Environmental protection of agriculture -clash of policies?

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Abstract

Agricultural primary production is extensively influenced by policies and regulation. On the level of European Union the common agricultural policy (CAP), frames the production environment. This study analyses the conflict of environmental and income policies in the context of CAP reform, eutrophication, the Water Framework Directive and Finnish policies. As targets of the policies do not coincide and often conflict, the environmental problems of farming have not been solved in the past decades. The comparative analysis is conducted quantitatively under static non-linear optimisation framework of representative farms of cereal and milk production regions of Finland. The results indicate that the decoupling of subsidies from production has enabled more efficient abatement policy. The current policies are still far away from the first best abatement solution. According to the results, main policy failures lie in uniform instruments, which even on a national level ignore the heterogeneous farm structures and environmental conditions. Instead of providing tailored instruments for nutrient load problems, the reform of Finnish agri-environmental subsidy scheme fails to respond to growth trends of nutrient loads on animal intensive regions.

Key words: nutrient, abatement cost, non-point source pollution, agriculture, CAP

1. Introduction

Agricultural primary production is extensively influenced by policies and regulation. On the level of European Union the common agricultural policy (CAP), the biggest expenditure of EU, frames the production environment. On a national level, variety of country specific policies and subsidies add on to the government intervention of agriculture. While majority of the policies are targeted towards farmers' income, several are associated with specific targets, such as environmental protection. Although, the European policy reforms have somewhat detached subsidies from production, the common intuition in economics would be that income subsidies increase production. Indeed, besides transferring public funds to farmers, keeping arable land in production seems to be one the desired goals of CAP (Baylis, 2007). Despite that much of the recent discussion on agriculture in Europe is based on the more production favourable concept of multifunctionality (OECD 2001, Zander et al. 2007), the negative environmental impacts of agricultural production have not disappeared. In the Southern-Europe the problems relate to water availability, soil degradation and biodiversity loss (EEA 2007). In the Northern-Europe, eutrophication, ground water pollution and odour nuisance are topical problems of the intensive agriculture (EEA 2007, Baldock et al. 2002, Baylis et al. 2007). It would seem that the common agricultural policy and its national implementations have failed to ensure the good quality of environment in Europe. This study analyses the conflict of policies in the context of CAP reform, eutrophication and the Water Framework Directive of the European Union. The aspect of national implementation is demonstrated by the Finnish case.

In Finland, the national subsidies and their administration are among the most complex in EU, at least when measured with the thickness of the instructional documentation (Suomela 2007). EU policies have increased the amount of arable land in Finland contra to the national fears at the advent of the adhesion (Niemi & Ahlstedt 2007). Simultaneously, while the fertilisation intensity of agriculture has decreased, the average farm sizes have increased. Alas, the water quality has not improved in general and toxic algae blooms have been occurring frequently in the Baltic Sea (Granlund et al. 2005, Kahru 1997, Jansson & Dahlberg 1999, Kononen, 2001). Moreover, the Finnish agri-environmental policy did not achieve the ambitious 50% nutrient load reductions that the government set for 2005 (Ministry of Environment 1998, Palva et al. 2001, Granlund et al. 2005). In terms of farmer participation, though, the scheme was a success. Despite that the Finnish farmers find the system bureaucratic and complicated, over 94% of active farmers participated in the scheme of 2000-2006. Besides reducing the reduction targets themselves, the government and administration proceed with similar agri-environmental scheme for 2007-2013. Indeed, it would not be far fetched to argue that even the agri-environmental payments are targeted at limiting land abandonment where farming is unprofitable (e.g Baldock et al. 1996). Following from the water quality targets set on the EU level, the preservation of the status quo of agriculture will be more challenging in the future. Improving the quality of water while the climatic conditions to do so are likely to decline; will most certainly require more action on behalf of the agriculture, the biggest anthropogenic source of nutrient loads in Finland. However, if the quality targets cannot be met by 2015, the directive leaves room for the member countries to gather evidence on the excessive economic costs for achieving the quality targets (Anon. 2000). Hence, it is important for national governments, but also for the EU to know how expensive it is to reduce arable nutrient loads.

While several studies have touched the topic of nutrient load abatement costs in agriculture (see e.g. Innes 2000, Shortle & Abler 2001, Brady 2003, Johansson et al. 2004, Helin et al. 2006), the climatic conditions, the ever changing policies and different farm production structures complicate the gathering of a cost curve for this diffuse pollution source. This study focuses on the implications of some farms specialising in animal husbandry, while others produce only crops. To elaborate the effects of income policies the pre and post CAP-reform policy frame are compared. Similarly, the effects of the reformed national agri-environmental subsidy scheme are studied. The comparative analysis is conducted quantitatively under static non-linear optimisation framework developed for representative farms of cereal and milk production regions of Finland (Helin et al. 2006, Helin ibid.). The detailed farm level approach allows inclusion of various abatement methods and the policy instruments used in practise. In contrast to sector model studies (e.g. Lehtonen et al. 2004), the capacity to model economy wide price effects is rather limited, but in turn production technologies and nutrient flows can be described more accurately. As uncertainties in the underlying eutrophication processes and the related damage functions have not been resolved, abatement cost paths for both nitrogen and phosphorus load are considered individually.

2. Methodology

The problem of efficient nutrient abatement is presented in a simplified framework. Suppose that the abatement of nitrogen and phosphorus is considered by a national decision-maker for two types of farms, of which *B* produces cereals and *D* keeps animals for various products. For profit maximising risk-neutral farmers

$$\max_{X,N,P} \pi_B = py_B(X,N,P) - c_B(X,N,P) \tag{1}$$

$$\max_{X,N,P,F,A} \pi_D = py_D(X,N,P,F,A) - c_D(X,N,P,F,A) \tag{2}$$

where π is the profit for each farm type. Respective revenues from price *p* and yield *y* are given by functions of land *X*, nitrogen application *N* and phosphorus application *P*. The inputs incur cost *c* for each farm type. For the animal farm choice variables include also feeding *F* and number of animals *A*. Production indices for crop type, animal type, nutrient source and tillage technology have been omitted here for clarity. Besides non-negativity constraints, the farms face many technological limitations, which among with the more detailed descriptions of the production functions, are illustrated in Helin et al. (2006) and Helin (ibid). In contrast to Helin et al. (2006), the phosphorus application is not fixed to nitrogen levels and has an additive yield function.

The nutrient inputs lead to externalities as they leach from farm soil to water bodies. Farm land is a diffuse pollution source, which is spread evenly on two geographic regions. Assume that each of the regions is dominated by a single farm type and that the regions are equal in size. The loads for each farm type and each nutrient are functions of crop and fertiliser choice given by the solution of the profit-maximising problems (1) and (2)

$$C_D(\bar{P}_D^L) = \pi_D^* - \hat{\pi}_D(\bar{P}_D^L) \tag{3}$$

$$C_D(\bar{N}_D^L) = \pi_D^* - \hat{\pi}_D(\bar{N}_D^L) \tag{4}$$

$$C_B(\bar{P}_B^L) = \pi_B^* - \hat{\pi}_B(\bar{P}_B^L) \tag{5}$$

$$C_B(\bar{N}_B^L) = \pi_B^* - \hat{\pi}_B(\bar{N}_B^L) \tag{6}$$

The formulas from (3) to (6) give the abatement cost functions *C* for each nutrient and each farm type. As the load P^L and N^L are constrained from the level associated with optimum profits π^*, the profits decrease by definition. Hence, the abatement cost curve is given by difference in profits as the allowed load goes to zero. Given the assumptions, the total load for each nutrient is the sum of the load of the two farm types.

The overall abatement goal is set by EU in the water framework directive. In general terms, the objective is to reach good water quality target or failing that, the member states could demonstrate that reaching the quality targets would have resulted in excessive costs. The damage functions of each of the nutrients are not known for certain as the limiting nutrient changes over time and space. Furthermore, agriculture is not the sole source of nutrient water pollution. Hence, the national decision maker sets reduction targets of agriculture based on some estimated or desirable level of each nutrient. In Finland, the government has recently set new reduction targets of 34% for both nitrogen and phosphorus from the average levels of arable loads of 2001-2005 (Ministry of the Environment 2006). Given the national targets, the abatement should be cost-effective, even though pareto efficiency or social optimum of the measures could not be ensured. Consider the simplest case where the spatial and temporal aspects of the pollution do not play a role and the Baltic Sea is regarded as the only and perfectly mixed pool of nitrogen and phosphorus emissions for both farm types.

$$C'_B(\bar{P}^L_B) = C'_D(\bar{P}^L_D) \tag{7}$$

$$C'_B(\bar{N}^L_B) = C'_D(\bar{N}^L_D) \tag{8}$$

which says that for cost-effectiveness of any given abatement target the marginal abatement costs of the two types needs to be equal.

Subsidies are paid to farmers for various reasons and constitute an important form of income redistribution. Main bulk of income subsidies are determined on the EU level, while the national government retains control of instruments related to environmental protection. However, the EU policy requires that the compensation under EU financed agri-environmental measures does not exceed the cost of the measure by more than 20%, the share, which is referred to as transactions costs. The national agricultural producers compete within the EU domestic markets and national subsidies can shelter domestic producers and the government popularity and tax base. Consider such situation where the income subsidies are the prime objective of the national decision maker and the environmental concerns are secondary i.e the second-best framework (Antle and Just 1991). As the EU has been forced to respond to demands from WTO, the common agricultural policy is reformed from top to down and from one pillar to another one. The system of single farm payment (SFP) is a step further from direct subsidies of production in general, but in terms of the national decision-maker, the impacts on the types of farm and regions can be mixed. A mixed subsidy scheme where the animal husbandry farmers still benefit from production subsidies, while crop production is largely decoupled will affect the effective abatement too. Denoting such second best marginal abatement cost by $\hat{C}'_D$

$$C'_D(\bar{P}^L_D) \leq \hat{C}'_D(\bar{P}^L_D) \tag{9}$$

$$C'_D(\bar{N}^L_D) \leq \hat{C}'_D(\bar{N}^L_D) \tag{10}$$

By definition production subsidy is positive and will increase the opportunity cost of foregone production. Hence, the second-best abatement costs for dairy farm are higher. As a result from equations (7-9), the crop farm is expected to abate more with a higher cost while the dairy farm receives the production subsidies.

The abatement cost functions are estimated empirically by mathematically programming the constrained profit maximisation problems in 3-6 for abatement levels from 0 to 40% of each nutrient. These simulated abatement costs are used for fitting quadratic cost functions by OLS, correspondingly for both nutrients and farm types. The effects of policies on abatement costs are compared between the 2003 CAP and 2007 Single Farm Payment (SFP) and between the national agri-environmental schemes of 2003 and 2007.

$$C_D(\bar{P}_D^L) = \alpha_D(\bar{P}_D^L)^2 \tag{11}$$

$$C_B(\bar{N}_B^L) = \beta_B(\bar{N}_B^L)^2 \tag{12}$$

$$C_B(\bar{P}_B^L) = \alpha_B(\bar{P}_B^L)^2 \tag{13}$$

$$C_D(\bar{N}_D^L) = \beta_D(\bar{N}_D^L)^2 \tag{14}$$

The baseline year for the parameters is 2003. The parameterisation of the model abstracts from weather. The average load parameters have been obtained by 10 year weather data. The soil type and quality are uniform between farms. Parameters are calibrated to match the VEPS model developed for nutrient load forecasting in Finland. The key component in terms of arable land is the ICECREAM model, a Finnish version of CREAMS with more suitable modifications for winter conditions (Tattari et al. 2001).

The subsidies are split between Northern- (C2-region) and Southern-Finland (A-region), which is also the division between the farms types. In South, the farms are represented by the crop type (Helin et al. 2006) and in the North by the dairy type (Helin, ibid). The dairy farms are entitled to milk subsidy and receive higher per hectare payments due to the northern aid. The limitations set by the milk quota were not considered. Due complexity of the Finnish agri-environmental subsidy scheme, which includes several optional measures for farms depending on their geographical location and animal densities, the analysis in this study is limited to the basic measures, of which the nutrient recommendations are included in the quantitative results. In order to obtain the lump sum per hectare of arable land agri-environmental subsidy, the farmers need to follow the fertilisation recommendations, which have been revised for the period of the new scheme of 2007-2013. For the agri-environmental subsidies of 2007, the analysis relies on the national plans, as upon writing, the European commission has not sanctioned the revised agri-environmental scheme[1]. The regionally significant crop types were considered in the analysis. The maximum share of turnip rape, sugar beet and potato was constrained. The crop growth functions were parameterised for each region to represent the climatic differences and follow Lehtonen (2001) in the nitrogen response calibration and Helin et al. (2006) in the tillage effect calibration. The annual effect of phosphorus fertilisation on crop yield follows from Finnish field experiments (Saarela 1997), and was modelled additively on top of the nitrogen yield (Helin ibid.) The milk yield parameters were from Finnish dairy data of various feeding experiments (Huhtanen, ibid).

[1] The national agri-environmental scheme for 2007-2012 was turned down by the European commission in spring of 2007. The revised version is currently negotiated.

The land area available for both farm types was set equal. The minimum and maximum of CAP fallow requirement was retained. Manure nutrients were endogenously determined by functions of fodder nutrient intake of the cattle (Huhtala ibid, Helin ibid.). Manure nutrients were regarded equivalent to chemical fertiliser nutrients in term of fertiliser effect and load susceptibility. For animal farm it was assumed that all manure must be applied on the farm's fields. For the crop farm, manure application costs based on the assumed capital, labour and distance of transport, were higher than the nutrient value of manure and hence no manure was applied. The costs of other field operations are assumed equal between farms and based on costs of outsourced capital and labour in 2003. Input and output prices are equal between farms and kept at the 2003 level for the analysis of the reformed policies to abstract from the annual variation.

Results & Discussion

According to the results, dairy farming in the northern region was more profitable than crop farming in the south. Given the same field area, the intensively operated dairy farm could earn as many as five times the amount of profit as the crop farm, while causing 22% less of nitrogen load and 24% less of phosphorus load. The difference between crop and dairy farm profits is explained by considerably higher profits obtained on dairy farms due milk sale revenues and other subsidies[2]. The difference in the nutrient loads is a result of land allocation on silage, which retains the plant cover over the wet winter months and hence reduces loading significantly when compared with malt barley of the crop farm. The basic fertiliser limitations of the national agri-environmental scheme reduce the baseline optimum nitrogen load of crop and dairy farms respectively by 2.5% and 4.2% The simulated abatement cost of nitrogen and phosphorus are presented in the Figures 1. and 2. for all the policy scenarios.

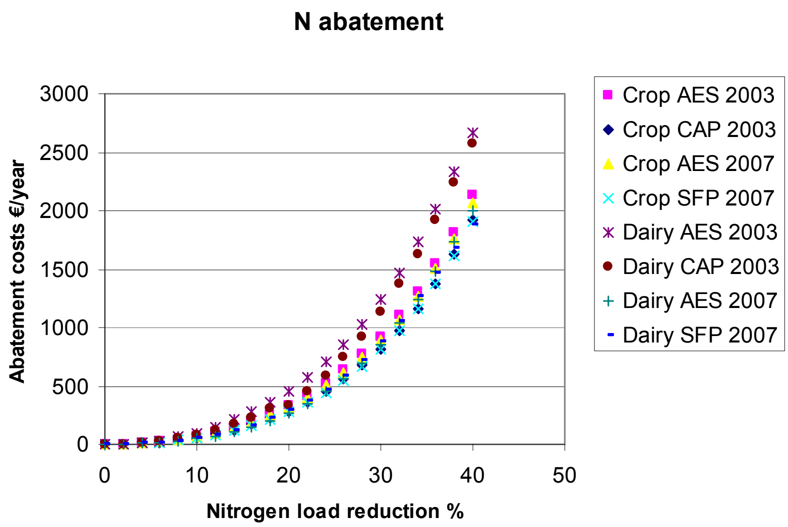

Figure 1. Simulated abatement costs for nitrogen.

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[2] One should remember that that no limitations were given for the farm milk quota

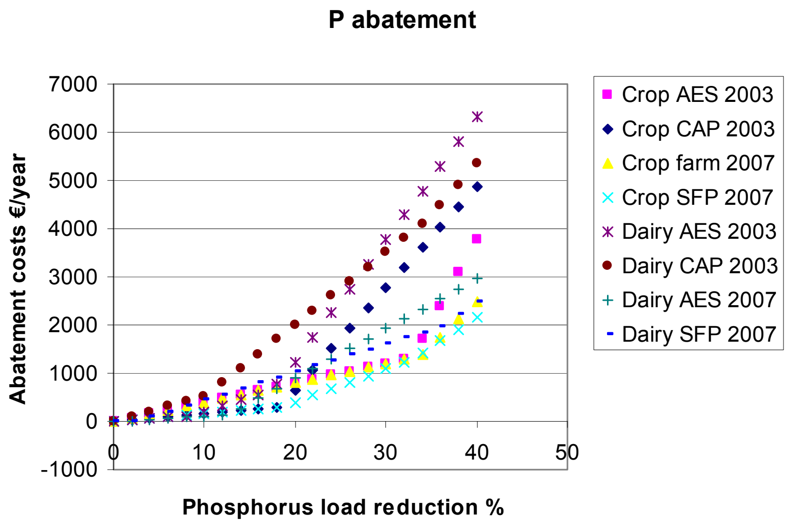

Figure 2. Simulated abatement costs for phosphorus.

As can be seen from Figures 1 & 2, differences in the income policy schemes and farm types can have considerable impact on the abatement costs. The changes caused by the hectare based agri-environmental subsidies and the basic measure nutrient load limitations are less marked. By looking at the nitrogen abatement costs only, one would neglect the variation in phosphorus abatement. As expected from the theory, the simulated abatement costs on the dairy farm are higher than on the crop farm. The coefficients for the OLS estimated cost functions are presented in Table 1.

Table 1. Coefficients for the abatement cost functions

		Nutrient			
		N	N	P	P
Farm type	Policy	**2003**	**2007**	**2003**	**2007**
CROP	environmental subsidy scheme	0.025	0.037	10.45	7.90
	NO environmental subsidy scheme	0.022	0.021	8.25	7.28
DAIRY	environmental subsidy scheme	0.054	0.036	38.79	17.72
	NO environmental subsidy scheme	0.051	0.035	43.24	19.20

The steps towards production decoupled income subsidies have generally decreased the abatement costs on both farm types and nutrients. The changes in the existing national agri-environmental scheme distort the abatement costs, but the effect is marginal for example when compared with the effect of farm type or the income policy.

The efficient allocation of the abatement targets set by the national government would result in approximately 63% share of N and 76% of P for the abatement on the crop farm. The allocation for 2003 without agri-environmental subsidies is presented in Figure 3.

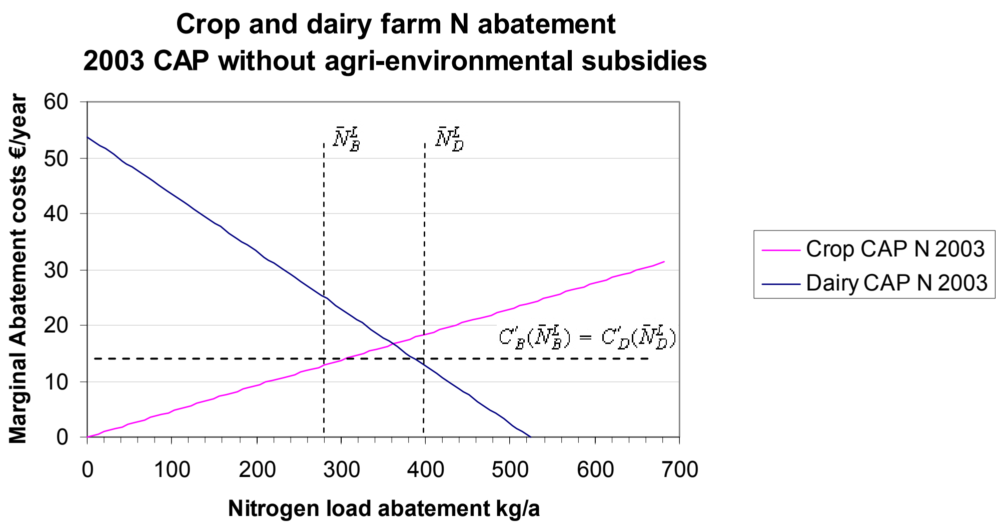

Figure 3. The cost-effective abatement costs for nitrogen. The abatement for the dairy farm should be read from right to left. The horizontal dashed line indicates the cost level where marginal abatement costs between farms are equal (€14).

For both farm types the main nitrogen abatement method is the reduction in the use of chemical fertiliser. The dairy farm compensates the reduced yields by increasing the amount of purchased fodder. Due efficient production and purchased fodder in the optimum solution, the dairy farm is also able to sell wheat which was subsidised by more than € 600/ha in 2003. The results indicate that crop farm would abate also more phosphorus, but the findings are sensitive to assumptions on the effects of national agri-environmental scheme. However, the fertilisation limitations of the agri-environmental scheme did not have an impact on the phosphorus loads of the baseline economic optimum. The good P status of the fields warranted the optimum yields with less than 1 kg P/ha. The marginal abatement costs for phosphorus are presented in Figure 4.

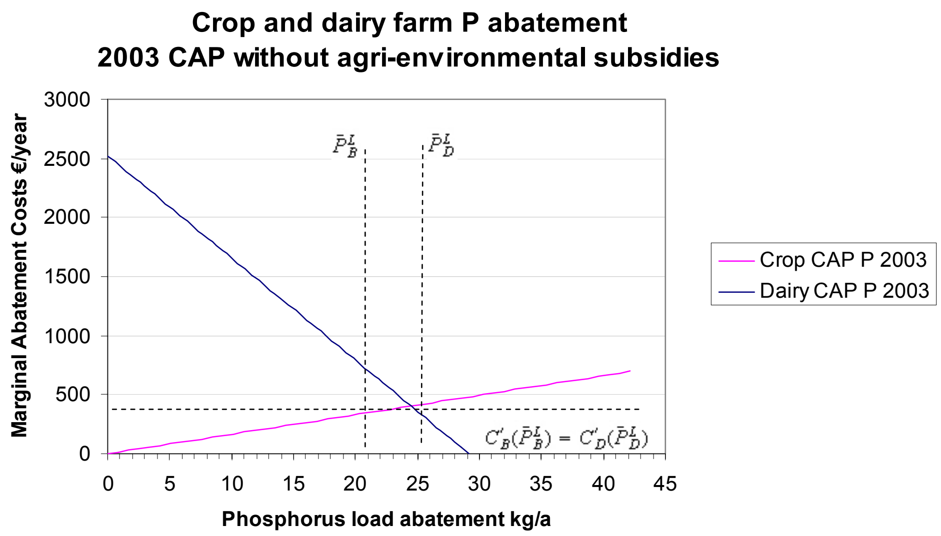

Figure 4. The cost-effective abatement costs for phosphorus. Marginal abatement cost are € 336.

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Under the SFP system the profitability of representative crop production declined by 27% The SFP figures do not include the effects of the top-ups, which on the basis of 2003 yields would have been around €600 for the model crop farm. Considering a situation with no environmental subsides or regulation, the land allocation between the single farm payment scheme and the previous scheme is similar. The starch potato farming is discontinued on the crop farm following the subsidy changes. For the dairy farm, the decline in profitability for adopting the SFP and other changes in national subsidies is only 8%. Figures 5. and 6. compare the cost-effective allocation of abatement between the income policies for nitrogen and phosphorus, respectively.

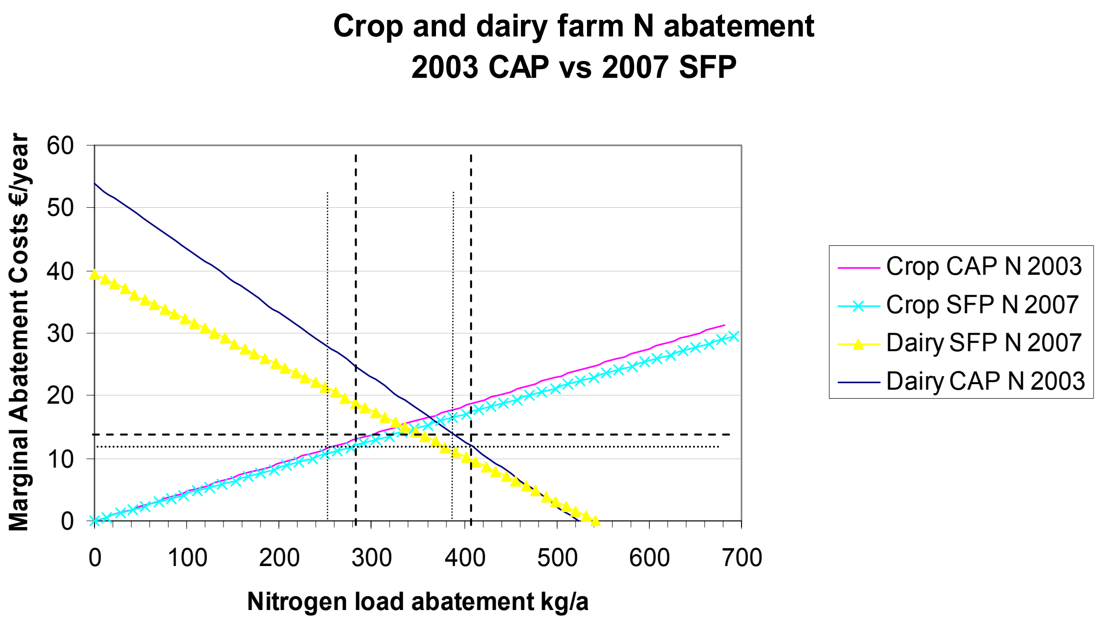

Figure 5. The nitrogen abatement costs. The figure does not include the subsidies of the agri-environmental scheme.

As a result of the single farm payment scheme implementation of Finland, more nitrogen load abatement takes place on the dairy farm and the 34% abatement target is reached with less costs. The main cause for different abatement paths of the subsidy regimes is fallow, which receives more subsidies from SFP and is thus a more competitive abatement method. While the dairy farm still receives the milk production subsidies, its profit margin is not as severely dependent on the land use as the margin of the crop farm. The purchased fodder input can substitute own fodder production.

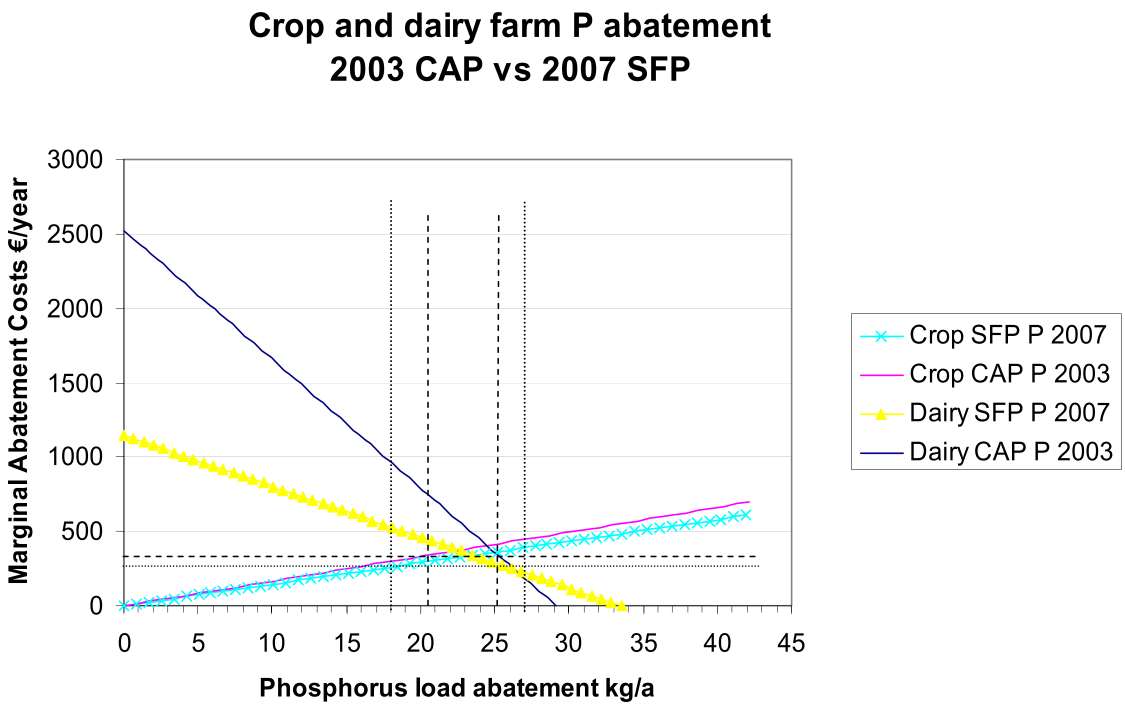

Figure 6. The phosphorus abatement and income policies without the agri-environmental scheme.

Base phosphorus load of the crop farm decreases as the decoupling of the starch potato subsidy leaves malt barley production as the more profitable crop choice. Similar to nitrogen, more phosphorus abatement occurs on the dairy farm due to the shift in the subsidy regimes. On the dairy farm the phosphorus load is decreased by reducing tillage of wheat and giving up more intensive farming of sugar beet and potato for fallow. On the crop farm, the no-till technology is the cost-effective abatement method.

The SFP does not increase the amount of green fallow on the representative farms. But when considering the allocation under no environmental subsidy scheme and single farm payment, the share of fallow increases as stricter P-constraints are faced. So while the SFP might encourage setting land aside as indicated in many earlier studies (e.g. Rabinowicz 1999, Lehtonen et al. 2005), the share of green fallow might even diminish. Indeed, the reformed agri-environmental scheme seems to anticipate this, as a national compensation of €39 is specifically targeted for green fallow. The previous agri-environmental scheme did not pay subsidy for fallow. While the new green fallow subsidy is not sufficient incentive to steer away from crop production on the representative farms, it steers the management of set aside land towards green fallow.

The revised agri-environmental subsidies for basic measures exceed the modelled abatement cost for the water protection targets of the farms. Even the tightening of environmental standards in the revised national agri-environmental scheme leads to a loss of only €15 to the crop farm and €13 to the dairy farm. The compliance cost is only a fraction of what is paid by the scheme. Unsurprisingly, also the new scheme in Finland has been adopted by most of the farmers. What remains to be seen is if other aspects of multifunctionality can justify the handsome compensation.

The manure transport between the regions was not profitable in the model. Naturally, the distance between the farms plays a role in the transport costs, but more detailed geographical analysis would be needed in order to tackle the question of manure transport. Moreover, due to the assumption that the crop farmer would require the spreading capital himself, the manure application was prohibitively expensive at outset. Besides providing potential solution to the regional concentration of production lines, the manure issue is politically on the Finnish agenda as the current EU ruling forbids compensating the crop farmer for receiving manure.

Recent increases in the crop prices would besides increasing the crop farmer income, increase the abatement costs calculated in this study. As the reduction of fertiliser use is one the effective abatement methods for nitrogen, the favourable price development of crops leads to higher privately optimal fertilisation use and increases the abatement cost. At the same time, the fodder costs of dairy farmer would increase, although the model does not have explicit links between commercial fodder prices and general crop prices. For phosphorus the short-term significance for crop yields was so small that similar effect is not expected. In case of phosphorus abatement, the analysis would benefit from fuel price and machinery cost sensitivity analysis.

Assessing the effectiveness of the Finnish agri-environmental scheme on reduction of concrete nutrient loads would require further studies. In addition to illustrating the practical impacts of nutrient recommendations, which was attempted in this study, the significance of temporal constraints e.g. on the period of manure allocation should be assessed. The Finnish subsidy scheme contains stricter timing limits than given in the nitrate directive, but the economic and environmental significance of these instruments has not been published. Furthermore, the analysis should be extended also towards spatial heterogeneity of soil and to include real production structures and locations within the regions. Without variation in the soil quality and farm profitability, the analysis of entry and exit effects in agriculture lacks the true edge. In the light of these results, the interpretation of the excessive costs of abatement in the water framework directive presents a dilemma; does the CAP itself constitute as excessive cost?

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