)	(0.25)	(43)	(0.27)	(8.2)
Share of	0.065	21	0.085	9.7**	0.19**	27*	0.19**	-0.25***
rented land	(0.098)	(12)	(0.094)	(3.3)	(0.10)	(15)	(0.19)	(0.083)
Age	-0.0039	-0.33	0.0038	-0.33*	-0.00038	0.24	-0.0026	-0.25***
	(0.0035)	(0.44)	(0.0034)	(0.12)	(0.0037)	(0.39)	(0.0036)	(0.083)
Regions								
P1 - Nö	-0.46**	-59**	0.54***	23**	-0.80***	-58	-2.2***	-23
	(0.21)	(26)	(0.20)	(9.1)	(0.19)	(49)	(0.22)	(16)
P2 - Nn	0.024	4.7	1.3***	13	-0.30*	-8.6	-0.98***	6.5
	(0.22)	(21)	(0.19)	(10)	(0.17)	(23)	(0.19)	(6)
P3 - Ssk	-0.17	-23	1.0***	14	-0.12	9.3	-1.9***	-11
	(0.21)	(21)	(0.19)	(9.6)	(0.16)	(17)	(0.20)	(13)
P4 - Ss	-0.32	-38	0.98***	5.4	-0.13	16	-1.7***	1.0
	(0.22)	(22)	(0.20)	(9.4)	(0.17)	(18)	(0.20)	(11)
P5 -Gns	-0.060	9	0.69***	8.6	-0.38**	-24	-0.24	4.5
	(0.21)	(18)	(0.18)	(8.5)	(0.15)	(25)	(0.18)	(2.8)
P6 -Gsk	-0.19	-7.6	0.68***	4.0	-0.38*	-8.5	-0.54**	1.5
	(0.27)	(26)	(0.23)	(9.9)	(0.21)	(30)	(0.23)	(4.5)
P7-Gmb	-0.091	-2.7	0.44**	-0.010	0.44**	26	0.11	-1.3
	(0.27)	(23)	(0.21)	(9.3)	(0.18)	(28)	(0.24)	(3.3)
Dummy for specialized production								
Crop	-0.22**	-52***	-0.28***	1.52	-0.48***	-66**	-0.082	-6.0
	(0.090)	(15)	(0.10)	(4.0)	(0.12)	(30)	(0.11)	(3.9)
Dairy	1.2***	125***	0.44***	0.37	0.29***	21	1.13***	14**
	(0.098)	(29)	(0.088)	(3.8)	(0.094)	(18)	(0.091)	(7.8)
Arable land	0.000036**	0.010***	0.000042***	0.00014	0.000022***	0.0024**	0.0000010	0.0024***
	(0.0000055)	(0.00095)	(0.000007)	(0.00020)	(0.0000062)	(0.0011)	(0.0000065)	(0.00016)
Pasture land	0.000028*	0.0043***	0.000058***	0.0012***	0.000019**	0.0037***	0.000016**	0.00031
	(0.000015)	(0.00088)	(0.000010)	(0.00020)	(0.0000080)	(0.00087)	(0.0000079)	(0.00020)

***,**,* indicate statistical significance at 1, 5 and 10% respectively

The parameter estimates and standard deviations of the 2SLS-estimation of the farm performance equation are reported in Table 2. The model was estimated with and without dummies for production regions and separately for each of the eight production regions. The first column reports the results when dummies for production regions are included. None of the dummies for production regions are significant at a 5%-level. The parameter of the participation dummy is 0.089 and signifikant at a 1%-level. Thus, this estimate suggests that participation in agri-environmental programs increases the profitability of the average farm by 8.9%. In the second column, the results of estimation without the production region dummies are reported. For this model, the parameter of the participation dummy is 0.12 and significant at a 1%-level. Thus, both models suggest that the impact from participation in agri-environmental programs is positive and significant (8.9-12%) for the average farmer.

The remaining eight columns report the results when the model is estimated for each production region separately. An intersing finding is that the impact from participation on farm performance differ among the regions because the estimated parameter of the participation dummy differ among the regions (it should be noted however that the parameter estimates are not significant in all cases). For example, the results suggest the average impact on farm performance for a farm located in production region 2 (located in the northern part of Sweden) is 14% (significant on a 5%-level). Thus, the results suggets that participation in agri-environmental programs has a higher impact on farm profitability for farms located in region 2 than the average farmer. For the farms located in the southern part of Sweden (production regions 5-8), the impact from program participation on farm performance is less than avarage. It should be noted however, that most of these parameter estimates are not significant at a 5%-level. The results when the model is estimated for production region 6 is somewhat unexpected since the estimate of the dummy parameter is negative (-0.31) and significant. It should however be noted that this region is the region that has the fewest number of observations (n=84).

Table 5. 2-SLS estimates of farm performance equation.

	2SLS- estimates Dependent variable: ROA (Return on Assets)									
	All farms		*P1 – Nö* *N=280*	*P2 - Nn* *n=269*	*P3 –Ssk* *N=282*	*P4-Ss* *N=296*	*P5-Gns* *n=491*	*P6-Gsk* *n=84*	*P7-Gmb* *n=112*	*P8-Gss* *n=104*
Constant	-0.21*** (-0.030)	-0.24*** (0.028)	-0.22*** (0.043)	-0.19*** (0.049)	-0.37*** (0.14)	-0.21*** (0.048)	-0.17*** (0.044)	0.79 (0.10)	-0.14 (0.18)	-0.34** (0.14)
Dummy for participation	0.089*** (0.034)	0.12*** (0.035)	0.084 (0.070)	0.14** (0.061)	0.19 (0.13)	0.084** (0.046)	-0.031 (0.050)	-0.31*** (0.096)	-0.11 (0.21)	0.062 (0.15)
Share hired labor	-0.16*** (0.019)	-0.16*** (0.020)	-0.18*** (0.047)	-0.19*** (0.042)	-0.16** (0.067)	-0.15*** (0.043)	-0.14** (0.045)	-0.61 (0.14)	-0.20 (0.12)	-0.24 (0.17)
Share rented land	0.013* (0.0072)	0.012 (0.0078)	-0.0041 (0.018)	0.025 (0.018)	0.027 (0.025)	0.013 (0.015)	0.00076 (0.015)	0.049 (0.034)	-0.042 (0.031)	0.085 (0.049)
Age of farmer	-0.00061 (0.00028)	-0.000024 (0.00029)	-0.000047 (0.00029)	-0.0014** (0.00066)	0.0014 (0.0013)	0.00097 (0.00067)	-0.00066 (0.00050)	-0.0030** (0.0015)	0.00053 (0.0012)	- 0.00014 (0.0017)
Regions										
P1 - Nö	0.00034 (0.015)	-	-	-	-	-	-	-	-	-
P2 - Nn	-0.28* (0.14)	-	-	-	-	-	-	-	-	-
P3 - Ssk	-0.0091 0.014	-	-	-	-	-	-	-	-	-
P4 - Ss	-0.0095 (0.015)	-	-	-	-	-	-	-	-	-
P5 -Gns	-0.025* (0.013)	-	-	-	-	-	-	-	-	-
P6 -Gsk	-0.015 (-0.18)	-	-	-	-	-	-	-	-	-
P7-Gmb	-0.12 (0.016)	-	-	-	-	-	-	-	-	-
Spec. dummies										
Crop	0.16*** (0.0084)	0.16*** (0.0087)	0.16*** (0.017)	0.14*** (0.021)	0.16*** (0.032)	0.096*** (0.017)	0.17*** (0.021)	-0.018 (0.054)	0.21 (0.12)	0.28*** (0.090)
Dairy	0.13*** (0.012)	0.12*** (0.013)	0.073** (0.031)	0.12*** (0.028)	0.11*** (0.034)	0.068*** (0.024)	0.17*** (0.018)	0.10** (0.041)	0.27*** (0.0044)	0.29*** (0.060)
Land	0.80E^{-6}** (0.34E^{-6})	0.59E^{-6}*** (0.35E^{-6})	0.13^{E-5}*** (0.16E^{-5})	-0.13E^{-7} (0.53E^{-6})	-0.19^{E-5} (0.53E^{-6})	0.73E^{-6} (0.51^{E-6})	0.10E^{-5} (0.99E^{-6})	0.66E^{-5} (0.29E^{-5})	0.50E^{-5}*** (0.14E^{-5})	-0.93E^{-6} (0.24E^{-5})

***,**,* indicate statistical significance at 1, 5 and 10% respectively

7. Concluding comments

In this study, farms' participation and level of participation (measured in hectares) was analyzed for the largest programs in the Swedish agri-environmental program. Moreover, the impact of participation on farm performance (measured by profitability/return on assets) was analysed.

The results of the estimations of the participation equations suggest that the localisation of the farm often has a significant impact on the participation choice but not on the level of participation. As could be expected, larger farms (in terms of land) are more likely to participate in agri-environmental programs.

In the second part of the analysis, the impact of participation on farm performance (profitability) was analysed. The results suggest that the average impact from participation on profitability is 8.9-12% on average and significant at a 1%-level. When the model was estimated for each of the eight regions separately, the impact on farm performance from participation seems to vary across the regions (however, the coefficient of the participation dummy was not significant for most regions). From a policy perspective, the results suggest that the average farmer is overcompensated for his/her commitments in the agri-environmental programs. Thus, the results suggest that the agri-environmental program in Sweden is not cost-efficient at the present subsidy levels since the farmers' compensations are larger than their forgone revenues from conventional production (on average).

Although this study provides some information about the efficiency of the current agri-environmental program in Sweden, it is difficult to make concrete suggestions concerning the design of an optimal payment program based on the results. A desirable objective would be to calculate the "minimum required compensation" for the different agri-environmental measures and for different groups of farms. However, this was not possible in the current study because of the following reasons: i) There are several different types of agri-environmental programs with very different nature. The impact on farm performance from participation in a specific program is therefore difficult to sort out. ii) The level of participation (in terms of hectares) varies among participants. iii) Profit, revenue and costs functions are probably not possible or difficult to estimate because of lack of variation in price data.

An idea for further research is could be to evaluate methods to determine the effects of participation in specific programs and thereby be able to make more concrete suggestions on, for example, optimal payments for specific programs.

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Appendix

Production regions in Sweden

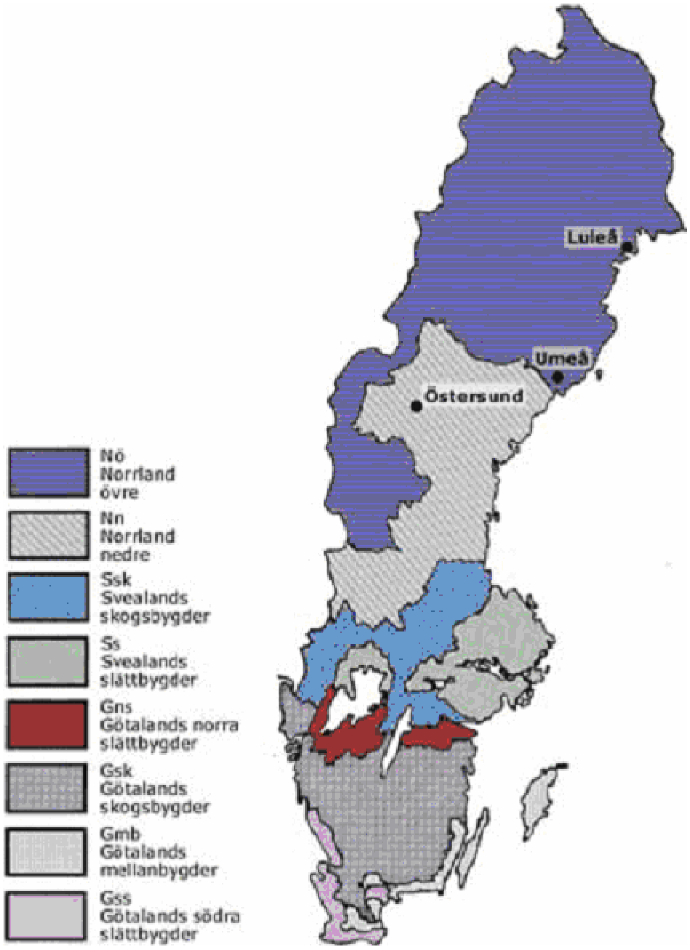

Figure 1. Production regions in Sweden (Agriwise, 2005).