CHAPTER 14. THE USE OF GREEN TAXES IN DENMARK FOR THE CONTROL OF THE AQUATIC ENVIRONMENT

Hans Larsen[1]

Abstract

In preparation for the Aquatic Environment Plan III, separate economic models were developed to assess the use of economic instruments to control for nitrogen and phosphorus pollution from agriculture. These included taxes on various inputs; taxes on surpluses (inputs less outputs) at the national, sectoral and farm levels; and tradable quotas. The results indicated that to achieve the same reduction in nutrient surplus (a proxy for pollution) the adjustment costs for farmers were much higher when inputs were taxed than when surplus were taxed. While the government decided to not adopt a nitrogen tax (because of the success of the current regulation regime) it has introduced a tax on mineral phosphorus in feed (while having the largest adjustment cost for farmers this tax is simpler to administer). A review of the Danish pesticide tax suggested that it has been effective in moving pesticide consumption closer towards the substance quantity targets.

Introduction

As a point of departure, it can be assumed that lower economic costs can be achieved by tax measures than by general control (traditional regulatory or command-control systems). However, regional control may be cheaper than economic instruments if there is considerable variation in the damaging effects involved (geographically-determined or point-specific).

This paper describes in detail Danish assessments of economic instruments for the control of both nitrogen and phosphorus in agricultural. This is followed by brief descriptions of the current tax systems applying to pesticides and growth promoters.

The economic instrument assessments were a major part of the preparatory work in 2003 for Aquatic Environment Plan III which, on a foundation of transparency, self-management and considerations of sustainable agricultural production, was intended to prepare for a basis of decision in the future control of the general effect of agriculture on the aquatic environment. The fundamental principle was that the discharge of phosphorus and nitrogen should continue to be reduced. The environmental policy aims were to be achieved in a manner that ensured the best environmental value for money, and an effort was to be made to reinforce the role of the individual farmer as an active environmental custodian through incentives and freedom of action. The objective was a simpler, more cost-effective system than the current control regime, which is based on standards for the use of nitrogen differentiated in accordance with soil type, crop, etc.

1. Ministry of Taxation, Denmark.

The purpose of the work on economic instruments was to describe the advantages and disadvantages that are associated with the use of economic options for the control of agricultural use of phosphorus and nitrogen. Tax and quota options were assessed. The control of phosphorus and nitrogen were assessed separately.

Economic instruments for the control of agricultural use of nitrogen

Nitrogen is a necessary nutrient for growth and it is the nutrient that goes into agricultural production in the largest quantities. But increasing the nitrogen supply to lakes and coastal waters alters the ecological conditions. An increased quantity of nitrogen increases the incidence of algae in lakes and marine areas, with the following consequences:

- The water becomes muddy and unclear
- The natural plant growth receives insufficient light
- Increased oxygen consumption to break down algae on the bottom
- Alteration in fish stocks
- Incidence of troublesome and possibly toxic blue-green algae
- Occurrence of oxygen depletion, resulting in the death of fish and bottom-dwelling organisms.

Seven different economic options for the control of agricultural use of nitrogen have been assessed. The point of departure is a simple option that was subsequently expanded in such a way that the basis of assessment addresses the potential environmental impact – the agricultural excess of nitrogen. It is demonstrated that the costs of reducing the nitrogen surplus fall as the options expand.

The environmental impact of the various options is measured in terms of the reduction in nitrogen surplus. This parameter is not necessarily the right one since the damaging effect of nitrogen is dependent on a large number of other factors including the state of the nitrogen (nitrate or ammonia), the sensitivity of the site to nitrogen loss, the soil etc. It is not possible to determine whether a tax exercises too little or too much control in a given area.

The theoretical model for agricultural nitrogen use

Because there is plenty of knowledge available about the agricultural use of nitrogen it has been possible to construct a theoretical economic model for nitrogen use, including empirically determined production functions for agricultural crops and assumptions regarding nitrogen absorption by animals.

A fundamental prerequisite in the economic model is that the various agents should act rationally, that is to seek to maximise surplus or benefit. If a rational choice is to be undertaken, knowledge is required of physical correlations between production and the use of raw materials – the production function[2] – and knowledge of prices.

2. A production function may look like this:

Yield = $U_N(N)=10,7417+05822xN-0,0027N^2+0,0000346xN^3$, where the yield is calculated in hkg.

In practice, widely varying production functions apply, and the model distances itself from the actual situation in a given place at a given time by generalising the production functions etc. on the basis of average assumptions. Although information is lost in the generalisation of a complex reality it is nevertheless the case that no one on the margin will defray greater costs to reduce the basis of assessment than the rate of levy. By using a formalised model rather than more ad hoc examples, assessments that may not be consistent are avoided.

The model's predictions for the effects at a given place in a given year will not necessarily prove true, but there is no reason to suppose it is more likely that the effects will be greater than that they will be smaller. Whether the effect of the taxes is especially great or small in particularly sensitive areas cannot therefore be determined in advance.

There is of course considerable uncertainty about the model's quantitative effects which operate through the following channels:

- If nitrogen prices are higher, the optimum economic option will be to reduce the nitrogen supply.
- If nitrogen prices are higher, it will be potentially more profitable to utilise a greater proportion of the nitrogen in waste and in livestock manure.
- In the event of a change in contribution margin between different crops, the cultivations where there is the smallest drop in contribution margin will be favoured and the reverse.
- If the value of livestock manure increases, it will be potentially more profitable to increase livestock manure production.
- If the value of livestock manure increases, cheap feed that is of limited value in terms of animal production but produces a great deal of manure will be more advantageous.

There can be no doubt about the sign of these effects. On the other hand, uncertainty is associated with the degree of magnitude of the correlations. In addition, the model is subject to a degree of uncertainty as a result of the fact that it is assumed that the price of nitrogen in livestock manure (measured in commercial fertiliser equivalents) will follow the price of commercial fertiliser in the ratio 1:1. This assumption may involve over-valuation of the quantity of nitrogen from livestock manure used to replace commercial fertiliser. Especially at high tax rates, the price of nitrogen in livestock manure will not rise to the same degree as commercial fertiliser, because the transport costs over long distances will reduce the value of the nitrogen in livestock manure. Furthermore, the model is based on short-term production functions for crops, and this may also exaggerate the environmental effect.

The options assessed

Seven different tax options for the control of agricultural use of nitrogen were assessed in greater detail using the model described above:

1. Tax on commercial fertiliser.
2. Tax on commercial fertiliser and livestock contribution.

3. Tax on commercial fertiliser, livestock contribution and nitrogen fixation in plants.

4. Nitrogen surplus at national level (deposit-refund system): combined input of nitrogen (N) in fertiliser, animals and feed to Denmark minus output of N in fertiliser, animals and feed etc. from Denmark. Nitrogen fixation in peas etc. is added.

5. Nitrogen surplus for the agricultural sector (deposit-refund system): combined input of N in fertiliser, animals and feed etc. to the agricultural sector minus output of N in fertiliser, animals and feed from the agricultural sector. Nitrogen fixation in peas etc. is added.

6. Nitrogen surplus at farm level (deposit-refund system): input and output of N of the individual enterprise.

7. Tradable quota/permits of nitrogen.

The simplest option is a tax on commercial fertiliser and other goods that are marketed as nitrogenous fertiliser (option 1). This tax does not cover ordinary livestock manure. It is an indirect tax that is levied on importers and producers. The advantage of this tax is that it is levied on a limited number of large businesses. It is passed on to the individual consumer in terms of higher commercial fertiliser prices, which will raise the price of alternative nitrogen sources including livestock manure and nitrogen-fixing plants. A commercial fertiliser tax must therefore be expected to cause a uniform rise in the fertiliser value of livestock manure. Major efforts will therefore be expended in the direction of correct storage and application of livestock manure with a view to superior utilisation. An incentive will also be provided towards wider use of nitrogen-fixing plants.

The problem with a commercial fertiliser tax is that some of its advantageous effects are unfortunate in that it causes an additional burden on vegetable production while making animal production more profitable. It would also involve unintentional incentives for increased livestock levels, greater manure production through more intensive protein feeding, larger acreages devoted to nitrogen-fixing plants and reorganisation of crops in favour of those with less nitrogen consumption but not necessarily less nitrogen surplus.

It would be possible to neutralise some of the disadvantages of the commercial fertiliser tax by expanding the tax regime to include a levy on livestock manure (option 2). The tax rate for nitrogen in livestock manure must be lower than for nitrogen in commercial fertiliser since nitrogen in livestock manure has a lower utilisation percentage than nitrogen in commercial fertiliser.

The tax on livestock manure could be organised in various ways. The most appropriate way would be to levy a contribution from livestock (estimated nitrogen quantity corrected for utilisation percent) as a supplement to the commercial fertiliser tax, which would be calculated by abattoirs and dairies and in the export of all important livestock, and the quantity of meat converted using standards for the combined fertiliser production from such meat production. Such a tax could be levied as a standard excise duty, and the basis of assessment would be the same as that underlying the settling of accounts between the processing industry and the farmer. Although such a tax would potentially be reasonably precise at the macro level, the livestock contribution would be based on an approximate method, and the imprecision would, in individual cases, potentially generate unfortunate effects.

Other disadvantages of option 2 could be neutralised by also including a tax on nitrogen-fixing plants (option 3). It would be the responsibility of the farmer to indicate the nitrogen supply by stating the acreage and converted nitrogen quantity to be taxed. The scope of nitrogen fixation would have to be determined by using standards. The tax rate would have to be determined in such a way that the

effect of the commercial fertiliser tax on acreages of nitrogen-fixing plants would be neutralised. The tax can only be a rough approximation of the supply of nitrogen by this route. Administration could presumably be organised so that it was combined with the administration of the EU hectare support scheme, under which the acreages on which nitrogen-fixing plants are grown could be separately reported, and control could then be exercised by the Danish authorities managing the hectare support schemes. Although the nitrogen fixation calculated by summary standards might sometimes be wide of the mark, it would not be administratively tenable to attempt to calculate nitrogen fixation more precisely.

One of the disadvantages of options 1-3 is that they generate an impetus towards a change in crop composition to plants with less need for nitrogen. Options 4-7 attempt to neutralise this effect. Options 2 and 3 presuppose the use of a number of standard assumptions and conversion factors which will be incorrect where the actual circumstances deviate from the standards or the average. It will be possible to eliminate these sources of imprecision if a nitrogen surplus option, like options 4-6, was used. Furthermore, a number of administrative and regulatory difficulties would be associated with some of the tax elements in options 2 and 3.

Options 4-6 are based on the calculation of the nitrogen surplus. For the individual farmer, the central elements in the calculation of the nitrogen balance are the purchase of feed, seed grain, commercial fertiliser and nitrogen capture from nitrogen-fixing plants, minus sold feed, other vegetable and animal products and sold livestock manure. This calculation assumes calculation at farm level, and it presupposes the calculation of purchase and sale between the individual farms (option 6). A tax on nitrogen surplus at farm level (direct consumption tax) would therefore involve major administrative burdens.

However, it would be easier to calculate the nitrogen surplus if we could exclude purchase and sale between the individual farms in the basis of assessment and simply look at purchase and sale to and from the agricultural sector (option 5). An indirect calculation of the basis of assessment may be obtained by taxing the supply of nitrogen (feed and commercial fertiliser) to those who sell nitrogenous products to agriculture, allowing them to pass on the tax in the price of the products, reimbursing those who purchase from agriculture and allowing them to pass this reimbursement back to agriculture. Decisive administrative advantages are obtained by moving the levying of tax and the reimbursement of taxes away from primary agriculture, and no penalty is paid in terms of adverse environmental effect. However, this indirect consumption tax should be supplemented by a tax on nitrogen-fixing plants. Such a tax assumes a calculation and payment on the part of the individual farmer, in that it would not be possible to levy such a tax in an indirect way. The administrative and regulatory problem could of course be dealt with in a simple and appropriate manner, if the control could be combined with control of the hectare support scheme. These are the main elements of option 5.

The calculation of the nitrogen surplus could be further simplified if domestic trading in Denmark in animal and vegetable goods were excluded by calculating the basis of assessment on import and export (option 4). The importers and exporters could, in the same way as in option 5, pass on and pass back the taxes and reimbursements to the farmers, who would change their behaviour on the basis of the effect on price of the tax, in the same way as they make other changes when output prices alter. In this instance the option should be supplemented by a tax on nitrogen-fixing plants. In this way, the nitrogen surplus in the urban trades would also be captured.

Option 4, which is the simplest option to manage and control, would presumably be in conflict with the EU's market schemes. Option 6 is administratively cumbersome, without being able to demonstrate improved and environmental effects that could justify the considerably greater

administrative burdens as compared to option 5. The visibility of a tax under options 5 and 6 is the same since the information in options 5 and 6 – with the exception of domestic trade – is based on data from the farmer's suppliers and customers, and therefore the incitements to the individual farmer to change his behaviour are the same in both options. The number of registered businesses – and therefore payers-in and businesses that must be controlled – is much greater in option 6 than in option 5. Option 5 is administratively simpler than option 6. However, the implementation of option 5 requires a more detailed assessment with reference to EU law in order to ensure observance of the Nitrate Directive.

Option 7 is a control scheme based on tradable permits that are allocated free. These permits would have the same environmental effect as taxes, if the permits were allocated in the same way as the gross return of or deduction from the tax, and the permits confer the right to acquire the various bases on which tax was alternatively payable (tax on nitrogen surplus), but the allocation of quotas requires the same information level as a return of a tax yield, and would have the same consequences for agriculture in terms of allocation.

The tradable permits option describes how, instead of returning a sum of money to agriculture, transferable quota certificates could be returned either to agriculture or to the businesses that purchase agricultural products. These quota certificates would then have to be surrendered by farmers on the purchase of nitrogenous products (feed and fertiliser) and restored to agriculture when they supply products to their customers. The quotas that could be transferred could be put into circulation through an allocation on the basis of historical data showing the farmers' deliveries of nitrogenous products or nitrogen balance (surplus), if applicable reduced to a politically acceptable level. Purchasers of agricultural products would be allocated quotas on the basis of goods purchased from agriculture.

In the allocation of the quotas, the farmers could be guaranteed a right of ownership to the quotas in question, and it would be possible to take account of individual circumstances and special local or regional environmental conditions in the allocation, which however would not prevent the delivery of more nitrogen than stated in the quota in particularly sensitive areas. In this option too it is agriculture's suppliers of nitrogenous goods and their purchasers who must keep an account of the delivery of goods or purchase of goods and quota holdings in the same way as they must keep account of the taxes in the tax option.

Administratively and environmentally speaking, there is therefore no great difference between the tax option and quota option. But the quota option has the clear advantage that it does not require the levying of tax and therefore affecting the yield return to agriculture where applicable.

Current control and the point of departure of the model

One of the prerequisites for the use of economic instruments is that the existing control (regulation) regime would, as far as possible, be dispensed with and that there would be an overall reduction in the combined regulatory burden. To facilitate comparison of the effects of the different options (reduction in nitrogen surplus, costs of adjustment etc.), a point of departure has been calculated. This point of departure is an estimate of the use of nitrogen, yield, number of animals etc. in 2001, if much of the current regulation were removed. 2001 was chosen since this is the most recent period for which there is sufficient data.

However, parts of the current control regime that are governed by EU regulations cannot be abolished (*e.g.* harmonisation requirements) and other measures have been undertaken and will not be reversed even if the control is removed (the covering of liquid manure tanks, new application equipment etc.).

The most important control that would be abolished through the introduction of economic instruments involves the norms for the allocation of nitrogen, including norms for the utilisation of nitrogen in livestock manure and existing tax on nitrogen.

Under the EU Nitrates Directive, certain rules must be observed, including the times of application of certain types of manure and livestock manure storage capacity requirements. The extent to which the proposed economic instruments would be sufficient to guarantee application at the right time and to ensure adequate storage capacity in the event of increased quantities of livestock manure, or to facilitate the observance of other Nitrates Directive rules, has not been examined in greater detail.

Current control in Denmark involves regulation of the supply of nitrogen, so it is natural to make comparisons with reference to a tax on the supply of nitrogen. As previously mentioned, production functions have been calculated for the crops in which it is possible to optimise the use of nitrogen at various tax levels, including a zero-rated tax. It is clear from these calculations that the yield of these crops at the moment is more or less equivalent to the yield from a commercial fertiliser tax of DKK 2/kg of nitrogen. It is assumed that the control of nitrogen in livestock fertiliser has been more expensive than the control of nitrogen to fields, since this control has been in force for a longer period. It is also assumed that the control of nitrogen in livestock manure is approximately equivalent to a tax of DKK 6/kg of nitrogen, which on average is equivalent to a tax of DKK 4/kg of nitrogen in commercial fertiliser.

Results

In the comparison and selection of the options it is of particular interest to consider the reduction in the nitrogen surplus and the adjustment costs to agriculture of such reductions. These adjustment costs include lost contribution margins as a result of reorganisation of crop composition, costs of increased utilisation of livestock manure etc. These costs must not be confused with agriculture's administrative costs which, moreover, they would substantially exceed. The adjustment costs of the current control regime have not been determined, but according to the economic theory these would exceed the adjustment costs of a tax on commercial fertiliser, which is the tax that has most in common with current regulation.

Table 1 shows the tax rates needed in the various options to achieve a reduction in the nitrogen surplus of 1 000 tonnes in comparison with a situation lacking control other than that obligatory under EU regulations. Adjustment costs to agriculture are also shown. Taxes on the agricultural use of nitrogen (options 1-3) generate adjustment costs considerably higher than taxes on nitrogen surplus (options 4-6) which are more closely tailored to the environmental problem with the same reduction of the agricultural nitrogen surplus.

Table 1. The tax level and adjustment costs of obtaining a 1 000 tonne reduction in nitrogen surplus

	Tax rate per kg of nitrogen (DKK/kg)	**Adjustment costs** (DKK million)
Option 1	6.75	800
Option 2	6.25	675
Option 3	6.00	600
Options 4-6	4.75	225

While the model is subject to a degree of uncertainty it is considered to be perfectly capable of ranking the various options in terms of tax level and costs. The model also provides an indicator for the quantitative differences in adjustment costs between the different options.[3]

Policy application

A nitrogen tax, whether on inputs or surplus, was not included in the Aquatic Environment Plan III. The greatest obstacle to a nitrogen tax is the existing control regime which since it was implemented has generated the desired reduction in the agricultural nitrogen discharge, and has been managed by the farms and the authorities without major problems. Furthermore, it should be noted that a tax on the agricultural use of nitrogen would in no way be an uncomplicated one; it would be far-reaching and would require the comprehensive registration of businesses and farms to an extent currently unknown in other green taxes, but it would nevertheless be on a smaller scale than the current control regime. Another obstacle to a tax on the agricultural nitrogen surplus levied from businesses that deliver or receive nitrogen to/from agriculture is the Nitrates Directive which to some extent requires control at farm level.

It seems politically difficult to replace an existing control regime that has functioned as intended by a tax that on the face of it may appear complicated. The tax would also generate a major yield that would have to be returned to agriculture without causing distortions, though this problem could be avoided by introducing a tradable permit scheme. In the event of further reduction requirements, the adjustment costs would become more obvious than in the past, and this might make a tax/tradable permits more attractive.

Economic instruments for the control of the agricultural use of phosphorus

Phosphorus is applied to the soil in three ways: in commercial fertiliser, livestock manure or from waste/sludge. The phosphorus in livestock manure results from the fact that the individual animal has not completely utilised the quantity of phosphorus administered via its feed.

To the extent that insufficient phosphorus is available naturally in the feed, mineral phosphorus or the enzyme phytase may be added to increase the availability of existing phosphorus. The availability of phosphorus depends on factors such as whether the feed has been heat-treated.

Phosphorus constitutes a problem to the degree that it reaches the aquatic environment. The phosphorus surplus does not necessarily end up in the aquatic environment, but at present largely remains bound up in the soil's phosphorus pool. A surplus of phosphorus is chiefly a problem in soils to which a large quantity of livestock manure is applied. Loss of phosphorus is historically determined to a much greater extent than loss of nitrogen, and a realistic aim in the control of phosphorus is therefore a reduction of the accumulation of phosphorus in the soil and not an on-the-spot reduction of leaching.

Several different tax options for the control of agricultural use of phosphorus have been assessed. It has not been possible to analyse a tax on phosphorus to anything like the same extent as a tax on nitrogen, since there is less information available about phosphorus than about nitrogen – including the possibility of calculating production functions. Furthermore, certain tax options for a phosphorus tax can be rejected as being impossible to administer or having only a limited environmental effect.

3. A cautious comparison may be drawn with reference to the operating result of agriculture, which in 2001 was calculated as just under DKK 6 billion. The difference between model 1 and models 4-6 of c. DKK 575 million would thus make up just under 10% of the agricultural operating result.

The following tax options have been assessed with reference to the control of phosphorus:

1. Tax on phosphorus in commercial fertiliser;
2. Tax on mineral phosphorus in feed;
3. Tax on phosphorus in feed;
4. Tax on phosphorus in feed combined with a basic deduction;
5. Tax on phosphorus in commercial fertiliser and in feeds;
6. Tax on phosphorus surplus;
7. Need-based tax.

The theoretical model

An environmental tax on phosphorus could reduce the application of phosphorus to fields in several ways:

- Less application of phosphorus to acreages to which commercial fertiliser is applied
- More even distribution of livestock manure, replacing commercial fertiliser
- Less intensive feeding of animals with feed containing phosphorus by
  - Reducing the norm for the feeding of animals with digestible phosphorus
  - Increasing the proportion of phosphorus that is digestible, *e.g.* by phytase/less heat treatment.

The following effects of the administration of phosphorus via feed in animal farming have been correspondingly examined:

- Use of phytase to increase percentage availability;
- Increased use of home mixing, in which a larger proportion of the naturally-occurring phosphorus is available as a result of less heat treatment;
- Improved feed, including the replacement of feed with a naturally high gross phosphorus content in relation to nutritional value by feed with a naturally lower phosphorus content, and by using feed types with a naturally higher utilisation percentage, for example other types of mineral phosphorus where types with a utilisation percentage of about 67% can be increased to around 80%.

However, it is also important to consider the extent to which the purpose of economic instruments is to stop the accumulation of phosphorus in the soil. If this is the objective, because it is assumed that accumulation in the soil pool constitutes an environmental problem, a tax on phosphorus surplus would be the best way of addressing the environmental impact, but such a tax on phosphorus might prove difficult to implement, and other bases of assessment would have to be considered.

The options assessed

A tax on the phosphorus in commercial fertiliser (option 1) would be comparatively simple. Such a tax would increase the incentive to reduce phosphorus from commercial fertiliser, for example by paying more attention to the phosphorus count of the soil and by cultivating crops that require less use of phosphorus. It should however be noted that nowadays it is chiefly livestock farming that has an excessive phosphorus count (1 mg of phosphorus per 100 grams of soil, *i.e.* the quantity of phosphorus in the soil) and that the variation in the phosphorus needs of crops is not great, so that the quantity of the two effects referred to will be limited. On the other hand there is usually a balance between the input and output of phosphorus in the case of plant growers who do not apply livestock manure.

The reasonableness of a tax restricted to the phosphorus in commercial fertiliser is questionable, since the effect would be uneven in that farms without access to livestock manure would pay a disproportionate amount of tax. The environmental effect would be chiefly derived from the fact that livestock manure would be transported further and spread on greater acreages than at present. The demand for phosphorus would fall to some extent. Because of the costs of transport in relation to realistic tax rates, the effect of this would be limited, though measurable.

A tax on mineral phosphorus (option 2) added to feed would result in more reduction (whether in the growth of the phosphorus pool or leaching) than a tax on commercial fertiliser. Mineral phosphorus is added to feed that is lacking in available phosphorus. It is thought that a tax on mineral phosphorus would be easier in administrative terms than the other taxes described. The environmental effect would consist in the reduction of added mineral phosphorus as a result of the increased use of phytase etc.

A tax on all the phosphorus in feed (option 3) would also stimulate the incentive to replace feed phosphate with phytase, and reduce the use of feed with a high content of non-utilisable phosphorus. It would also reduce the safety margin (overfeeding).

The tax would be levied on the total content of phosphorus in feed mixtures for livestock, with the exception of the part never traded. There would therefore be tax on the phosphorus content of all forms of feed ingredients. This means that if corn, maize or soya were used in a feed mixture that was traded, a tax on the phosphorus content would have to be paid. In addition certain waste fractions used for feed would have to be taxed (*e.g.* mash from the breweries).

It would be difficult if not impossible to impose tax on, and subsequently to monitor, livestock feed sold internally. If feed sold internally is to be subject to tax, the producer must be aware of the content and quantity of phosphorus. It is hardly likely that anyone knows how much phosphorus a cow ingests from a meadow. It would also mean that all livestock farmers that produced their own feed and did not exclusively sell their production to the corn and feed trade would have to be registered under the Taxation Act. The administration of a tax on feed sold between farms would be unlikely to be worthwhile in terms of the environmental potential of the tax. A tax on feed sold would increase the incentive towards own cultivation (which is in conflict with trade agreements).

A tax on phosphorus in feed combined with a basic deduction (option 4) corresponding to the natural phosphorus content of corn would mean that the natural phosphorus content would be more or less exempt from tax, which would be imposed on added feed phosphate and especially feeds containing phosphorus. In this way the economic gross burden on agriculture before return would be less than through a general tax on the phosphorus content of feed.

The basis of assessment for option 4 corresponds to that for option 3, in other words the content of phosphorus in livestock feed that is sold by a corn and feed business. Home-grown feed and the sale of feed between farms would not be included because of administrative and regulatory problems. The tax would also have to be paid by the same businesses as in option 3. The basic deduction would be the same irrespective of the composition of the feed and of the animals to be fed.

A basic deduction should be granted with reference to feed units, solids or the quantity of raw protein and not per kg of feed, which would penalise concentrates unnecessarily. Linking the basic deduction to the feed unit would also remove the incentive to "dilute" the basis of assessment, but other problems might arise instead. The ideal solution would be a basic deduction linked to the general nutritional content, but such a target is hardly likely. It may prove to be the case that the only parameter that can realistically be used in connection with the basic deduction is the solids quantity, though even this formulation would not be ideal and might involve unintentional distortions.

A tax with a basic deduction linked to the phosphorus content of a kg of solids would have the same effect as a general phosphorus tax, but with a feed supplement per kg of solids, and it might be difficult to assess the quantitative changes a basic deduction would generate. Nevertheless, a tax with a basic deduction would reduce the incentive towards own cultivation of feed not sold through a corn and feed business. However, a tax with basic deduction would still involve discrimination between domestic feeds and imported feeds with a high phosphorus content.

A tax on phosphorus in feed and phosphorus in commercial fertiliser (option 5) would reduce the phosphorus content of livestock manure and phosphorus applied in commercial fertiliser. The reduction in phosphorus content of livestock manure may be achieved through more precise feeding, choice of raw materials with high phosphorus availability (and if applicable low phosphorus content), stimulating the utilisation of phosphorus in feeds and reduced use of mineral feed phosphate. A reduction in the use of phosphorus and commercial fertiliser may be achieved by monitoring the soil phosphorus pool more carefully and cultivating crops with less need for phosphorus.

Livestock farms in particular have excess soil phosphorus levels as a result of the livestock manure applied. By taxing only the phosphorus in feed, it would be possible to avoid paying tax by expanding the farm's own production of feed for its animals. Taxing the phosphorus in commercial fertiliser would penalise plant cultivation by on average a sum corresponding to the profit achieved through the production of home-grown feed.

A combination tax based on the two alternatives described above might result in feed being taxed more than once – first a tax on the phosphorus in commercial fertiliser, then a tax on the phosphorus content of the feed produced with taxed commercial fertiliser when it is traded.

A tax on phosphorus surplus (option 6) taxes the agricultural phosphorus surplus. The surplus is calculated as the difference between the phosphorus input and the phosphorus output.

Tax is to be charged on the combined input of phosphorus (P in commercial fertiliser, P in added feed and P in waste). The tax is levied from importers and producers of commercial fertiliser and feed dealers and importers. Reimbursement is granted for the phosphorus content of goods that form part of agricultural output (*i.e.* milk, eggs, vegetable products etc.). The tax is repaid to the purchasers, *e.g.* dairies, abattoirs etc. If a farm is in balance in this way (input of phosphorus equal to output of phosphorus), the overall tax burden will be equal to zero.

One advantage of a tax on phosphorus surplus is that the basis of assessment of such a tax more directly addresses the environmental impact than a tax on commercial fertiliser and/or feed. A tax on

phosphorus surplus is more cost-effective in terms of the farm's adjustment costs than an input tax. The tax would contribute to better distribution of livestock manure. An allowance should also be made for the official costs of tax administration.

Under EU law and other international regulations, Danish-produced goods and imported goods must be on an equal footing in terms of tax. Over a number of years, some Danish producers will be able to draw on the quantity of phosphorus accumulated in the soil, which will give them a tax advantage. This may be problematic, since foreign producers will be unable to avail themselves of the same advantage. Furthermore, allowances may be granted for phosphorus on which it is uncertain that tax has been paid in the past. However, in general the plant growers will also have to pay tax, especially in the longer term.

A tax on the phosphorus surplus would require a lot of administration, but would be easier than a tax on nitrogen surplus, since phosphorus cannot be bound from the atmosphere like nitrogen (nitrogen-fixing plants). It would therefore not be necessary to register the individual farm.

Finally, a need-based tax (option 7) was assessed. There is some possibility that the addition of phosphorus to soil that has a high phosphorus content carries a risk of increased leaching of phosphorus. A tax aimed at preventing the addition of phosphorus to high-phosphorus soil would therefore address the environmental impact more directly than an input tax.

However, a need-based tax cannot be recommended for administrative reasons. In particular it is considered difficult to define a form of sample-taking that could create a foundation for tax exemption/reimbursement of tax paid. Samples are currently taken on farms that wish to achieve optimum use of fertiliser. There is a great difference between the reliability and lack of ambiguity that must be present for an advisory sample intended to ensure optimum use of fertiliser and the sample on which the reimbursement of tax paid could be based.

Results

Some of the options can be rejected immediately – for example a tax on only the phosphorus in commercial fertiliser, since such a tax would address the environmental impact only in part, and would particularly affect the plant growers, where the environmental problems are fewest, and exempt livestock farming where the environmental impact is greatest. The administration of a need-based tax is not considered feasible as a result of difficulties in measuring soil phosphorus content with sufficient reliability.

A tax on mineral phosphorus added to feed is probably the tax that is easiest administratively. Since mineral phosphorus constitutes only a small proportion of the quantity of phosphorus used in agriculture, such a tax would accordingly have a limited scope. A tax on phosphorus surplus is the option that would address the environmental impact most directly, but it is administratively cumbersome, and would therefore only be of interest in conjunction with a tax on nitrogen surplus, since it would be the same businesses and the same products that would be affected.

The effects of the different taxes have all been calculated using a rate of DKK 4/kg,[4] and a phosphorus surplus of 28 000 tonnes, which is the surplus for 2003/04 (estimated with a degree of uncertainty). Table 2 shows the effect of the four options assessed.

4. With reference to other forms of phosphorus discharge control (the Danish wastewater tax) there is no environmental basis for tax rates higher than DKK 4/kg.

The optimum tax – if we disregard EU problems and administration – is a so-called tax on phosphorus surplus (option 6). This tax levies a charge on all phosphorus input to agriculture from outside, while reimbursement is paid on all phosphorus output from agriculture. This tax is comparable with a gross input tax (option 5). The tax on phosphorus surplus may be reduced to a gross input tax if reimbursement is not paid for output products. The gross input tax may be reduced to a feed tax with basic deduction (option 4), so that it involves only phosphorus in feed purchased from outside, and so that a basic deduction is also given. Finally, the basis of assessment may be reduced to a tax on added mineral phosphorus (option 2)**.**

The most appropriate solution is a tax on mineral phosphorus, since this is the most uncomplicated tax. If a more powerful environmental effect is desired, and a nitrogen tax is also to be introduced, a tax on phosphorus surplus is recommended. This tax has the lowest adjustment costs, but is administratively more cumbersome and especially difficult to reconcile with the EU. The EU problems are in principle of the same nature as with a nitrogen tax, but even greater.

Table 2. Estimated effects of various phosphorus-based taxes

	Tax on phosphorus surplus	**Tax on gross input of purchased feed and commercial fertiliser**	**Tax on purchased feed with basic deduction (4 g/kg of solids)**	**Tax on added mineral phosphorus**
Yield without change (DKK mill.)	110	315	140	55
Yield with change (DKK mill.)	80	280	115	35
Phosphorus surplus decline (tonnes)	8 100	8 700	6 200	5 200
Adjustment cost, (DKK/kg)	2	2.15	2.20	2.35

Policy application

A tax on mineral phosphorus in feed phosphates forms one of the elements of Aquatic Environment Plan III, and on 9 June 2004 the Danish Parliament adopted the "Act on the taxation of mineral phosphorus in feed phosphate". It has been decided to return the yield from this tax to agriculture by a reduction in the land taxes. As a result of this return, at the time of writing the Act is awaiting state aid approval from the EU Commission.

The Danish tax on pesticides

The Danish Pesticides Tax Act came into force on 1 January 1996, and from 1 November 1998 the tax rates were increased by an average of 100% (Table 3). Even before the first Act, there was a tax on small packages of pesticides (typically agents used in households), and a tax of the character of a fee for the approval of pesticides for the Danish market. The 1996 Act therefore represented a definite expansion in comparison with the existing taxes.

The tax

It was thought in 1994 that the aims of the Pesticides Action Plan for a halving of the quantity of active substances could be achieved, but that without additional initiatives there was no prospect of

achieving a halving of the frequency of use. The Danish Parliament therefore adopted the Pesticides Tax Act based on the retail value of pesticides. On 1 November 1998 the pesticides charge rose by an average of 100%, because there was a good deal of evidence that the aim of a 50% reduction in pesticide use by 1997 had not been achieved.

It was decided to differentiate the tax rates for a number of reasons. In the first place, there are substantial cost differences per treatment with the various agents, so that a tax differentiation that imposed a higher rate on the cheap agents than the expensive ones would approach the effect of a tax on each treatment. In the second place, there are variations in the degree to which different types of pesticides are disseminated in nature, and therefore how damaging they are to the environment.

Table 3. Tax rates on pesticides

	1996		1998	
Pesticide	**Percentage of retail price including tax and excluding VAT**	**Percentage of retail price excluding tax and excluding VAT**	**Percentage of retail price including tax and excluding VAT**	**Percentage of retail price excluding tax and excluding VAT**
Insecticides, combined insecticides and fungicides, livestock parasite agents and soil disinfectants	27	36.98	35	53.85
Fungicides, deterrents, herbicides and growth regulators	13	14.94	25	33.33
	Percentage of wholesale value including tax			
Wood preservatives, anti-slime agents, algicides, rat poisons and microbiological agents		3		3

Until the general tax was introduced, the initiatives for achieving the Pesticide Action Plan reduction objectives had consisted chiefly of additional consultancy, training, guidance and information services. A further requirement was that records be kept of pesticide consumption, and forms of production with less environmental impact (such as afforestation, organic farming, extensification, spray-free margin zones etc.) were subsidised.

The effect of the tax

The combined sale/consumption of plant protection agents to/in agriculture has fallen from 6 972 tonnes of active substance in 1981-85, to 2 889 tonnes in 2000 (Table 4). Consumption has shown both positive and negative variations since 2000. Agriculture's share of the total consumption of pesticides constituted 85-95% during this period and at present amounts to about 85%.

The fall in the quantity of active substance is largely due to the fact that consumption has switched to low-dose agents, which are used for the control of weeds. During the period 1980-2001 the combined cultivated land area was also reduced by about 8% and this has also reduced the consumption of biocides. Increased conversion to organic farming has also been of importance.

The consumption of biocides measured in quantities fell for the most part during the period 1990-2003, though 1995, 2001 and 2003 were exceptions. The expected tax increase in 1995 was the reason for an extraordinary rise in pesticide sales in that year. The increase in 2003 may have been caused by an increased acreage of winter crops and more spraying in the autumn as a result of good "spraying" weather. A corresponding reduction is expected for 2004, because of less spraying in the spring.

Table 4. Consumption of pesticides and treatment frequency

	1981-85	1997	1998	1999	2000	2001	2002	2003
Total use (tonnes of active substance)	9 743	4 582	4 326	3 605	3 551	3 687	3 556	3 553
Agricultural use (tonnes of active substance)	6 972	3 675	3 673	2 929	2 889	3 127	2 912	2 991
Treatment frequency	2.67	2.49	2.27	2.33	2	2.09	2.04	2.17

As regards the consumption of biocides measured in terms of frequency of use, the conclusion is nothing like as positive. Despite falling consumption, the aim of halving it by 1997 was not achieved. During the period 1981-85, the average frequency of use was 2.67. In 1999, this had fallen to 2.33 and in 2003 to 2.17 (an increase compared with 2002).

The experience gained from pesticides taxation shows that the tax – in conjunction with a range of other measures – does have an effect, and that the increase in tax has brought biocide consumption close to the environmental objective as regards active substance quantities.

The future of the tax

Pesticide Action Plan II was unveiled in 2000. The reduction aim for 2002 was a frequency of use below 2.0 before the end of the year. In 2000, major work was initiated on assessing the possibility of readjusting the *valorem* tax to a basis of assessment that would address the environmental impact of pesticides more directly, *i.e.* frequency of use.

The conclusion was that it was impossible to tax frequency of use directly, so various options for linking the pesticides tax to frequency of use have been proposed, which differ from each other in terms of complexity and environmental effect. Basically there are two ways in which the tax could be readjusted. One is an additional differentiation of the existing *valorem* tax. The other is a unit tax on each standard dose (area weight). A standard dose tax produces a greater environmental effect than an additional differentiation of the *valorem* tax, but this must be weighed against the difficulties in terms of legislation, EU law, administration and control of this basis of assessment. For political reasons, none of the proposed alternatives has been implemented.

The objective of the latest Pesticide Action Plan (2004-09) is to reduce frequency of use in agriculture to 1.7 by the end of 2009. Means of achieving this would include approval schemes for pesticides and consultancy. In addition it is clear that the pesticide tax is once again to be examined with a view to readjustment to link the basis of assessment more closely to the environmental impact.

The tax on growth promoters

Denmark has another agricultural related tax that is not though without affecting the aquatic environment. The Act on the taxation of growth promoters came into force on 1 September 1998. Antibiotics and growth-promoting substances are used as feed additives with a view to increased growth and production.

The advantage of using growth promoters is affected by factors such as the animals' weaning age, feed composition, accommodation and stall hygiene. A more environmentally-correct feed composition with a lower nitrogen content and modified stall systems, *e.g.* shift work in sectioned stall systems, will therefore reduce the advantage of using growth promoters. The aim of the tax is for livestock production to take place in such a way that the welfare of the animals is not jeopardised.

The tax is differentiated as regards the permitted maximum additive content in full feed for piglets, so that the cost of using growth promoters for piglets is increased by about DKK 2.5 per piglet. It is expected that this will produce a steady reduction in the use of the additives referred to and an increased incentive to produce porkers under conditions that enhance the animals' health.

In 1998 the tax produced a yield of DKK 16 million and in 1999 a yield of DKK 14 million. The trade has entered into an agreement under which growth promoters are no longer used in Denmark, and the tax has produced no yield since 1999. Nevertheless it remains in place, since it underpins the trade's agreement to a prohibition on growth promoters.

Conclusion

Economic instruments work and are more cost effective than traditional command and control measures. Denmark has been using economic instruments for environmental control for many years. However, they are general instruments and if the environmentally damaging effects (the externalities) are very uneven in terms of regional distribution there may be a need to reinforce economic instruments by other forms of control, particularly if differentiated rates (corresponding to various externalities) are unwieldy in terms of both administration and control. Tradable permits have the same environmental effect as tax but solve a possible yield return problem automatically in that the cash flow is replaced by a quota flow.

BIBLIOGRAPHY

Ministry of the Environment, Ministry of Food, Agriculture and Fisheries and Ministry of Taxation (2004), *Rapport fra Fosforfokusgruppen – regulering af fosfor (Økonomiske virkemidler til regulering af landbrugets anvendelse af fosfor), Arbejdsrapport fra tekniske undergruppe ved forberedelsen af VMPIII, 2004* ["Report of the Phosphorus Focus Group – control of phosphorus (economic instruments for the control of agricultural use of phosphorus): working report of the technical subgroup in the preparation of Aquatic Environment Plan III, 2004"], www.vmp3.dk.

Danish Environmental Protection Agency (2003), *Bekæmpelsesmiddelstatistikken 2003* ["Biocide Statistics 2003"].

Ministry of Taxation, *et al.* (2003), *Afrapportering fra Arbejdsgruppen om økonomiske virkemidler til regulering af kvælstof og fosfor, Arbejdsrapport fra tekniske undergruppe ved forberedelsen af VMPIII, 2003* ["Report by the working party on economic instruments for the control of nitrogen and phosphorus: working report of the technical subgroup in the preparation of Aquatic Environment Plan III, 2003"], www.vmp3.dk.

Ministry of Taxation, *et al*. (2001), *Rapport om muligheden for at omlægge pesticidafgiften til en afgift på behandlingshyppigheden* ["Report on the feasibility of readjusting the pesticide tax to a tax on frequency of use"].

Forslag til lov om afgift af vækstfremmere ["Growth promoters' tax bill"], L 11 of 26 March 1998.

TABLE OF CONTENTS

Page

Part VI
EVALUATION OF ADVISORY AND INSTITUTIONAL MEASURES

Part VII
EVALUATION OF POLICY MIXES