Cross-Compliance policies and EU Agriculture:

Missing all targets at the same time? [¤]

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Abstract

After the 1992 Common Agricultural Policy Reform, the idea of introducing cross-compliance into the European Union agricultural policy has become more and more popular. Cross-compliance can be defined as making income support conditional on farmers conforming to environmental regulations and standards imposed on agricultural production. From economic theory it is known that, in order to establish an efficient policy, there should be correspondence between the number of policy objectives and the number of instruments. This has been neglected in the case of European cross-compliance policies and, in order to discuss the effects of the Common Agricultural Policy and efficiency properties, a simulation model has been applied to analyse the effects of introducing environmentally related objectives concerning nitrate leaching as a supplement to the current aim of income support in the Common Agricultural Policy. Results suggest that combining output reduction and nitrate leaching reduction is less effective than separate policies for these two objectives.

Key words: Common Agricultural Policy; Cross-compliance; Nitrate leaching.

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Background and aim of the paper

Since the creation of the European Union (EU), agricultural policy has been one of the cornerstones of the common policies. Initially the Common Agricultural Policy (CAP) aimed at improving income and productivity within the agricultural sector as well as creating a high level of self sufficiency. These aims were pursued by the use of policy measures such as price support, intervention purchasing, export subsidies, import levies and production quotas for certain products. Similar agricultural support schemes were seen in most other OECD countries, leading to distortions of the world market and global welfare losses (see e.g. Anderson & Tyers, 1991). Therefore, discussions within the GATT-organization on reducing agricultural support levels were at the top of the agenda at the start of the Uruguay negotiation round in 1986. The primary aim was to lessen distortion of the world market by liberalizing world trade in agricultural products. Furthermore, discussion concerning the ethical and budgetary aspects of over-production of cereals and bovine products within the EU created an internal pressure to reform the CAP.

Along with the agricultural policy discussion, massive attention has been drawn to the interactions between agricultural production and the environment. Negative changes in the environment have been linked to the intensification of agricultural production and this has called for policy action, with particular respect to reducing nitrogen losses from agricultural land. The concern arising from considerations of the side effects of the agricultural support schemes and the environmentally detrimental effects of agricultural production led to two different policy initiatives in the EU. Firstly, the Nitrate Directive was introduced in 1991 aiming at reducing and preventing water pollution by nitrate output from agricultural sources (Directive 91/676/EEC; see also Rude and Frederiksen, 1994, for further details). Secondly, the CAP reform came in 1992 changing the agricultural support scheme from price support to hectare and animal premiums in order to reduce the effects of the support payments on production volume. Additionally, the payment of hectare premiums was made dependant on farmers setting aside a certain percentage of their land in order to reduce the production of specific crops, and in this way the receipt of income support was coupled with an extra obligation related to the aim of reducing over-production.

The idea of making income support dependant on whether farmers comply with production restrictions which were related to other policy aims was called *cross-compliance;* an example

of this within the CAP is the set-aside requirements which should be complied with in order to receive hectare premiums. Cross-compliance is currently discussed in relation to environmental protection as a measure to reduce the expected negative cross achievement effects on the environment of the agricultural support schemes (see e.g. Baldock, 1993; Russel & Fraser, 1995; Spash & Falconer, 1996; Brouwer & van Berkum, 1996). Cross-compliance policies were typically divided into two different groups termed: red-ticket ("stick") or green-ticket ("carrot") cross-compliance. As indicated, the red-ticket type created incentives in such a way that the farmer lost the right to receive income support or part of this if he did not comply with the additional rules (e.g. set-aside obligations). On the other hand, the green ticket type gave the farmer the right to additional support if he complied with the rules (e.g. increased hectare payments in return for reduced use of nitrogen fertilizers). Regardless of the type of cross-compliance, the policy was in principle based on creating participation incentives through subsidies, and the difference between the red and green ticket type was whether the subsidy was negative or positive.

This paper considers the effectiveness properties of cross-compliance policies, through the analysis of the effects of introducing different restrictions to the current CAP regime. Introduced obligations of 10% set-aside (rotational and non-rotational) and a 40% reduction in nitrogen fertilizer were analyzed with respect to the current targets of the EU Agri-Environmental policies; income support, reducing crop production and reducing nitrate losses from arable land (nitrate leaching). The scenarios chosen are shown in Table 1.

The analysis was performed for specialized wheat producers on homogeneous and heterogeneous soils. Thus, the results should not be generalized to the aggregate farming sector, as the interaction between livestock and crop production on mixed farms may make farmer response to the analyzed policies more complex. In order to narrow down the analysis the paper focuses on the effects on the three previously mentioned targets of the EU policy. Other properties of importance for the policy efficiency, such as the participation rate and administrative costs, are not discussed.

Table 1. The analyzed scenarios.

Scenario	Policy measures[1]
Basis	Hectare premiums alone
S1	10% rotational set-aside
S2	10% *non*-rotational set-aside
S3	40% reduction in nitrogen fertilizer use
S4	40% reduction in nitrogen fertilizer use and 10% rotational set-aside
S5	40% reduction in nitrogen fertilizer use and 10% *non*-rotational set-aside
S6	No restrictions and no hectare or set-aside premiums

1. In scenario 1 to 5 the policy measures indicate the cross-compliance needed to receive hectare premiums and/or set-aside premiums.

The applied models

In order to establish a framework for integrated policy analysis both a behavioural (economic) model and a technical model were applied. In the following section each model is described.

The economic model

The model used in this paper is based on Rygnestad and Fraser (1996) who assumed that the farmer's objective was to maximise the net present value of profits over a finite time period by the optimal choice of nitrogen application rates. With additional assumptions of constant returns to scale and no carry-over effects from year to year, the optimal nitrogen application rate for each year was constant and could be determined for each hectare of soil of a given type.

Nitrogen fertilizer use and wheat yield were connected by a Mitscherlich response function as discussed in Paris (1992). The function used in this paper has incorporated differences between soil types:

$$y(N_j) = m_j \, (1 - d_j \, e^{(b_j N_j)}) \qquad (1)$$

where: y = yield (t/ha)

N_j = nitrogen application rate for soil type j (t/ha)

m_j, d_j, b_j	=	parameters of the function
j	=	1-6, soil types/qualities in the model

In the response function, m_j indicates the yield potential of the soil type. The other parameters, d_j and b_j, determine the decreasing marginal productivity and the responsiveness of the soil to nitrogen application, respectively. In this paper m_j is also used as a measure of the quality of the soil type in question. Thus, soil types are used as approximations for soil qualities.

The revenue function for each year is given by the production income, hectare premium and set-aside premium when both are provided:

$$R = \sum_{j=1}^{6} [L\,(l_{tj} - a_{tj})\,p_w\,y(N_j) + L\,(l_{tj} - a_{tj})\,y_a\,k + L\,a_{tj}\,y_a\,s] \tag{2}$$

$$;\ t = 1\ ..\ T \quad ;\ \sum_{j=1}^{6} l_{tj} = 1 \quad ;\ \sum_{j=1}^{6} a_{tj} = a = \%\ \textit{set-aside rate}$$

where:	T	=	time horizon
	L	=	area of land (ha)
	l_{tj}	=	% of land in year t of soil quality j
	a_{tj}	=	% set aside in year t of soil quality j
	$y(N_j)$	=	actual yield of soil quality j (t/ha)
	p_w	=	price for wheat (ECU/t)
	y_a	=	reference yield (t/ha)
	k	=	hectare premium (ECU/t)
	s	=	set-aside premium (ECU/t)

The cost function for each year is given by costs of nitrogen fertilizer use, other variable production cost and a fixed costs component:

$$C = \sum_{j=1}^{6} [L\,(l_{tj} - a_{tj})\,p_f\,N_j + L\,(l_{tj} - a_{tj})\,p_p\,m_j + L\,FC] \tag{3}$$

$$;\ t = 1\ ..\ T \quad ;\ \sum_{j=1}^{6} l_{tj} = 1 \quad ;\ \sum_{j=1}^{6} a_{tj} = a = \%\ \textit{set-aside rate}$$

where:	p_f	=	cost of nitrogen fertilizer (ECU/t)

p_0	=	other variable production costs (ECU/ha)
FC	=	fixed costs excluding interest on land, insurances and CO_2 taxes (ECU/ha)

Subtracting Equation (3) from Equation (2) gives the yearly social land rent (referred to as profit, π). This is then discounted and summed over the specified time horizon, T, to give the net present value (NPV) of profit:

$$NPV = \sum_{t=1}^{T} \left[\frac{\pi_t}{(1+r)^t} \right] \tag{4}$$

where: r = discount rate.

The optimal choice of nitrogen application rate (N_j^*) is found by setting the derivative of the profit function (Equation (3) - Equation (2)) with respect to N_j equal to zero. From (1), (2) and (3) this is given by:

$$N_j^* = \frac{1}{b_j} \ln\left[\frac{p_f}{p_w \, m_j \, d_j \, b_j} \right] \tag{5}$$

Note that, for soil of heterogeneous quality, the farmer can choose which part of the farm to set aside in order to maximise the profit. In general, poorer quality soil is taken out of production. For the purpose of this study the choice variables were limited to the amount of nitrogen fertilizer used per hectare on each soil quality, N_{ij}, and what part of the farm to set aside, a_{ij}.

The leaching model

In addition to the economic production model, a model of the interaction between fertilizer use, the combination of crops and nitrate leaching from the root zone is applied. The model is of the "black box" type, and has been estimated on the basis of Danish empirical field trials carried out during the 1980's (Simmelsgaard, 1991). It has been used in a number of different studies of Danish agriculture (Skop, 1993; Schou and Vetter, 1994; Paaby et al., 1996) and it has also been validated against other models of nitrate leaching with promising results (Skop, 1993). In its most comprehensive setup, the model quantifies nitrate leaching from agricultural land as a function of soil type, precipitation, crop rotation and the

application of nitrogen from fertilizers and animal manure. For the purpose of this analysis a reduced form of the model is used including winter wheat production on different soil types, but in one climatic region only and with application of nitrogen by commercial fertilizers alone (no animal manure).

The model can be described by the following equation:

$$X = x_j \, e^{(0.7\,(\frac{N_j}{N} - 1))} \qquad (6)$$

where: X = calculated nitrate leaching per hectare

x_j = standard nitrate leaching per hectare ($N_j/N=1$) on soil type j

N_j/N = the ratio between actual and standard nitrogen application

According to the model, nitrate leaching increases with a higher level of fertilizer use indicating that an increasing proportion of applied nitrogen is lost through nitrate leaching. It should also be noticed that the model is dependant on soil types. Therefore, calculations for the heterogeneous soils are done for each soil type separately so that the total nitrate leaching from winter wheat is the sum of nitrate leaching from each soil type. The standard leaching per hectare is shown in Table 2.

In order to apply the production model, Danish cost and income structures for wheat production in the 1994/95 growing season were used to establish the basis scenario for the numerical analysis (See Table 2). In addition, data from Danish field trials formed the basis for the estimated yield response functions linking nitrogen fertilizer use and wheat yield.

Parameter values for the average yield response function in Table 2 were estimated from this data, whereas the functions for poor and good soils were constructed according to certain assumptions. It was assumed that poorer soils had a lower yield potential (i.e. a lower m_j value, see Equation 1); a lower marginal productivity of nitrogen (i.e. a lower d_j value); and a lower response rate to increased nitrogen use (i.e. a higher b_j value). The reverse assumptions were adopted to construct the yield response function for good soil (see Table 2). Furthermore, it was believed that wheat yields improved when a parcel of land previously

set-aside was brought back into production. This was in line with Clarke (1995) and Froment and Grylls (1992) where field trials indicated a yield benefit from one year set-aside of up to 10% of previous cereal yield on heavy soils and up to 15% on light soils.

Table 2. Cost-structure and Yield Response Functions and Standard Nitrogen Application Rates for three land qualities in the basis scenario[3]

	Unit per farm hectare	Poor land	Average land	Good land
Fertilizer costs	ECU/ha	89	113	125
Other var. costs	ECU/ha	127	196	243
Fixed costs	ECU/ha	542	542	542
Total costs	ECU/ha	758	851	910
m_i	-	5.45	8.45	10.45
d_i	-	0.51	0.53	0.55
b_i	-	11.09	11.07	11.06
N_i^* (Actual)	t/ha	0.16	0.21	0.23
N (Standard)	t/ha	0.18	0.19	0.20
Yield, $y(N_i^*)$	t/ha	5.00	8.00	10.00
x (Standard)	kg/ha	45.00	39.00	35.00

Notes: 1 Yield response function: $y(N_i^*) = m_i (1-d_i e^{-b_i N_i^*})$.

2 Other data used in the analysis $p_w = 108$ ECU/t $p_f = 549$ ECU/t
$k = 42.26$ ECU/t $s = 57$ ECU/t
$a = 10\%$ $L = 21$ ha

Sources: DIAFE, 1995; Landbrugets Rådgivningscenter, 1985-95

Optimum nitrogen fertilizer rates were found not to change after the set-aside rotation. This was adopted as a principle in the numerical analysis. Thus, it was assumed that poor or light soil responded more to rotation benefits, and that the yield increases at optimal nitrogen use in the first year after set-aside were 12%, 10% and 7% for poor, average and good soils, respectively. From the above discussion six possible yield response functions were found; before rotation and after rotation for all three main soil qualities (j=1-6).

Results

The following numerical application analyses the effect of different cross-compliance policies on the level of wheat output, nitrogen fertilizer use and income support in five policy scenarios compared to a defined basis scenario. The analyzed policy measures include set-aside, reduction of nitrogen application use and a combination of these. It was found that these policies lead to an initial reduction in output, nitrogen use and income from the basis, but the magnitude of this reduction varied between policy measures. Three main factors were believed to affect this magnitude on the specialized wheat producer which are considered here: combinations of measures leading to increased danger of policy ineffectiveness; soil heterogeneity on farms affecting production decisions; and which input factor that is restricted. The basis scenario was set to be the situation when no restrictions were put on the farmer in the form of environmental regulations or standards. However, non-conditional income support was provided through a hectare premium. The remaining scenarios are given in Table 1.

To structure the presentation of the results this section is divided into three subsections. First the results from the basis scenario are presented with the numerical results of the analysis. This is followed by a discussion of the results from the analysis of the single policy measures (Scenarios 1 to 3), and last the results from the analysis of the combined policy measures and the situation with no obligations and no premiums (Scenarios 4, 5 and 6) are presented.

Basis scenario

To enable a clear presentation of the results two farms with different soil quality combinations have been chosen. Farm A is described as having 100% average soil quality thereby representing farms with homogeneous soil types. Farm B has 40% poor soil and 60% good soil thereby representing farms with heterogeneous soil types. These examples have been chosen to create a distinct baseline for the analysis since Farm A and Farm B have the same level of output and nitrate leaching in the basis scenario. In Table 3 the numerical values from the basis scenario are shown. The results are presented with respect to production volume (yield), net present value of profit, nitrogen application and nitrate leaching. All values are calculated per year and per hectare.

Table 3. Numerical results from the basis scenario. All values shown per year.

	Homogenous soil (Farm A)	Heterogeneous soil (Farm B)
Yield, t/ha	8.0	8.0
NPV, ECU/ha	193.7	195.6
N use, kg/ha	206.1	201.9
N leaching, kg/ha	40.5	40.5

In terms of production value, Farm B has slightly higher profit than Farm A after the six year period (238 ECU or +1%). This is because of the lower use of fertilizer on poor soil compared to average and good. In other words, Farm B has input cost savings while producing the same volume and receiving the same income support as Farm A.

Scenarios 1, 2 and 3: Single policy measures

Tables 4 and 5 show the results of all scenarios as indices where the basis scenario is set at 100. Under the ***rotational set-aside scheme*** the farmer has to take 10% of the farm land out of production each year to receive income support through a hectare premium and a set-aside premium. No fertilizer is applied to land out of production. Each hectare of farm land can only be set aside once every five years, thus the policy is referred to as a six year rotational scheme (Thus T=6). It is assumed that the farmer choses to set aside the poorest yielding area in the first year to keep good soil in production for as long as possible. Thus, in this case 40% of the total land area (primarily of good quality) is not aside in the six years.

Table 4. Changes in production volume and NPV. Basis scenario = 100.

	Homogenous soil (Farm A)		Heterogeneous soil (Farm B)	
	Yield	NPV	Yield	NPV
Scenario 1	91	82	92	87
Scenario 2	90	80	94	90
Scenario 3	91	88	92	88
Scenario 4	83	71	85	76
Scenario 5	82	68	86	79
Scenario 6	100	5	100	6

For the rotational set-aside option, output on Farm A decreased by 9% from the basis. For Farm B output reduction is lower (8%) due to the soil heterogeneity and larger yield benefits. As explained earlier, a large proportion of good soil is not set-aside, thereby increasing average output; this is known as the "slippage effect" (see Rygnestad & Fraser, 1995 for further discussion). Nitrate leaching falls by 2% on both Farm A and B due to the introduction of rotational set-aside. However, as a secondary policy effect, reduction of nitrate leaching wa expected to be low.

Table 5. Changes in nitrogen application and nitrate leaching. Basis scenario = 100.

	Homogenous soil (Farm A)		Heterogeneous soil (Farm B)	
	Application	Leaching	Application	Leaching
Scenario 1	90	98	91	98
Scenario 2	90	95	92	96
Scenario 3	60	74	60	74
Scenario 4	54	72	55	72
Scenario 5	54	70	55	70
Scenario 6	100	100	100	100

Income levels are lower in the rotational scheme compared to basis. This is due to the 10% reduction in productive land and lower hectare payment. This means that the set-aside premium does not fully cover the loss of production income and support from the basis. However, the income level falls by more on Farm A (-18%) than Farm B (-13%) due to the advantage of both higher average yields and lower fertilizer use on farms with mixed soil quality.

In the ***non-rotational set-aside scheme*** the farmer has to take the same parcel of land out of production for the whole period. The set-aside rate is 10% and no fertilizer can be applied to this land. The farmer is assumed to enter the poorest yielding soil into the scheme to attract the income support through a hectare premium and a set-aside premium.

The non-rotational set-aside option reduces output to its full potential (10%) when Farm A is considered. However, Farm B has a grade of soil quality mixture which leads to a smaller

reduction of 6%. Low yielding land is moved from production permanently, thereby increasing average farm output. Nitrate leaching falls by 5% and 4% on the two farms, respectively, indicating that the change in nitrogen application on average was slightly smaller on Farm B due to differences in the marginal changes of nitrogen application on good compared to poor soil.

With lower output and a smaller productive area, Farm A has a drop in profit in spite of the extra set-aside premium and reduced fertiliser costs. The 20% reduction in profit for Farm A exceeds the similar situation for Farm B (-10%). This is because of the opportunity Farm B has to keep good soil productive thereby maintaining high production income. The benefits for farms with soil heterogeneity can be seen as Farm B has a 14% higher end profit compared to Farm A.

The third policy option requires farmers to ***reduce total nitrogen application use by 40%*** to receive a hectare premium. The farmer chooses the percent reduction of nitrogen use on all soil types by optimizing the NPV of profit. In general application rates are reduced by more on poor soil due to the lower marginal benefit from nitrogen use.

Output levels drop on both farms due to the lower fertilizer application use, even though this is not the primary objective of the policy. However, optimum nitrogen rates in the basis scenario are in the higher regions of the yield response curve. Thus, even a large reduction in nitrogen use only causes an 9% yield drop on Farm A with only a slightly smaller decrease on Farm B. This is due to the different nitrogen application rates on the heterogeneous soil. In this scenario nitrate leaching drops by approximately 26% on both farms, reflecting the reduction in nitrate application. The fact that nitrate leaching does not decrease by 40% illustrates the indirect link between nitrogen application and nitrate leaching.

Some cost savings on fertilizer input are offset by lower production income and hectare payments and add up to a net reduction in profit. With no extra income support for cross-compliance, total profit falls by, on average, 12%. Farm B is in a slightly better position because of the proportion of low input soil (i.e. poor soil). However, total profits on the two farms are only separated by 2% after six years.

Scenarios 4 and 5: Combined policy measures

The fourth policy option attempts to combine a ***rotational set-aside scheme with a reduction in applied nitrogen*** on productive land. In return for this cross-compliance, the farmer receives a set-aside premium on land out of production and a hectare premium on remaining productive land. The set-aside rate is 10% and total nitrogen use is reduced by 40%.

The output levels are affected by both a reduction in the productive area and lower nitrogen input. Farm A has a 17% output reduction compared to 15% on Farm B. With initially equal output levels, this policy combination leaves Farm B with a 2% higher output than the homogeneous soil quality farm. The combination of reduced nitrogen application and set-aside reduces nitrate leaching by 28% on both Farm A and B.

In total, Farm B finishes with 8% higher profit after six years compared to Farm A. In other words, farms with heterogeneous soil can take more advantage of yield benefits from rotation and a relatively smaller drop in yield after nitrogen reduction. In relation to the basis scenario, profit has fallen by between 24% and 29% for the two farms.

The fifth policy option combines ***non-rotational set-aside with a reduction in nitrogen fertilizer use.*** Participating farmers are awarded a set-aside premium for land out of production and a hectare premium for the productive land. The set-aside rate is 10% and nitrogen use is reduced by 40%.

The 10% reduction in productive area and 40% reduction in nitrogen use on the productive land lead to a reduction in output levels. On Farm A, output is reduced by 18% from the basis, whereas for Farm B the output reduction is only 14%. The higher output level on Farm B is due to the permanent set-aside of poor, low yielding soil and a relatively small reduction in nitrogen use. The introduction of non-rotational set-aside and limited nitrogen use reduces nitrate leaching by 30% on Farm A and 30% on Farm B.

In this policy option the extra set-aside premium and savings on fertilizer use do not make up for loss of output and lower hectare payment. Thus, final profit after six years on Farm A falls by 32% from the basis. Similarly, Farm B loses 21% of the profit. Thus, farms with

heterogeneous soil quality have an opportunity to reduce losses from this policy.

S6: No restrictions and no hectare or set-aside premiums

The sixth and last policy option is the alternative to complying with the rules within a red ticket cross-compliance policy scheme - that is production without hectare and set-aside premiums. Since there is no set-aside requirement and the premiums do not affect the production function (see Equations 1 and 2), yields, nitrogen application and nitrate leaching do not change from the basis scenario. On the other hand, the abolishment of the premiums has dramatic effect on the economic outcome of production as the net present value of profit falls by 95 percent compared to the basis scenario.

Discussion

When comparing the different policy options it is evident that all provide some level of reduction in output and nitrate leaching. This is calculated here through percent change in output and nitrate leaching from the basis scenario. By comparing these reductions with the NPV of profit under different policy options, the effectiveness has been determined. Several factors seem to negatively affect the policy effectiveness. Firstly, when combining two or more policy measures the effectiveness is often reduced compared to individual policy results. This can be seen when comparing Scenarios 4 and 5 with Scenarios 1 to 3 for the two farms. The combined measures only offer an additional 7-10% decrease in output and a 3-5% decrease in nitrate leaching compared to Scenario 3. However, these small reductions lead to big additional profit losses of 10-23%. Considering the importance of income maintenance under the CAP, this may be hard to justify.

Secondly, soil heterogeneity on the farm decreases the positive effects of the policies. The yield reduction on Farm A (homogeneous soil) is almost the same for Scenarios 1, 2 and 3 compared to the basis. But, as indicated above, Scenario 3 gives a 10% higher NPV of profit. For Farm B output reduction is lower and profit is higher than on Farm A due to soil heterogeneity. Thus, farms with heterogeneous soil can take more advantage of: yield benefits from rotation; permanent set-aside of poor soil; and a smaller drop in yield after nitrogen reduction. In total, output reduction on homogeneous soil is obtained through nitrogen reduction (Scenario 3) to the same degree as in Scenarios 1 and 2 (the set-aside

schemes), but with a smaller loss in profit. Such a distinction is less significant on heterogeneous soil.

Thirdly, policy tools have a positive primary effect when the point of impact is close to the policy objective. However, there are often one or more secondary effects which are more or less intentional. This is particularly clear in the numerical analysis of the policy effect on nitrate leaching. Both Farms have a small decrease in nitrate leaching in Scenarios 1 and 2. However, the 40% reduction in nitrogen application use has a large effect on both farms. This is because a reduction in nitrate leaching is a primary objective in Scenario 3, but a secondary objective of the set-aside policy.

Some policy scenarios seem more effective than others in the numerical analysis. However, the policy success is dependent on farmer participation in the policy schemes. Individual farm situations govern production decisions and therefore policy effectiveness. An overall feature of the analyzed scenarios is that if the profit level is the only determining factor for farmer participation, all of the analyzed policies (Scenarios 1 to 5) will be superior to the situation where hectare and set-aside premiums are abolished in return for farming without any restrictions (Scenario 6). Thus, an overall feature is that farmers prefer participation in the different policy schemes if the alternative is total loss of hectare and set-aside premiums as in Scenario 6 (red-ticket cross-compliance). This is in line with the conclusion in Roberts et al. (1996) on set-aside participation. Turning to the profitability for farmers of the different policy scenarios, farmers preference for participation is found by comparing profit levels in the different scenarios. With individual policy measures (Scenarios 1 to 3) preference on Farm A (homogeneous soil) is clearly towards nitrogen reduction (Scenario 3), followed by rotational and then non-rotational set-aside. On Farm B (heterogeneous soil) the choice situation is different. The preferred policy option is the non-rotational set-aside, then nitrogen reduction and then rotational set-aside. Due to the nature of combining two policies as in Scenarios 4 and 5, profits after six years are lower than under the individual policies. However there are choice differences between the two scenarios. On Farm A Scenario 4 (rotational set-aside and nitrogen reduction) is preferred but on Farm B Scenario 5 (non-rotational set-aside and nitrogen reduction) is preferred. In addition, the policy option preferred by the farmers leads to the smallest output and nitrate leaching reduction when the

scenario are compared individually.

Conclusion

This analysis indicates that a combination of set-aside and reduction of nitrogen application has only a small additional effect on crop production and nitrate leaching compared to individual policies, but leads to a significant loss of profit (NPV). Thus, a reduction in nitrogen fertilizer application use seems to offer a more effective way of reducing both output and nitrate leaching than set-aside and combined measures when income levels are considered. Also, farms with heterogeneous soil can take advantage of yield benefits from rotation, permanent set-aside of poor soil and a small drop in yield after a 40% reduction in nitrogen use. This is reflected in lower policy effectiveness and higher NPV of profit compared to farms with homogeneous soil. In addition, if policies are constructed in a way that farmers can choose between the different policy measures, they will choose the options that have the least potential to reach the policy objectives of reducing output and nitrate leaching. This indicates - not surprisingly - a negative cross achievement effect between, on the one hand, maximising the increase in profits due to income support and on the other hand reducing production of certain crops and reducing nitrate leaching from arable land. Thus, the analysis shows that cross-compliance policies should not be seen as a way to effectively achieve a number of goals with one strike, but rather an opportunity to take different cross achievement effects into account when deciding upon new agri-environmental policy measures.

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