# EU Common Agricultural Policy direct payments, Nitrogen balance and eutrophication of the Baltic Sea

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Abstract

Eutrophication continues to be a priority threat to the Baltic Sea and further reduction of nutrient run-off is necessary. Since big part of nitrogen inputs originates from agriculture, impact of common agricultural policy (CAP) direct payments needs to be assessed. According to our hypothesis the direct payments create a possibility to use bigger quantities of procured inputs like mineral fertiliser and farm animal fodder than would otherwise be used, thus contributing to surplus nitrogen that is leading to the run-off and thus eutrophication of the Baltic Sea. We checked the hypothesis by comparing the payment levels to nitrogen balances and use in EU member states. The analysis revealed a reliable correlation between these, that is consistent with our hypothesis of higher payments leading to bigger surplus and hence contributing to eutrophication. We therefore conclude that CAP direct payments are a case of environmentally harmful subsidy and abolishing these would represent a cost-effective measure on the way to improve environmental status of the Baltic Sea.

## 1. Introduction

### 1.1. Eutrophication as a key threat to the Baltic Sea

Eutrophication is apparently among the most serious of the environmental threats faced by the Baltic Sea today. During the course of 20$^{th}$ century the whole sea has changed from oligotrophic to eutrophic (HELCOM, 2015). In spite of some reduction of nutrient input during last couple of decades (HELCOM, 2015) and the resulting first signs of environmental improvement (Andersen et al 2015),

eutrophication effects, including spread of anoxic bottoms and toxic algal blooms, remain severe and the main key to combat these lies in further reductions of nutrient run-off, especially from land-based sources (Carstensen et al 2014, Elmgren et al 2015, HELCOM 2013).

A complex legal system for protection of the Baltic Sea includes international conventions, most importantly the Helsinki Convention (Convention on the Protection of the Marine Environment of the Baltic Sea Area), EU directives like the Nitrates directive, Water Framework Directive (WFD), Marine Strategy Framework Directive (MSFD) and others, and national law of the countries on the catchment area of the sea; the institutional setting for implementing these is provided by the Helsinki Commission (HELCOM), European Commission and national governments. This system has proved to be part of the solution but has obviously not yet delivered the sufficient improvement of the environmental status of the sea (Nilsson & Bohman 2015, Tynkkynen et al 2015). The Contracting Parties of the Helsinki Convention have agreed to nutrient run-off reduction targets under the HELCOM Baltic Sea Action Plan (BSAP) and its updates agreed by the ministerial meetings (HELCOM 2013). This far, in spite of some progress in nutrient reduction, the agreed targets have mostly not been met, with most of the countries failing to achieve the necessary reductions for at least one of the sea basins (Progress...).

Agricultural diffuse load has been identified as the key nitrogen source (HELCOM, 2011). Not surprisingly then, EU Common Agricultural Policy (CAP) has been named both as part of the solution and part of the problem (Karlsson, Gilek, Lundberg 2016; Tynkkynen et al 2015). Many measures have been proposed to address the run-off from agriculture, and analysis of their cost-effectiveness has been carried out (Wulff et al 2015). Surprisingly little attention however has been dedicated to assessment of the impacts of CAP direct payments on agricultural run-off and possibility to abolish these payments as part of eutrophication mitigation efforts.

### 1.2. Agricultural Nitrogen as a key driver of the Baltic Sea eutrophication

According to European Nitrogen Assessment (ENA 2011) global nitrogen cycle is more altered than that of phosphorus (and even more altered than the carbon cycle). EU-27 is a hot spot in this sense, producing 10% of global anthropogenic reactive N, even though its surface covers less than 3% of the total world continental area. The focus of our analysis is thus on nitrogen, especially since this is the limiting element for the spring blooms in Baltic Proper and on increasingly so also in the Bothnian Sea (Rolff & Elfwing, 2015).

On the level of individual fields inputs of nitrogen are determined by application of manure and mineral fertilisers, and biological fixation by crops. Since animals do not possess ability of biological nitrogen fixation from the atmosphere, the nitrogen in manure originates from the feed. Feed of local origin does not constitute an input on the level of whole farm since nitrogen in it is derived from the local soil. Therefore, on the farm balance the nitrogen input must be calculated based on purchase of mineral fertiliser, animal feed and manure, and biological fixation by crops. Since manure is not imported into EU, on the continental scale the nitrogen input consists of mineral fertiliser application, feeding animals with imported feed, and biological fixation by crops.

According to ENA (2011) annual nitrogen inputs to the EU agriculture are of the following magnitude: mineral fertiliser 11.2 Tg, imported feed 3.1 Tg and biological fixation by crops just 1 Tg (Tg is equal to million tons). This large input results in a surplus of reactive nitrogen that inevitably leads to impacts on biosphere. Nitrogen losses from agriculture to environment are as follows: emissions of ammonia and nitrogen oxides 3.6 Tg, denitrification from agricultural soils 4.5 Tg and run-off to the water 6.2 Tg.

Input as such is not the main direct cause of eutrophication, since agricultural run-off is determined more directly by the nutrient balance, that is input minus removal by the crops. However, even in case of fixed efficiency of nutrient uptake and linear relation between input and the yield per hectare, the absolute surplus and resulting run-off will increase as a linear function of input. Therefore, for run-off not to increase with increased inputs, these must be accompanied by proportional increase in efficiency of nutrient uptake. While in some exceptional cases this can happen, the overall trend is opposite due to well-known nonlinear impact of nutrient availability: with higher nutrient application rates the efficiency of nutrient uptake by the plant decreases leading to diminishing return (e.g. Tillman et al, 2002). This means that more intensive fertiliser input results in higher run-off not only in absolute but also in relative terms. In other words, the surplus rises as a rule quicker than the application (e.g. Bertilsson, 2010).

### 1.3. Impact of the Common Agricultural Policy (CAP) direct payments on nitrogen use and balance.

The law of diminishing return results in economic optimum for fertilisation that is below the level that would result in maximum yield (ENA 2011). High prices of agricultural products draw the economic optimum close to the level of maximum yield, while high prices of fertiliser push the

economic optimum down. Hence the tax on fertiliser would also push the economic optimum to lower levels and lead to environmental benefit of reduced run-off, while subsidies for fertiliser or for production would push it up together with associated damage to environment. It is thus not surprising that production-related subsidies are considered to be environmentally harmful (OECD 1998 and 2016). CAP reforms have gradually removed this kind of subsidies by decoupling direct payments from production. Since 2007 the bulk of the payments have been decoupled, and this was reaffirmed by the last reform that took effect in 2014 (Overview... 2013).

It is believed that decoupled subsidies do not have effect on production-related choices and hence are not any more environmentally harmful (Schmid, Sinabell, Hofreither 2007). A pilot study conducted in Ireland however has reached the conclusion that decoupled subsidies tend to have a similar, albeit smaller, effect on production decisions to the coupled subsidies they have replaced (Howley et al 2012). Indeed, by creating "free money" the direct payments provide farmers with possibility to buy more farm inputs than would be sensible if all the costs were to be recovered from product sales. It is therefore reasonable to expect a negative environmental influence of the current direct payments even though this impact is probably not as strong as that of subsidy for fertiliser or production.

Last CAP reform also introduced so called "greening" to the direct payments, that is officially considered a success by the Commission (Overview... 2013). Independent evaluations however see the result in much less flattering light, with some calling it outright "green-wash" (Anania and Pupo D'Andrea 2015, Bureau and Mahé 2015, Erjavec, Lovec and Erjavec 2015, Matthews 2015, Swinnen 2015). The new requirements – crop "diversification", protection of permanent grasslands and introduction of the so called "ecological focus areas" - are not connected to the use of procured inputs and therefore are not expected to reduce negative environmental impact of the payments on the Baltic Sea.

If our reasoning about the decoupled subsidies still having a negative environmental impact by contributing to the nutrient run-off into the Baltic Sea one would expect the levels on payments to be correlated with relevant agri-environmental indicators. Below we will look if the CAP direct payments are linked to the indicators related to nutrient balance on the EU level, and also "zoom in" the Baltic Sea region. We will take a sample year in the previous period with most data available and the latest year we have the data on nitrogen balance. We will discuss what is the meaning of our findings. Based on our findings we make a simple proposal for future CAP reform that would benefit the Baltic Sea.

## 2. Material and methods.

We extracted data on nitrogen-related agri-environmental indicators (nitrogen inputs, livestock density and nitrogen balance) for all EU member states from publicly available Eurostat home page. For nitrogen input the data was available for 2010 only, and we therefore used this year for most of the comparisons. For the nitrogen balance however there is a dataset with longer time span. We used the latest data, from 2014 to assess if any changes could be detected. The data used in the analysis are presented in Annex 1. For CAP direct payments levels per hectare in the EU Member States no publicly available data table was found, therefore we made an information request to the Directorate-General for Agriculture and Rural Development of the European Commission. The Commission was able to provide the data on the so called baseline levels of payments for the 2013 reform and the forecast for 2020 according to the reform agreement (Bollen 2016). The data are presented in the Annex 2. It was not possible to get official data on payment rates per hectare for other years, therefore the values of agri-environmental indicators both for 2010 and for 2014 had to be compared to subsidy levels of 2013. We also compared the subsidy levels for 2013 and these expected for 2020. The values of agri-environmental indicators were also compared to each other for year 2010 where data was available for all three. Pearson's and Spearman's correlation coefficients were calculated in order to be able to detect both linear and non-linear monotonic dependencies between the investigated parameters. The default level of significance was $p<0.05$. We performed separate analyses for EU as a whole and for Baltic Sea region member states.

## 3. Results

We found statistically significant Spearman and Pearson correlations between level of direct payments in 2013 and nitrogen balance per hectare for both analysed years, and both on EU and on the Baltic Sea region level. Figure 1a shows this relation on the EU-wide scale for year 2010 and figure 1b for year 2014. The same relation for the sub-set of Baltic Sea region EU member states is presented in figures 1c and 1d. The Pearson's correlation values are shown on the graphs; corresponding Spearman's correlations were 0,74 and 0,80 for all EU, and 0,93 and 0,83 for the Baltic Sea region member states.

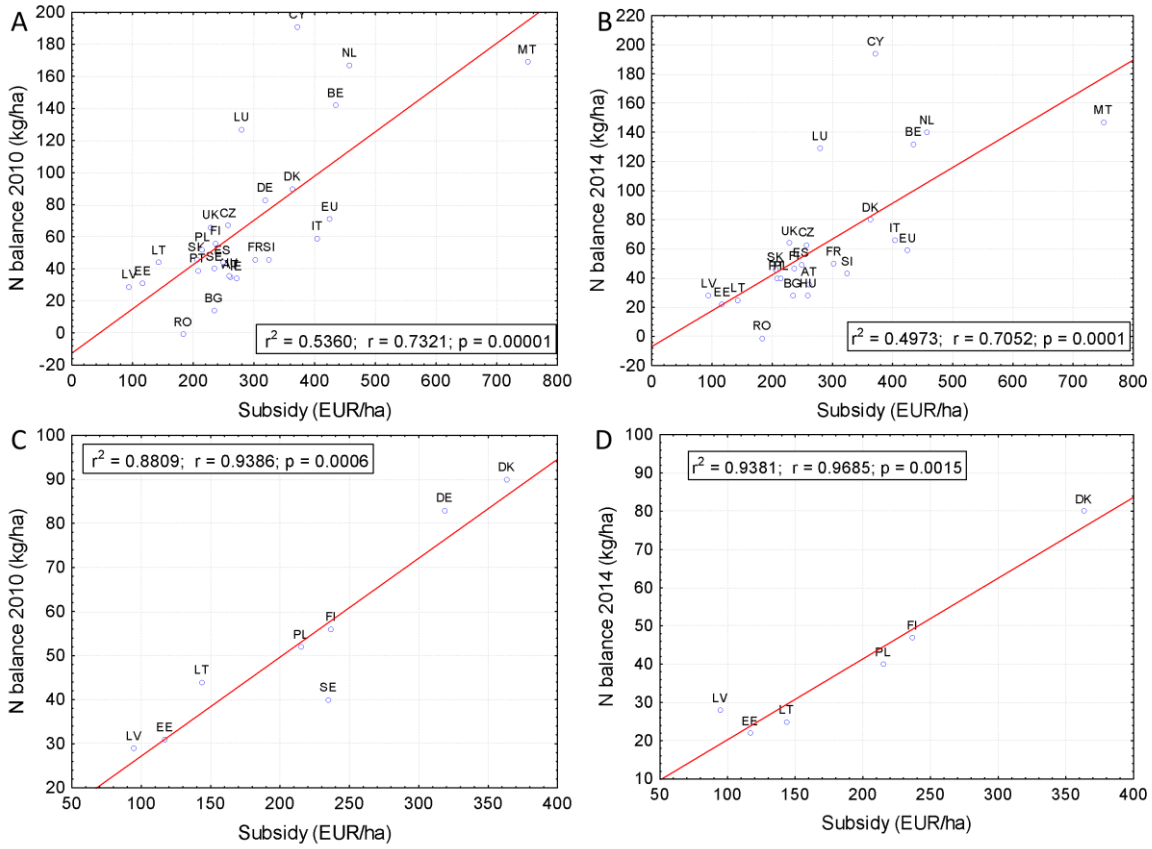


**Figure 1.** Correlation between nitrogen balance in 2010-2014 and subsidy in EU (A,B) countries and in BSR (C,D).

There was also a statistically significant correlation between mineral nitrogen application and nitrogen surplus per hectare in 2010, the only year for which data on mineral nitrogen application is available. Figure 2a shows the relation, including the values for Pearson's correlation, for all EU member states and figure 2b for the Baltic Sea region. The corresponding values of Spearman's correlation are 0,46 and 0,90.

Link between subsidies and mineral nitrogen fertiliser application was less clear on the EU scale, Spearman's correlation of 0,40 being statistically significant; Pearson's correlation was not statistically significant. As seen on the figure 2c the relation indeed appears to be non-linear. Both correlation indices were however clearly significant in the Baltic Sea region, as seen for Pearson's on figure 2d; Spearman's correlation for the region was 0,90.

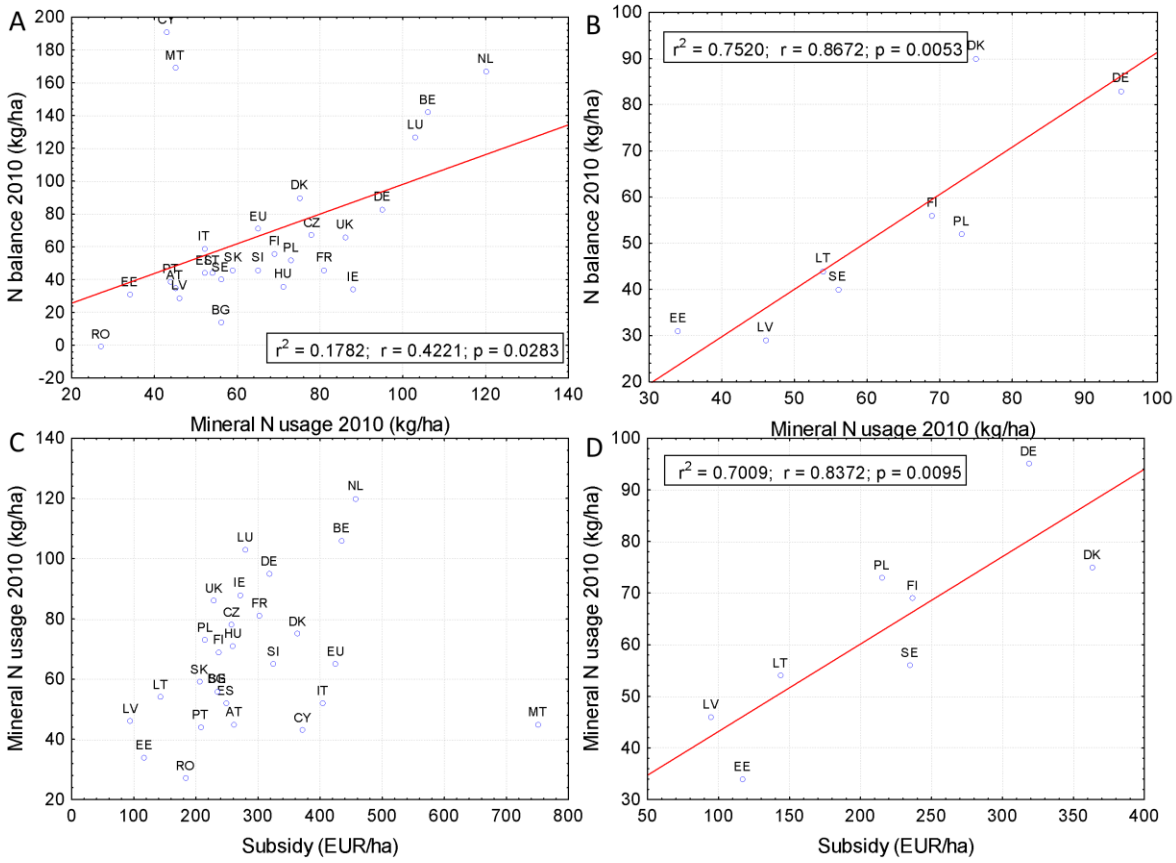


**Figure 2.** Correlation between nitrogen balance and mineral nitrogen usage in 2010 in EU (A) and BSR (B) countries and correlation between mineral nitrogen usage and subsidy levels in EU (C) and BSR (D) countries.

There was statistically significant correlation between direct payments and farm animal density both for EU as a whole and for the Baltic Sea region member states in 2010 (figures 3a and 3b), and the link between farm animal density and nitrogen surplus was also significant on both scales (figures 3c and 3d). The corresponding Speraman's correlations between direct payments and farm animal density were 0,76 and 0,90, and between farm animal density and nitrogen surplus 0,69 and 0,86.

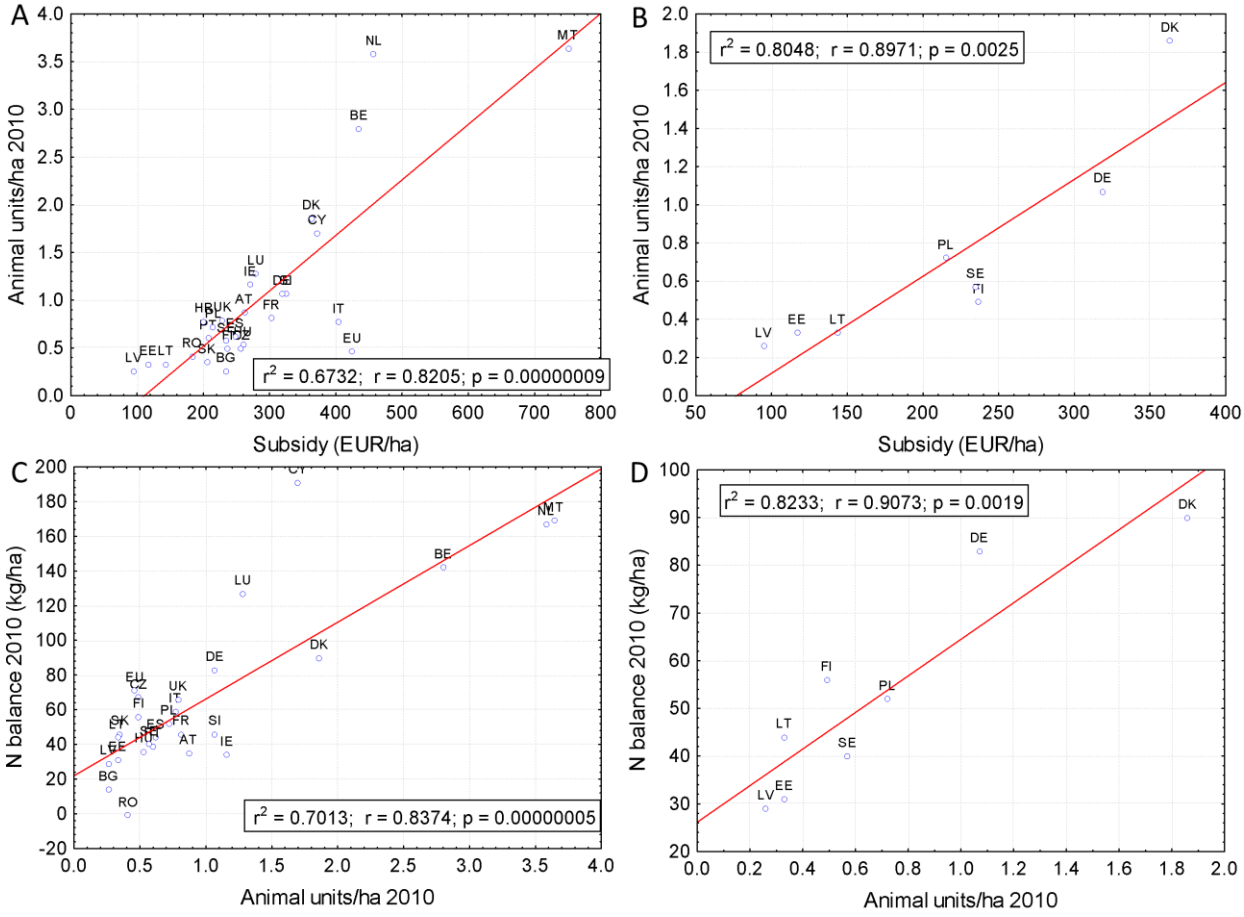


**Figure 3.** Correlation between animal units and subsidy in EU (A) and BSR (B) countries and correlation between nitrogen balance and animal units in EU (C) and BSR (D) countries.

Last but not least there was a very strong (over 0,99) and statistically significant correlations between subsidies in 2013 and those planned for the end of current period in 2020. The planned subsidies therefore naturally also correlated with the same variables as the subsidies for the previous period.

## 4. Discussion

The reliable correlation between the CAP direct payments levels and nutrient surplus is consistent with the hypothesis that higher subsidy stimulates higher inputs and thus contributes to surplus. Direct payments therefore appear to be a driver of eutrophication. The mechanism of this impact is elaborated upon below.

Our hypothesis is that higher subsidy levels permit procurement of bigger amounts of nitrogen-

containing farm inputs: fertilisers and animal fodder. Indeed, mineral nitrogen application is correlated to the subsidy levels, as expected. It is of course clear that there are also other factors at play and therefore it is hardly surprising that on EU scale the relation between payments and nitrogen balance was non-linear. On regional scale of Baltic Sea area member states, the overall conditions of agricultural production are more similar, and the correlation between subsidy and surplus clearly stronger, with the linear correlation also being reliable.

We were regrettably not able to get EU-wide data on fodder imports. However, the data on animal density can be used as a good proxy: very high numbers of animals cannot be sustained by local fodder and inevitably drive relevant imports. The finding of significant correlation between subsidy levels and animal densities was thus also in accord with our main thesis.

The fact that correlation is even stronger with the balance than it is with mineral fertiliser application is also in accord with nitrogen surplus being created via twin paths of mineral fertilisers and procured fodder (to be realised on the field level balance as additional manure). This reasoning is further confirmed by correlation between mineral fertiliser application and the nitrogen balance, as well as correlation between animal density and nitrogen balance. This finding is also consistent with the decrease of nitrogen use efficiency at the higher application rates due to diminishing returns. It can thus be summed up that bigger subsidies result in bigger use of procured inputs like mineral fertiliser and animal fodder that in turn lead to even higher nutrient surpluses.

There is of course an alternative explanation: the current decoupled subsidies were introduced as a replacement to production-linked support, and since the latter was by definition higher in areas with more intensive production and hence higher nutrient surpluses, the current correlation might be claimed to result from this historic background. However, even if this would be the sole cause of the significant correlations observed, we would still have to conclude that CAP goes completely against the “polluter pays principle” by making the highest payments to the biggest polluters. And, while partly obviously true, this alternative explanation fails to explain why is the link between the subsidy and surplus so persistent in time – after all, decoupling of CAP direct payments happened quite some time ago. Furthermore, the “historic link” fails to explain, why nitrogen surplus in Estonia almost doubled after EU accession, when CAP direct payments (that were already decoupled then) became available. Estonian surplus is still among lowest in EU, that is well in accord with second-lowest subsidy levels. It is however almost two times higher than the 12-15 kgN/ha of the post-communist pre-accession period, when Estonia was one of the very few countries with no agricultural subsidies at all.

It is therefore reasonable to conclude that the correlation is based on the two-fold link between the direct payments and nutrient surplus: while partly reflecting history of more intensive production, higher payments also contribute to bigger reliance on external inputs like fertiliser and fodder, and hence lead to higher excess of nitrogen. And because the subsidy levels now are closely correlated to these of previous financing period, it is reasonable to expect that nutrient surpluses are not going to be significantly reduced until 2020. We therefore make a forecast that the relation between direct payments and nitrogen-related environmental problems will remain largely unabated until 2020, and that "greening" is not expected to provide any benefits to tackle these. Even more so, at the lower end of the payment and balance levels, in Estonia, Latvia and Lithuania, some increase of nitrogen surplus can be expected together with subsidy rise. The CAP direct payments are thus an important obstacle on the way to achieve the nutrient run-off reduction targets agreed under HELCOM BSAP.

The data and the analysis are therefore suggesting that CAP direct payments should still be considered environmentally harmful subsidies. At the same time there is no evidence of this payment scheme providing clear socio-economic benefits. European Court of Auditors has noted in its Opinion No 1/2012 "… the specific objectives for direct payments to farmers within the framework of the CAP, are not disclosed in the articles of the Regulation (or in its preamble), neither are their expected results, impacts and indicators." This fact has regrettably not been taken into account but it cannot be neglected for ever. The poor targeting of CAP direct payments at providing any goods for the public has been criticised by many experts (Matthews 2017). The use of public money that has no clear objective and is environmentally harmful cannot be justified any longer after 2020.

If the next CAP reform will not fail again and will indeed result in abolishing environmentally harmful subsidies, relatively quick improvement is to be expected after 2020. It is however hard to quantify the probable gain. Assuming that it would totally eliminate nitrogen surpluses, as the linear relation based on the statistical analysis would suggest, is probably too optimistic. After all some, albeit a very low, nitrogen surplus existed even in pre-accession Estonia, where no subsidies were paid. There are other causes contributing to the nutrient balance in addition to environmentally perverse subsidies. Significant reduction of the surplus as the result of ending direct payments is however a reasonable hope.

We are after all not proposing to replace all the other measures to decrease eutrophication, but rather to compliment these with a robust, simple and cost-effective policy decision. CAP budget is almost 40% of EU multiannual financial framework (MFF), and direct payments take up about three quarters

of this money. Abolishing these would thus liberate significant finances, that could, at least partly be used for better financing agri-environmental measures aiming at run-off reduction.

When calling abolition of direct payments, a simple step we are referring to technical side of the decision and its future implementation. We have no illusion about such a decision being simple politically. However, the unsatisfactory outcome of the last reform resulted in calls to start the discussion of the CAP post 2020 shortly after the previous reform package had been implemented (Buckwell 2015). The discussion about the next CAP reform has started at last, and it would be completely irresponsible to proceed with "business as usual" in this important policy area.

## 6. Conclusion

CAP direct payments are an example of environmentally harmful subsidy and are contributing to eutrophication of the Baltic Sea. Given the continuation of current CAP until 2020 we forecast the failure to achieve the agreed BSAP nitrogen run-off reduction targets in time. Abolition of direct payments with next CAP reform would likely reduce run-off of nitrogen to the Baltic Sea and permit achieving the reduction targets, albeit later that originally agreed, while also saving public money. As such, while not alone solving all environmental problems of our sea, getting rid of CAP direct payments represents a cost-effective policy measure on the way to the good environmental status. Since CAP direct payments form a big part of EU budget, abolishing these would also free significant financial resources that could at least partly be used to finance further measures to improve the environmental performance of agricultural sector and protect marine environment.

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