P.K Rørstad (2008). Essays on the multifunctionality of agriculture and policy options. Doctor Scientiarum Thesis 2008:5. Norwegian University of Life Sciences.

Linking the pieces together

1. Introduction

The main aim of this first part of the thesis is to put the different papers into a wider perspective. The main theme of the papers in this thesis concerns correcting externalities in agriculture. Since the production of positive and negative externalities is interlinked with commodity production, one cannot analyze externalities in isolation from the production of commodities. It is therefore necessary to discuss the characteristics of the outputs from agriculture and the possible implications for regulation (Section 2). This is followed by a discussion about some of the policy options (Section 3). In Section 4 the Norwegian agricultural policy is briefly presented and discussed. The current policy in Norway is rather complex with a large number of schemes. Hence, a complete treatment would be a thesis in itself. Only a limited number of issues will therefore be discussed. The focus will be on the main types of policy instruments used and the level of support. Next, abstracts of the papers in this thesis will presented (Section 5), and in Section 6 the relevance of the papers will be discussed.

2. Characteristics of agricultural goods

2.1. Multifunctional agriculture

Agriculture produces more than just commodities that can be and are traded in markets. Agriculture also provides a large range of goods, bads and services[1] that are not traded in markets. The fact that agriculture produces multiple outputs is closely linked to the concept of multifunctionality, and OECD (2001:11) gives the following description of the concept:

> "Multifunctionality refers to the fact that an economic activity may have multiple outputs and, by virtue of this, may contribute to several societal objectives at once. Multifunctionality is thus an activity oriented concept that refers to specific properties of the production process and its multiple outputs."

The different outputs may have no (i.e. zero), positive or negative value to society, reflecting their contribution to different societal objectives. These values may change over time.

[1] A good is an object that when "consumed" increases the utility of the consumer. A bad is the opposite of a good, i.e. when "consumed" it decreases the utility of the consumer. Finally, a service is the non-material counterpart to a good. Even though they differ in characteristics, they have in common a non-zero value. Unless explicitly stated, the term good refers to any of the three types of outputs.

Technological development may in the future enable the production of biofuel from straw (so-called second generation biofuel), and thereby increasing the value of straw from almost zero. Preferences may also change over time, leading to changes in valuation. This means that multifunctionality is not a static concept.

As in all other production processes, multiple outputs in agriculture are unavoidable (Faber et al., 1998:131). This can be inferred from two of the laws of thermodynamics: conservation of mass and energy, and non-decreasing entropy. If follows (almost) directly form this that there is a dependency between output levels for some goods, i.e. if the level of one output changes, the output level of some other good will also change. This interlinkage between output levels is termed jointness. In addition to the technical reason mentioned above jointness may be due to economic factors like fixed allocable resources (land, capital and labor). Paper 3 gives a more detailed discussion about these issues, but we will return to the possible implications of jointness below.

With the concepts of multifunctionality and jointness in place, we move on to look at the different outputs of agriculture. The most central non-commodity elements of Norwegian multifunctional agriculture, i.e. elements with non-zero value, are (Romstad et al., 2000:1):

- *landscape*: biodiversity, cultural heritage, amenity values of landscape, recreation and access, scientific and educational value,
- *food related issues*: food security, food safety and food quality,
- *rural concerns*: rural settlement and rural economic activity, and
- *pollution*: losses of nutrients to water and air (e.g. nitrate and N_2O), erosion, and pesticide residues in food, soil and water.

Since multifunctionality is defined in terms of policy objectives, the list may vary from country to country. For example, rural concerns may not be an issue at all in some countries, while other issues not in the list might be important. Since natural conditions (climate, soil types, topography, etc) vary, flood control or desertification, for example, may be important issues related to agriculture in some countries. This means that the concrete content of multifunctional agriculture is “site” specific, but the meaning of the concept is universal.

Some of the goods may be provided also by other sectors than agriculture, and this is termed separate production below and in Paper 3. Agriculture is not necessarily the cheapest provider of all of the goods in the list above. However, since the outputs from agriculture are linked, i.e. joint, we need to compare the whole bundle when comparing. Simply put, agricultural production will affect all the four main categories of goods in the list above. Some of the goods may be relational in the sense that the value depends on the level of other goods, i.e. is context dependent. For example the value (to the public) of an old farm building may be higher if it is part of an active agricultural environment than in a museum. Likewise, the value of a natural cultural landscape may be higher than an artificial landscape. This does not mean that separate production never is optimal, but that the values of the goods are different. Or more precise, separate production may result in a (slightly) different good.

2.2. Market vs. non-market outputs

From economic theory we know that in a competitive[2] economy the market outcome will be Pareto optimal (Hanley et al., 1997:24), i.e. it is not possible to increase the welfare of one person without reducing the welfare of at least one other. This is know as the first theorem of welfare economics, and it basically means that as long as markets are competitive there is no need to do anything, the market will maximize total welfare[3]. However, for many goods produced in agriculture there exist no markets at all. The main reason emphasized in the literature is that property rights are not complete for these goods. Property rights are complete when they are well-defined, transferable, secure and that all the benefits and costs accrue to the agent (Kolstad, 2000:60). The landscape goods in the list above are linked to the land, and the property rights for land (as land) can be said to be complete, but it is hard for the farmer to capture all benefits e.g. from people benefiting from the scenic beauty of the landscape. In the case of pollution, it is hard to confront the individual farmers with the costs of pollution since most pollution in agriculture is hard to trace back to the emitter. For the two last groups of goods in the list, it is even harder to envision a (normal) market where the farmers can be paid for providing the goods.

The notion of externalities is closely linked to incomplete property rights and transaction costs[4]. An externality exists if the consumption or production decision of one person or firm affects the utility or production function of another person or firm without permission or compensation. Clearly, in the absence of any regulation most of the non-commodities produced in agriculture may be viewed as externalities, both positive (goods and services)

[2] The conditions for a competitive market are: complete property rights, atomistic participants, complete information and no transaction costs. No transaction costs will lead to complete property rights and complete information, i.e. the requirements may be reduced to atomistic participants and no transaction costs.
[3] There may be distributional issues, and they can be large, but these may be dealt with outside the market.
[4] The notion of transaction costs is discussed in more details in Papers 1, 3 and 4. Here it will suffice to define transaction costs as "…the costs of arranging a contract ex ante and monitoring and enforcing ex post" (Matthews, 1986:906).

and negative (bads). Since the effects (positive or negative) are not taken into account in the decision making process, the outcome will not be optimal.

If it is possible and costless (zero transaction costs) to bargain over an externality, bargaining will lead to an efficient outcome, regardless of the initial allocation of property rights. This is known as the Coase theorem, attributed to Coase (1960). Without transaction costs, initial allocation of property rights will only have a distributional effect. If transaction costs are positive, the initial property rights and the distribution of transaction costs will influence both the outcome of the bargaining, i.e. the total benefits, and the distribution of benefits (Vatn, 2005). If transaction costs are large enough and known a priori, there will be no bargain at all. In this case, given the institutions, status quo is the efficient allocation. Hence, the externality is Pareto irrelevant.

Since externalities can be bargained out when transaction costs are zero, this implies that transaction costs is the main reason for the existence of externalities[5]. If there are many agents involved on one or both sides of the table, bargaining costs will be large and possibly block a solution that otherwise would be beneficial for all parties. Even with few agents involved there is no guarantee that the bargaining will lead to an efficient outcome. Asymmetric information can lead to strategic behavior in the bargaining, and incomplete property rights can lead to that the agreement is not enforceable. As mentioned above, pollution in agriculture is hard to trace back to the emitter. Due to this, the farmers have incentives to not reveal their real preferences or costs in the bargaining, i.e. this is a principal-agent type of problem. In the case of landscape provision consumers have incentives to not state their real willingness to pay since there is the possibility to free ride.

Complete property rights would eliminate all externalities. There could still be some uncompensated losses, but complete property rights implies acceptance. For example, if the farmers have the right to pollute and this right is complete, this means that society has recognized farmers' right to pollute. If the farmers pollute without compensating the victims, this would still be Pareto optimal, but as implied by the Coase theorem, there is a potential Pareto improvement in this situation. If transaction costs are not too high, both parties would benefit from trading rights. In the case the consumers have the right to a clean environment, they could force the farmers to not start polluting (or force them to stop). This would impose

[5] The terms externality and external effects are often used also for cases where the externality is corrected for, but here the term is used according to the definition above. If the externalities are corrected for, they can be said to be internalized.

costs on farmers, but still be Pareto optimal. Hence, the distribution of property rights given that they are complete, will determine which Pareto optimal allocation would be the starting point of the bargaining or the final allocation if transaction costs are too large. However, as we will see in the next section, the nature of these goods, services and bads is such that it is hard to envision complete property rights.

2.3. Private vs. public goods and bads

Yet another way of analyzing the reason that some goods are non-marketable is to look at two specific characteristics of the goods: rivalry and excludability in consumption. A good is rival if one person's consumption of a unit of the good diminishes the amount available for other to consume, and a good is excludable if it is feasible and practical to selectively allow consumers to consume the good (Kolstad, 2000). Goods that are not rival are termed non-rival and goods that are not excludable are termed non-excludable. However, rivalry and excludability is in reality more relative than the definitions suggest. The "consumption" of a road can be said to be non-rival if traffic is low, but as congestion sets in, the "consumption" becomes rival. Likewise for excludability: for example, there is a (physical) limit on the number of consumers that can enjoy the same landscape. If there are many people at a view point, additional persons will be excluded since there is no room for them, while if there are few, the view is non-excludable. The degree of rivalry and the degree of excludability are therefore better descriptions of the real world. Table 1 shows a commonly used classification of goods along these two dimensions.

Table 1.Classification of goods.

		Degree of excludability	
		High	Low
Degree of rivalry	High	Private goods	Common pool resources
	Low	Club goods	Public goods/bads

Source: adapted from Randall (1983).

Most of the public goods, bads and services in agriculture have a low degree of rivalry and low degree of excludability, i.e. they are public goods or public bads[6]. The classification in the table above does not take into account the spatial dimension. The goods and bads may be provided and "consumed" at different spatial scales, e.g. they may be local, regional, national

[6] One may argue that the bads ends up in common pool resources like water and air and that the term bad in itself indicates rivalry in consumption. However, here we will use the conventional terminology.

or global public goods and bads. In some cases this distinction may be important. It is of little value to society to produce a local public good like a landscape in a place where there are none to enjoy the landscape.

If a good is a pure public good, i.e. consumption is completely non-rival and non-excludable, a market is not Pareto efficient if the price will exclude anyone who derives positive marginal benefit from this public good (Hanley et al. 1997:43). This is so since non-rivalry implies zero marginal social costs. A private firm cannot profit by providing a good for free, hence a market will not lead a Pareto optimal allocation.

Few goods in agriculture are pure public good, in the strict sense, but a low degree of excludability still represents a problem in a market (if it exists) regarding resource allocation. If people cannot be excluded from consuming the good, there is a possibility for free riding. Free riders consume the good without paying for it, i.e. the market will provide less of the good than social desirable. The other group of goods with low degree of excludability (common pool resources) seems less relevant for agriculture (but see footnote 6). However, also there markets may fail to allocate resources efficiently (Hanley et al. 1997:37).

Some of the goods/services, i.e. the food related issues, may also be provided in the form of private goods or by private actions, at least to some degree. Some use the term collective goods for public provision of such goods. The form of the good/service may be different when provided by society compared to the private case. At the national level food security is related to keeping agricultural resources (land, capital and knowledge) in production – or at least possible to bring back into production – storage and securing import possibilities in the case of crisis. At the private level, people can store food for the time of crisis.

Regarding private provision of the two other food related issues, food safety and food quality, this is closely related to information (transaction costs). The consumers need reliable information about the quality of the food in order to choose the right food. Public provision of such information (or public food control) will probably result in lower total costs than private information gathering.

To what extent the public should provide information about food safety and food control or support the agricultural sector directly for providing food safety[7] will remain unanswered in

[7] This does not mean that domestic products have to be "cleaner" than imported food, but some illnesses common in other countries are absent in Norway. For example, salmonella is (almost) absent in domestically produced agricultural products, while frequently found in other countries (Norwegian Institute of Public Health, 2007).

this thesis. Still, since food security and food safety is produced jointly with commodity production, these services will be produced in agriculture as long as there is food production.

In this section we have seen that agriculture produces a number of public goods, services and bads, and that in the absence of regulation they will not be produced at optimal levels. In the next section we will discuss how to regulate the multifunctional agriculture.

3. The regulation of public goods and bads

If markets are well-functioning there is no need to regulate the marketable outputs. However, we observe that there are many commodity support programs in place, even though the number is reducing. Such policies will lead to inefficiencies in the commodity markets. Still, there are some arguments that could justify the use of commodity support. First, efficiency is a purely economic (resource allocation) notion and as such it is amoral. This means that society may be willing to carry the costs of being inefficient in some markets if this leads to the fulfillment of e.g. some moral obligation. It is hard to see that this applies to agriculture, but should not be ruled out. Second, since agriculture contributes to several objectives, the use of commodity support may increase the overall efficiency by reducing the total costs of regulation (transaction costs). This will be discussed below and in Paper 3.

3.1. Non-point source pollutions

Most of the public bads in agriculture are in the form of non-point source pollutions. Substances are inevitably lost from the farm fields to the environment. These losses include ammonia losses to air, nitrate, pesticides and phosphorus losses to watercourses (including groundwater) and erosion (losses of particulates). A certain level of these losses may not be harmful, but above this level they may make the watercourses unsuitable for human use (e.g. as drinking water), increase the costs of utilizing the water (e.g. increased costs of water treatment) or reduce the benefits of other "water based" resources (e.g. fishing and recreation). The damages or reduced quality/value of the water may be a direct consequence of the pollution, i.e. contamination, or indirectly by e.g. increased oxygen demand in water or more generally, eutrophication.

Let us now briefly look at the processes that determine the damages. For the sake of exposition, let us assume that all natural processes are known with certainty (full knowledge and no stochastic processes). We may now divide the "problem" in two. First there is the part that the farmer can control directly (to some extent), i.e. the losses that leave the fields, and second the part that the farmer cannot control, i.e. the fate of the losses that leave the fields. The latter is determined by a number of different processes from the farm field to the recipients, where the damages will depend on the "supply" of compounds from all farmers in the drainage basin (and other sources). The damages will also depend on the characteristics of the recipient (like size, depths, water flow, etc). On the way from the field to the recipient the amounts may be reduces by processes like sedimentation and dentrification. This means that what leaves the field is not necessarily what enters the recipient. Regarding the losses from a field, these are determined by interactions between the actions of the farmer and processes in the soil - plant system. For example, losses will depend on the type of crop, tillage practice, the amount of nutrients applied and the soil type, etc. Since the processes in the soil and waterways are influenced by the weather, they are clearly stochastic, adding complexity.

Incentives to achieve the so-called first-best allocation[8], e.g. taxing the farmers according to the resulting marginal damages from their losses, are clearly unrealistic. Even though it is possible to measure the ambient concentrations of the different pollutants, it is impossible to measure the individual contributions.

In the following some of the options aimed at reducing the negative externalities from agriculture will be discussed. The discussion will not be exhaustible, and only economic instruments are discussed. Non-economic options are for example information and education programs, economic support to research and development, and direct regulations. All these policy options are to some degree present in the Norwegian agricultural policy. For a more complete review of economic policy options, the reader is referred to Shortle and Horan (2001) and Horan and Ribaudo (1999).

When designing policy instrument there are three important issues that need attention: who to target, what to target (what compliance measure to use; where to place the incentives) and how to target (how to induce the desired changes; mechanism). Regarding the first issue, farmers are clearly the polluters, but as argued above, the contributions of individual farmers are highly uncertain. Both individual farmers and groups of farmers may be targeted, dependent on the compliance measure. When choosing what to target, the compliance measure should be correlated with the environmental problem at hand, enforceable and targetable (in practical terms). The literature in this field has focused three different general

[8] The first-best allocation is defined in the absence of transaction costs. As noted above, externalities exist due to transaction costs. This means that the so-called first-best allocation is defined for a situation that does not exist. Still, we will use first-best as a reference point.

options: ambient concentration, emission proxies and inputs/practices (Shortle and Horan, 2001). Regarding how to target, Shortle and Horan (2001) list the following options: taxes/subsides, standards, markets, contracts/bonds and liability rules. In this thesis standards and markets will be termed non-tradable quotas/permits and tradable quotas/permits, respectively. In theory it is possible to use permits to regulate practices, however, this option is normally used on inputs. We will see below that also outputs may be targeted, and should therefore also be added to the list. Relevant options are shown in Table 2.

Table 2. Non-point pollution control instruments.

	Compliance measure		
Mechanism	Inputs/Outputs/Practices	Emission proxies	Ambient concentration
Taxes/Subsidies	X	X	X
Non-tradable permits	X	X	
Tradable permits	X	X	
Contracts/Bonds	X		
Liability rules	X		X

Source: adapted from Shortle and Horan (2001:258).

Inputs/outputs/practices and ambient concentration are rather straight forward in the sense that these compliance measures are directly based on observable objects or actions. Emission proxies are a collection of different approaches that approximate emissions. For example, the proxy may be based on modeled losses or nutrient balances. Regarding the latter, if both the input use and the amounts of nutrients removed with harvest are measured (or modeled), it is possible to estimate the amount of the applied nutrients that remain in the soil after harvest, i.e. the nutrient surplus. This surplus is correlated with the emissions. In the following we will focus on the first compliance measure (inputs/outputs/practices).

Griffin and Bromley (1982) develop what they call a nonpoint externality theory. They show that if the relationships between the different inputs and outputs and emission (they call these relationships nonpoint production functions) are known with certainty, it is possible to set up an efficient (first-best) system of taxes/subsidies or permits. Taxes are levied on inputs and outputs that are negatively related to emissions, while subsidies are used if the input or output reduces emissions. Unless all farms are equal, this means that the efficient policy, i.e. permit levels or tax/subside rates, is farm specific. If uncertainty is added to the model, Shortle et al. (1998) show that this policy still can result in the first-best solution. However, Shortle and Horan (2001:266) note that this tax/subsidy system "…is a nice theoretical prescription for obtaining the first-best allocation, but unrealistic. The scheme is exceptionally information intensive and complex…". The discussion about transaction costs is almost absent in this literature, but it is evident that as the precision increases, i.e. loosely speaking the "distance" to the first-best allocation, the costs of information increase. In other words, there is a need to balance precision and transaction costs.

One issue related to this is information asymmetries. They pose challenges in all types of transactions, including public regulations. For example, abatement costs (costs of reducing pollution) differ from farm to farm, but this is in most cases private information. This may cause moral hazard and adverse selection problems, especially if the regulation is farm specific. In general, private information will lead to uncertainty about the outcome (reduction of damages) since the regulator does not know the response to incentives. In terms of a tax on inputs, there are uncertainties about the tax level that would lead to the wanted reduction in pollution (or the optimal reduction). Griffin and Bromley (1982) note that this problem can be solved by an iterative process where the tax rate is changed (by trial and error) until the goal is met. If the goal is linked to ambient standards, this may in reality not be as easy at it seems. Since processes are stochastic, mainly due to the weather, changes in the ambient concentrations are due to both changes in the weather and the induced changes in farming practice. Hence, it is close to impossible to use the iterative procedure. If reductions are defined in terms of input use, output levels or practices, the iterative procedure may work. However, it adds another type of uncertainty that may affect farmers' response: policy uncertainty. Since it is not costless for farmers to adjust to new and/or changed polices, they may respond differently if they expect the change to last than when they expect the policy to change in the near future. This is discussed in Paper 1.

There are methods that may reveal (at least some) private information, e.g. screening, signaling and auctions. However, it is outside the scope to discuss this issue further. The reader is referred to the rather a large literature on contract design, e.g. the seminal works of Akerlof (1970), Spence (1973) and Stiglitz (1975). In addition, Shortle and Horan (2001) review the literature relevant for non-point source pollution, and Latacz-Lohmann and van der Hamsvoort (1998) discuss auctions for public goods provision.

The choice between targeting inputs, outputs or practices will of course depend on the correlation with the environmental problem and tractability. Losses of soil are mainly dependent on management choices (especially tillage practice and crop cover in winter), since the main drivers are surface processes. Hence, regulating input use will have little or no effect. In stead one could tax practices that increases erosion, subsidize practices that reduces erosion or both. All three will be equally efficient in the short run if we assume zero transaction costs. This since the choice of the farmers is determined by the relative profitability of the different practices. In the long run taxes and subsidies yield different entry and exit incentives, hence the short and long run effects may differ. The costs of control may, however, vary. In the case of a subsidy, at most only those who apply for a subsidy on certain practices will have to be controlled, while in the case of a tax (and the combination of tax and subsidy) all farmers may be controlled. Even though there are costs of processing applications for subsidies, total transaction costs are probably lower in the subsidy case than for the other two options.

Regarding losses of nitrogen and pesticides, targeting input use is in most cases the preferable option. Practices are in general less correlated with the losses.

As is shown in Papers 3 and 4, transaction costs are lowest for uniform input taxes, and these costs are almost negligible. The reason is that the tax is levied on a good that is traded in a (well-functioning) market. This requires only one piece of information, the amount traded. If the scheme is implemented at an aggregate level, i.e. wholesale dealers, importers or producers, the number of point to collect information from will be low. The disadvantages are that it is blunt, in the sense that it does not discriminate according to marginal damage, and that the income effect is larger than alternative instruments (as discussed in Papers 1 and 2). It is possible to decrease the income effect by a lump sum reimbursement, but this will increase transaction costs.

One alternative to input taxes is input quotas, either tradable or non-tradable (Papers 1 and 2). This means that each farmer is granted the right to use or purchase a certain amount of a given input. If the quota is tradable, he/she might sell some of his/her quota to others or buy additional rights in the quota market. If the farmer is free to trade with whoever he/she likes, this will reduce the need for control, but at the same time it may change the environmental effect since quotas can be traded from less to more polluting farms (or vice versa). Tradable quotas will also result in lower income effects than comparable non-tradable quotas and a uniform input tax. Both types of quotas will have a lower income effect than a tax since there is no tax to be paid and the input use is roughly the same. Trade will only take place if both buyer and seller benefit from the trade. Hence, making quotas tradable will reduce the income effect. Transaction costs may reduce trade (Paper 1), and they are linked to the rules of trade. If the income effects (or abatement costs) are important, there should be few restrictions on trade. If there are large differences in how the different sources influence the recipient, a non-tradable quota might be better.

Theoretically it is not hard to set up a "perfect" incentive structure, but the world is not "perfect". In my view, it is better to use an imprecise policy measure that is transparent – in the sense that everyone can understand what is going on – and easy to implement than a overly complex instrument that is costly to implement.[9]

3.2. Public goods

We will now turn to public goods and different policy options. Public goods and public bads are clearly different in their appearance, but as (hopefully) will become clear, there are no large differences when it comes to sensible policy options.

The major difference between public goods and public bads is that the value of the former is positive and the latter is negative. Does this mean that (private) bads cannot be traded? This may be a matter of definition, but e.g. industrial waste may change "owner" more times before the final treatment. In stead of paying for the waste, one is paid to take care of the waste. Thus, not even the sign of the value seems to not matter much.

In most cases pollution from agriculture cannot be traded, in physical terms, since it is diffuse and often dissolved in water. Even though pollution rights may be traded (implicitly), the impossibility to trade the pollution directly means that there is a difference between point and non-point externalities. However, even here the difference with respect to efficient allocations is not as large as it might seem. Recall from above that Griffin and Bromley (1982) show that a set of input and output taxes/subsidies would result in an efficient allocation in the case of non-point pollution, given knowledge about the nonpoint production function. The latter is a representation of the relationship between different inputs and outputs and emission. Emission is just another output, and the partitioning of the inputs and outputs is really arbitrary. Hence, if input taxes/subsidies can lead to efficient allocations in the case of non-point outputs the same type of policy instrument can also result in efficient allocations in the case of point outputs. It should be kept in mind that transaction costs are assumed away in the model. Thus, their policy instrument may not be the optimal when regulating a point output.

The most important difference between point and non-point outputs is the possibility to

[9] This applies for the major types of pollutants in agriculture. If there is a large variation in emission between sources or damages are sensitive to extremes in emission, increased precision may be justified.

measure them. Commodities are well-defined, and since they are traded in a market they must be easy to measure. Hence targeting commodities are easy and the cost of doing so is low. As the outputs get more diffuse, our (current) ability to measure them becomes poorer and the targeting costs increase. The important question in this respect is: are the public goods produced in agriculture point or non-point goods?

The correct answer, at least semantically, is neither. Loosely speaking, if they were point outputs they could be traded in markets, i.e. they would be private goods. At the same time they are more observable and measureable than non-point source pollutions. This means that "pointness" is relative.

This does not mean that the distinctions between goods and bads and between point and non-point sources are meaningless, but for policy prescriptions they are only important to the degree they affect transaction costs. Hence, most of what is said for the case of non-point pollution applies also for public goods.

Most of the public goods jointly produced with commodities in agriculture are 'diffuse'. Not in the same sense as for diffuse pollution, but in the sense that they are not as well-defined as commodities. For example, what constitutes a cultural landscape? Is it topography, the crops grown, the size of the fields, grazing animals, border elements or everything? Unless we know this, valuation of the cultural landscape becomes very challenging. Valuation is necessary if we want to devise first-best policies. Still, we know that people value the agricultural landscape, but we do not know enough about how these values are formed. The conclusion is that the precision of any landscape policy cannot be very high. Similar argument may be used for the other public goods. It should be noted that some public goods may be more well-defined than others, for example some elements of cultural heritage, and for such goods it is possible to reach a high level of precision.

Regarding policy options, we may target the public goods directly or utilize jointness and target inputs, outputs or practices that are correlated with the public good in question. As is shown in Papers 3 and 4 there are large differences in transaction costs, with commodity support yielding (dramatically) lower transaction costs. On the other hand, commodity support may for some goods result in lower precision which also must be taken into account. If many public goods are jointly produced with commodities, the likelihood that the reduction in transaction costs is larger than the losses due to reduced precision increases.

Jointness is due to either physical/biological processes or economic factors like fixed allocable inputs. Setting the relative prices at the right levels is the main challenge in the latter case. Again this means that subsides/taxes on inputs, outputs and practices (or technology) is a viable option to secure optimal production of public goods. Transaction costs are important also in this setting.

Paper 3 deals with the other source of jointness, jointness due to biological and/or physical processes. This type may be divided into two sub-types: fixed and flexible. If jointness is fixed it is not possible alter the proportions of the two (or more) outputs, given the level of the outputs. Since the jointness is "locked" the optimal policy is to target the output that results in lowest administrative costs. If the jointness is flexible the policy that maximizes welfare will depend on more factors than just transaction costs. Flexibility implies that it is possible to increase the output of the e.g. non-commodity for a given level of the commodity output. However, if only commodity output support is used, there are no incentives for farmers to increase the level of the non-commodity output. This may (or may not) be optimal, dependent on the welfare function, the costs of increasing the non-commodity output, the budget (or scale of production) and the difference in transaction costs between the policy options. This means that it is not possible to draw a general conclusion with respect to the optimal policy option – precision (and the implied costs) needs to be balanced against the costs of regulation.

Even though the use of commodity price support, set at the right levels, can be shown to be efficient, it is not without problems. Commodity support can clearly be seen as trade distorting. It is also possible to view this from the opposite angle: free trade is distorting optimal polices for public goods provision. This is clearly a matter of rights, in which economics not necessarily should play the main role. Global efficiency reasoning seems more important than the discussion about rights in the trade-talks. As a WTO member we should of course abide by the rules, but we should be aware of the consequences.

4. The agricultural policy in Norway

Agriculture occupies 3.4% of the total mainland area of Norway (2.8 of the total area), and agriculture must thus be said to be a marginal land use activity. Due to the length of the country – from about 57° 57' to about 71° 11' northern latitude – and a varied topography, conditions for agricultural production vary throughout the country.

According to Statistics Norway (2008a) there were 51200 agricultural holdings in 2005, and a total agricultural area of about 1 million hectares. This means that the average holding is about 20 hectares. The average holding size in EU-25 is about 16.6 hectares (calculated from Eurostat, 2007b). The difference is even larger when we look at the distribution by holding size (Table 3). From the table we see that almost half of the farms in the EU-25 are less than 5 hectares, and that the enlargement (form 15 to 25 member states) has lead to a large increase in the share of very small farms. According to Eurostat (2007a:35) more than 90% of farms with over 10 hectares are located in the old member states. Without going into a lengthy discussion, this implies that the diversity in the EU is larger than in Norway, despite the large variation in climatic and topographic conditions in Norway.

Table 3. Agricultural holdings (%) in the EU and Norway by holding size, 2005.

	<5 ha	5-10 ha	10-30 ha	30-50 ha	>50 ha
EU-25[1)]	45	18	20	6	10
EU-15[1)]	37	30	26	4	3
Norway[2)]	12	19	51	13	5

Sources: [1)] Eurostat (2007a), [2)] Statistics Norway, 2008b.

If we compare the farm size in Europe with other countries, agriculture in Europe must be said to be small scale. For example, the average holding size in Australia in 1997 was about 3200 hectares (calculated from Bureau of Rural Sciences, 2001). Scale is important for the profitability and thereby competiveness, and is therefore one factor that may affect the “need” for support.

The total support in 2006 to producers in the OECD countries is estimated to € 214 billion, which is about 27% of total farm receipts (OECD, 2007). The latter is termed producer support estimate, PSE. However, there is a large variation between the different OECD countries. The PSEs for some selected countries are shown in Figure 1.

There are two other countries with about the same level of percentage PSE as Norway and Switzerland: Iceland and South-Korea. The figure indicates that the agricultural policy has been fairly stable in Norway and the other OECD countries over the last 20 years. Except for New Zealand, which reduced support to almost zero in the late 80ies, there have been few large changes, and in general the support level has been declining (in percentage terms). Still, the PSE for Norway (65%) is almost 2.5 times the OECD average (27%). In absolute terms, the PSE for Norway were about the same for the periods 2004-06 and 1986-88, the latter estimated at NOK 19083 million (OECD, 2007).

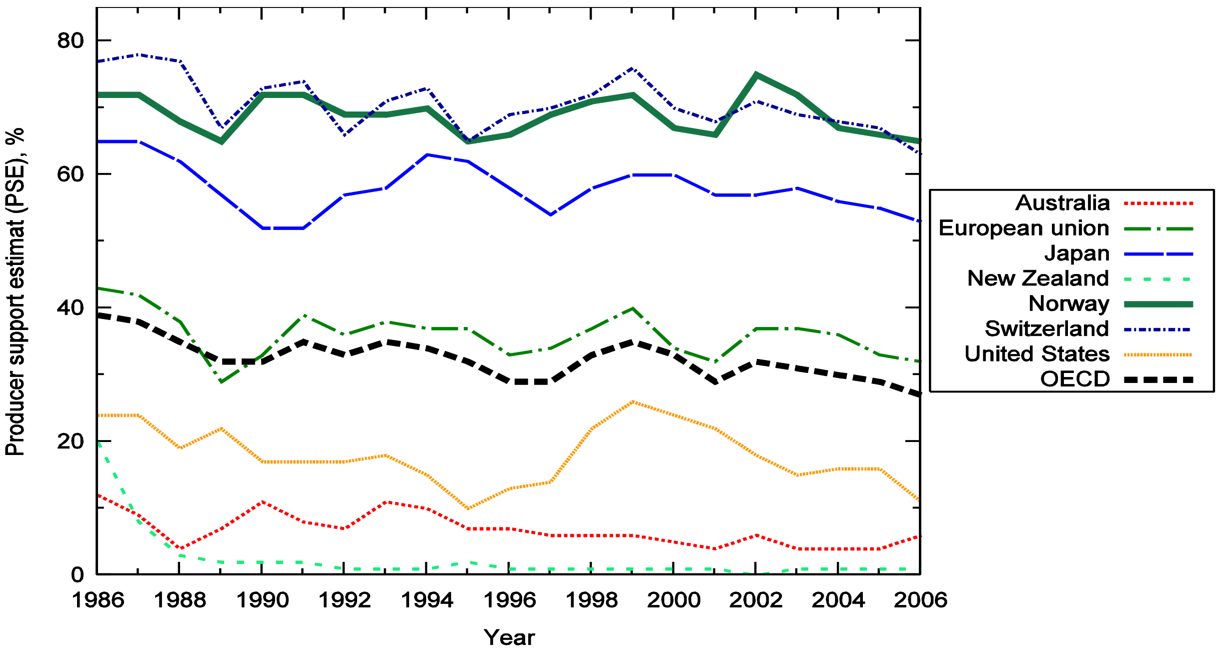

Figure 1. Producer support estimate, in %, for selected countries. Source: OECD (2007).

The PSE includes both budgetary support and indirect support like border measures (tariffs, import quotas, etc.) combined with target prices. The indirect support and payments based on outputs leads to a gap between the prices farmers receive and border prices. In 2006 the market price support was about 44% of the PSE, and the ratio between the average price received by the farmer and the border price (producer NPC) was 2.25. Even though support based on commodity output (in % terms) has declined over time, producer NPC is still significantly higher than the OECD average.

In Norway commodity output based support is complemented by a variety of other support measures, e.g. based on acreage and headage. Most of these other payments and target prices are set in annual negotiations between the government and farmers' organizations. A large share of the measures not based on commodity outputs are differentiated by geographical location (regions) and farm size (acreage and number of animals).

Only few large payment schemes target the production of public goods and bads directly: cultural landscape payment and taxes on pesticides. Other agri-environmental programs are handled regionally/locally, hence, measures vary throughout the country. Measures include support for reduced tillage, constructed wetlands/retention ponds, buffer strips and hydro technical installations. All are aimed at reducing erosion and losses of phosphorus. No economic measures are used to reduce the losses of nitrogen. Until the late 90ies there was a tax on nitrogen (and phosphorus) in fertilizers, but it was removed in favor for other measures. The main argument was the negative income effect (Ministry of Finance, 1999).

One measure that was introduced was mandatory fertilization plans, but the regulation does not contain any quantitative restrictions on the use of fertilizers. Some areas in Norway are defined as nitrate sensitive areas where the nitrogen application restrictions of the EUs nitrate directive apply.

The total support estimate (TSE), which measures the overall agricultural support financed by consumers, was about NOK 20.7 billion in 2006. This is about 1% of GDP, which is about the same as the OECD average (OECD, 2007).

The farm gate value of production (NOK 18.8 billion) is less than the support (PSE = NOK 19.1 billion and TSE = NOK 20.7 billion). However, the total value of production is larger since the OECD estimate only includes commodities. Politically, the value of the non-commodity outputs can be said to be large since the agricultural policy has been supported by various governments and parliaments during the last 20 – 30 years. If we are concerned about the resource allocation, this is however not a satisfactory observation.

The high level of support is not a large problem for Norway per se. Norway is a rich country, and spending about 1% of GDP on agricultural support is accepted by a large majority of the population. Still, 20 billion is a large sum, and the money may be used more effectively (in terms of welfare) in other sectors. Unfortunately, reliable estimates of the non-commodity values necessary to estimate the optimal “size” of Norwegian agriculture and the optimal policy mix are missing.

Even if we utilize economies of scale, i.e. increase the size of Norwegian farms, support is needed in order for agriculture to “survive” given current world market prices. Flaten (2003) uses a partial equilibrium model (JORDMOD) to estimate the effects on Norwegian agriculture from removing support completely and removing “only” border measures. Without any support Norwegian agriculture will vanish (almost completely). Only potato production and a very small grain area will “survive”. In the case only border measures are removed, the agricultural area will be reduced by about 87%. Only production of sheep meat will increase, while other productions will decrease dramatically compared to the base situation (1998). Flaten (2003) emphasizes that the results should not be taken literally, but they indicate that the competitiveness of Norwegian agriculture is (very) low (even if allowed to utilize economies of scale).

Brunstad el al. (1999; 2005) are attempts to include public goods production in a partial equilibrium framework by including cultural landscape and food security in the model.

Landscape is included by using a willingness to pay function. In Brunstad et al. (1999:542) they present a table over the willingness to pay to prevent a reduction in the agricultural landscape by one-half. The willingness to pay varies with the parameters of the function, and ranges from NOK 0.5 billion to about 3.0 billion per year. They stress that the estimates are uncertain, but still use them in their policy evaluations. If we take their approach to the extreme and use their willingness to pay function (and using the same parameter values as used in Brunstad et al., 2005), the total value of the Norwegian agricultural landscape is larger than NOK 20 billion. Hence, the current Norwegian agricultural policy would pass a benefit – cost test.

I fully agree that the parameters are highly uncertain, and that results form using then should be treated with great care. Nevertheless, Brunstad et al. (2005) conclude that at most 40% of the current support level can be defended by the production of the two public goods in question. The reduction in support would reduce the agricultural area by 36%. They also acknowledge that other public goods may affect (increase) the optimal support level.

More research is needed in order to find the optimal policy mix and level of support. Better estimates of the values of the public goods produced in agriculture are essential in this respect. As argued above, using commodity support to secure public goods production is clearly a viable option resulting in very low transaction costs, but more research on the (physical) relationship between private and public outputs is needed in order to device the optimal policy.

5. Abstracts of the papers

5.1. Paper 1: The effects of private transaction costs on tradable fertilizer quota markets

Private transaction costs may reduce trade in a fertilizer quota market since they reduce the net gain from trade. Transaction costs may influence both the decision to enter the quota market and the amount traded. A micro economic model is developed in the paper in order to analyze how fixed and variable transaction costs affect these two decisions.

The theoretical model is used to simulate fertilizer quota markets in four Norwegian regions under the assumption of a well functioning quota market, i.e. only variable transaction costs are included. The model is run for a wide range of transaction costs and quota levels.

The results show that transaction costs have a modest effect on trade, even at extremely high levels. Trade will increase if allowed between regions, but this has only a small effect on the aggregate nitrate loss. The effects within each region are larger.

The differences in aggregate environmental effects between tradable quotas, non-tradable quotas and a (comparable) fertilizer tax are very small. This implies that the aggregate nitrogen losses are mainly governed by total nitrogen use. If the income effect is a concern, this implies that the regulator should implement a tradable quota system with as low as possible transaction costs. Hence, a scheme with few, if any, constraints on trade is preferable.

5.2. Paper 2: Policy measures to induce split application of fertilizers

This paper is coauthored with Eirik Romstad.

The effects of pollution from nature based productions – like agriculture – do not only depend on the production decisions made. Nature, or more specifically the weather, is the main driving force in such productions. If possible, policies to reduce the environmental damages should therefore also seek to incorporate “the game nature plays”.

The characteristics of nature based productions vary. Consequently, policy instruments needs to be tailored to the specific production and environmental problems. In grain production growing conditions vary considerably between years. This variation carries over to the environmental damages. Research indicates that split fertilization is a promising measure to reduce nutrient leaching from agriculture since this opens up for utilizing information as it becomes available during the growing season. Split application of fertilizers in grain is rarely used, indicating higher profits from fertilizing only at the beginning of the growing season.

This paper looks at policy measures to induce farmers to practice split fertilization. These measures include a two-tiered input tax and a two period system of fertilizer quotas. It is demonstrated that a two-tiered tax will not work, due to the necessarily large difference in tax level between the two periods and the possibility to store fertilizers from one year to the next.

We have analyzed the effects of split fertilizer quotas and taxes on fertilizer nitrogen in southeastern Norway under current climatic conditions and under a possible future climate (2010 – 2048). The results show that the split quota will reduce losses to the environment at lower costs (both private and social) than a tax. Further research is needed to investigate if these promising results also hold in other regions in Norway.

5.3. Paper 3: Multifunctional agriculture – the policy implications of jointness and positive transaction costs

This paper is coauthored with Arild Vatn.

In a transaction cost free economy, jointness is of little interest since providing the incentives to farmers for producing all goods at the optimal levels is costless. However, regulation is not costless, and the paper shows that transaction costs are much lower for polices targeting commodities than polices targeting other goods. Also, the analysis shows that transaction costs can be reduced dramatically by reducing the number of support schemes.

If a non-market good is linked to a commodity in a way that cannot be altered by the farmer, what we term fixed proportions, targeting the commodity is the optimal policy, since it results in lowest transaction costs.

One property of (physical) joint production is that it exhibits economies of scope. This means that separate production of non-market goods and imports of commodities is optimal only if the difference between domestic costs and the world market price is large.

In the case of flexible proportions, i.e. it is possible to alter the relationship between outputs, it is not possible to draw universal conclusions regarding what type of output to target. The recommendation will depend on the trade-off between reducing transaction costs and securing precise delivery of the public good.

For a small country that is not competitive at world market prices, like Norway, we suggest, to use commodity support up to a certain point and to combine this with specific support schemes more directly targeted at the non-market goods to increase precision.

5.4. Paper 4: Why do transaction costs of agricultural policies vary?

This paper is coauthored with Arild Vatn and Valborg Kvakkestad and is published in *Agricultural Economics* **36**(1):1-11.

Policy related transaction costs (TCs) is an important issue when evaluating different policy options. However, TCs are often not taken into account in policy evaluations, but may be as important for efficiency as the direct production costs. Different policies may result in different TCs, and the main aim of the paper is to explore possible reasons for these differences. We compare the level of TCs for 12 different agricultural policy measures in Norway, and we analyze the causes of the differences along three different dimensions: asset specificity, frequency, and point of policy application. At the national level we find that all three dimensions are of importance when explaining the differences, while variation in TCs incurred by farmers are mainly due to differences in point of policy application and asset specificity. Data show that direct price support has the lowest TCs, while more direct payments for environmental amenities have the highest.

6. The relevance of the papers

It is argued above that there are no large fundamental differences between public goods and public bads in the sense that the same type of policy instrument may be used in both cases. However, in terms of scale there is a difference. Pollution (public bads) is foremost linked to intensity (input use and practices) while public goods are more linked to the presence of agricultural production and the structure of the agricultural sector. While public bads may be regulated at the micro level, public goods may be dealt with more effectively at the more aggregate level – that is, by the more general agricultural policy.

Regarding public bads in Norway, economic instruments are only used to regulate pesticide use. As mentioned above, taxes were used earlier on nitrogen and phosphorus, but replaced by compulsory fertilizer plans without quantitative restrictions on nutrient use. This will raise awareness about the problem, but the precision of this instrument must be said to be poor. One disadvantage of a tax is the negative income effect, and two of the papers in this thesis (Papers 1 and 2) discuss two alternatives with lower negative income effects: tradable fertilizer quotas and split application of fertilizers (in the form of quotas in two rounds). The former is clearly a viable option, both in Norway and elsewhere. Regarding the latter, more research is needed before a definite conclusion can be drawn. The results from the simulations are promising. However, this instrument uses the expected yearly optimal fertilization level, and more research is needed to investigate the possibility, accuracy and costs of estimating this.

Public goods are jointly produced with commodities. Due to the high cost level and unfavorable growth conditions in Norway, agriculture is not competitive given current world market prices. Without any support Norwegian agriculture will (almost) vanish (Flaten, 2003) or at least, the levels of public goods will fall short of the demand (Brunstad et al., 2005:484). This is also the situation in other countries like Iceland, Finland and Switzerland. Papers 3 and 4 are very relevant in this respect. The results from the papers support in principle the current Norwegian agricultural policy regarding the types of policy instruments used, i.e. support base on commodity output combined with other measures. However, the analyses clearly show that policy costs can be reduced substantially by reducing the number of policy schemes. Transaction costs in Norway can be reduced by using few and large commodity based support schemes, supplemented by smaller schemes targeting public goods production more directly. The first would induce a certain level of production, while the latter may be use to fine-tune public good production. If the agricultural sector is competitive and self-sufficient, output based policies will in most cases have distortive effects and should be avoided.

The efficient policy mix will differ from country to country due to differences in the links between commodities and public goods and bads. This means that efficiency in the international commodity markets may lead to inefficiencies in public goods/bads production in some countries.

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