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Discussion paper

Optimal provision of public goods. Implications for support to agriculture

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Optimal provision of public goods.

Implications for support to agriculture.[1,2]

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Abstract:

This paper summarises a decade of research by the authors into the welfare economic foundations for agricultural policy. The main results are that the levels of support to agriculture in rich developed countries like Norway are way out of proportion with what could conceivably be defended by welfare theoretic arguments. However, the present debate on the multifunctional role of agriculture points to valid arguments for agricultural support. In terms of welfare economics these arguments are found in the links between agriculture and public goods like landscape amenities and food security. This paper offers a modest attempt to quantify the Pigouvian subsidies that could be derived from these arguments.

Keywords: Food security, landscape preservation, public goods, Pigouvian subsidies, jointness, agricultural policy.

JEL Classification: Q18, Q26

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1. Introduction

Agriculture is a heavily supported industry in most developed countries. The support is widely perceived as a hindrance to economic growth and development and a major source of distortion of international trade. It has become one of the main focuses of OECD and has been at the centre of the ongoing and the last rounds in WTO.

Agricultural policy could be expected to interact with economic growth in two ways. Firstly, one could expect the proportion and intensity of subsidised agriculture in a regional economy, to attenuate the movement of labour and capital to other sectors (and/or regions) with higher returns, conserving structures of factor allocation at the cost of those paying for the subsidies. Secondly, the subsidies may also be expected to reduce or to distort farmers' incentives to change their mixes of products and/or methods of production. In this sense the subsidies are counterproductive as they hamper the growth in GDP. Bivand and Brunstad (2003, 2006), investigating convergence in economic growth in Western Europe, find some empirical support for this view.

The recent discussion about the so-called multifunctionality of agriculture may, however, indicate that agricultural activities produce benefits over and above the market value of agricultural production. For recent papers addressing this question, see Peterson *et al.* (2002) and Brunstad *et al.* (1995a,1999 and 2005). In terms of Pigouvian welfare economics agricultural production may have positive external effects on perceived public goods like the amenity value of the cultural landscape, see for instance Drake (1992). If this is the case, and if agricultural support is used as Pigouvian subsidies to internalize these externalities, growth is reduced only because we are measuring the wrong thing, traditional GDP instead of an extended GDP including the value of such amenities.

Partly the amenity value may come as a positive externality to other industries, in this case mainly tourism. The link between agriculture and tourism in this respect have been pointed out by several authors, se for instance Pruckner (1995). In this case the amenity will be included in GDP as part of GDP in tourism. However, to the extent that the amenity is a public good that affects the local population, it is not included in GDP even if it contributes positively to welfare. This paper explores the link between agriculture and public goods.

2. Main issues

It is widely accepted that there are externalities and public goods related to agricultural activity, such as the amenity value of the landscape, food security, preservation of rural communities and rural lifestyle (see Winters, 1989-1990 and OECD, 2001; and more recently Hediger and Lehman, 2003). What implications these externalities should have for national agricultural policy is a more controversial issue. What support levels can be defended by the so-called multifunctional role of agriculture, and what policy instruments are efficient? In the ongoing WTO negotiations, for example, some high-cost countries have used the multifunctional aspect to argue for continued high support levels, even in the form of tariffs and output subsidies. Low-cost countries reject such arguments as protectionism. The latter view finds support in a recent contribution from Peterson *et al.* (2002), who derive the efficient set of policies for a multifunctional agriculture, and show that efficiency cannot be achieved through output subsidies.

Present policy in OECD countries involves heavy support to agriculture. However this support is not targeted as Pigouvian subsidies at the possible positive externalities emanating from agricultural products or inputs on public or private goods, but is basically inherited from the past when they were based on traditional protectionist arguments. This paper sums up our efforts to give some empirical contributions to the debate on the multifunctional aspects of agriculture.

In earlier papers, we have examined the food security and landscape preservation arguments as separate issues.

In Brunstad *et al.* (1995a), the food security argument was discussed. A numerical model was applied to compute what Norwegian agriculture would look like if the only purpose of support was to provide food security. Compared to the actual activity in agriculture, the analysis indicated a decline in employment and land use of about 50 per cent.

Brunstad *et al*. (1999) dealt with the landscape preservation argument. A method for incorporating information on the willingness to pay for landscape preservation, as inferred from contingent valuation studies, was presented and implemented in the objective function of the model mentioned above. To illustrate the method, Norwegian agriculture was used as a case study, and optimal levels of production, land use, employment and support were calculated. Based on various simulation experiments, it was shown that only a minor fraction of today’s generous support level would be maintained, and production and employment would drop to low levels. However, even if the landscape preservation argument was not able to defend today's levels of production and employment, it was strong enough to keep a substantial part of today's agricultural area under cultivation.

Finally in Brunstad *et al*. (2005) the focus was on the cost complementarities (jointness) between these two public goods, and between public goods and private goods. We discuss the optimal policy when food security and landscape preservation are simultaneously taken into account. To what degree are these public goods complementary in the sense that supplying one of them more or less automatically would lead to supply of the other(s)? What is the link between the public goods and traditional food production? How much support is necessary to sustain reasonable levels of public goods, and what policy instruments are efficient, when cost complementarities are considered?

3. An agricultural model with public goods

To quantify the cost of providing public goods as well as cost complementarities we use a model of the agricultural sector in Norway[3]. This model is extended by incorporating a willingness-to-pay function for landscape preservation, and by including provisions for food security. The model, whose base year is 1998, covers the most important commodities produced by the Norwegian agricultural sector, in all 13 final and 8 intermediary product aggregates. Of the final products, 11 are related to animal products whereas 3 are related to crops. Inputs needed to produce agricultural products are land, labour (family and hired), capital (machinery and buildings), concentrate feed, and an aggregate of other goods. Furthermore, we distinguish between tilled land (T) and grazing on arable land and pastures (G), so that $G + T = L \leq \overline{L}$ where $\overline{L}$ is total arable land available. Domestic supply is represented by about 400 'model farms'. Each model farm is characterised by a Leontief technology, i.e. with fixed input and output coefficients. Although inputs cannot substitute for each other at the farm level, there are substitution possibilities at the sector level. For example, beef can be produced with different technologies (model farms), both extensive and intensive production systems, and in combination with milk. Thus, in line with the general Leontief model in which each good may have more than one activity that can produce it, the isoquant for each product is piecewise linear. Also, production can take place on small farms or larger, more productive farms. Consequently, there is a degree of economies of scale in the model. The country is divided into nine regions, each with limited supply of different grades

[3] An early version of the model is described in Brunstad and Vårdal (1989), but the model has been considerably improved since then. A technical description of the model is given in Brunstad et al. (1995b).

of land. This introduces an element of diseconomies of scale because, ceteris paribus, production will first take place in the 'best' regions. Domestic demand for final products is represented by linear demand functions. Economic surplus (consumer surplus plus producer surplus) of the agricultural sector is maximised, subject to demand and supply relationships, policy instruments and imposed restrictions. The solution to the model is found in terms of the prices and quantities that give equilibrium in each market. More details are given in Brunstad *et al*. (2005, pp.486-488). Column 1 in table 1 below presents a model simulation of Norwegian agriculture based on the current support system, using parameters based on actual subsidies and tariffs.

Table 1: *Production and main input levels in Norwegian agriculture*[4]

	Base solution	Landscape preservation	Food security	Landscape preservation and food security
Production (mill. kg or ltr)				
Milk	1671.5	139.1	832.1	709.6
Beef and veal	82.1	5.6	33.6	28.6
Pig meat	100.1	-	-	-
Sheep meat	23.0	28.0	18.4	29.7
Poultry meat	27.8	-	14.8	-
Eggs	43.8	-	16.7	9.8
Wheat	210.5	114.8	151.1	150.0
Coarse grains	1021.3	255.1	367.8	339.1
Potatoes	298.0	310.3	307.1	312.3
Land use (mill. hectares)	0.85	0.36	0.48	0.54
Tilled land	0.31	0.09	0.13	0.12
Grazing and pastures	0.54	0.27	0.35	0.42
Employment (1000 man-years)	59.7	9.8	17.3	17.7
Rural areas	40.1	7.0	n. a.[5]	8.0
Central areas	19.6	2.8	n. a.	9.7
Total support (NOK billion)	15.3	3.3	5.5	6.0
Border measures	6.7	-	-	-
Budget support	8.6	3.3	5.5	6.0
Composition of budget support				
Area planted or animal number	35%	100%	n. a.	58%
Other input use	52%	-	n. a.	42%
Output	13%	-	n. a.	-

4. Cultural landscape

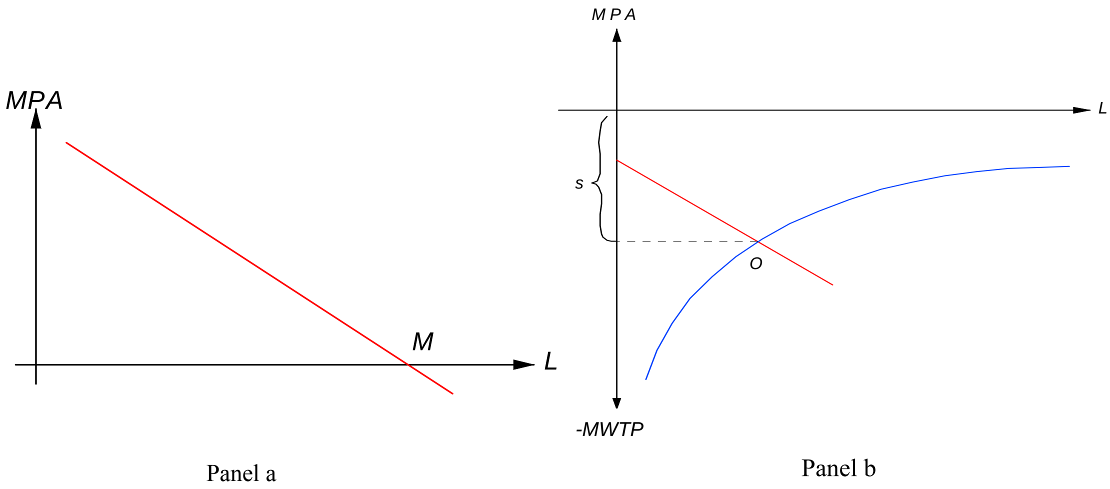
Assume that we have an agricultural aggregate L, representing both production and amenity benefits. Exposed to world market prices and receiving no support, the market solution

Details are given in Gaasland et al. (2001). The model is constructed to perform policy analyses, and has as such been used by the Norwegian Ministry of Finance and the Norwegian Ministry of Agriculture.

[4] The table is adapted from Brunstad *et al.* (2005)

would be at M in panel a of figure 1 below, where the marginal profit from agriculture (MPA) is zero.

Figure 1. *Socially optimal level of agriculture*



Assuming further that the curve in the second quadrant in panel b represents the positive but falling marginal willingness to pay (MWTP) for the amenity benefit, and also that agriculture is not profitable at any positive level of production without support, the optimal level of production would be at O, where MWTP would be equal to the negative MPA. A subsidy of s per unit of the agricultural aggregate would then represent the optimal support to agriculture.

Several studies have attempted to estimate the willingness to pay for the amenity value of the cultural landscape. Lopez *et al.* (1994), using data from Beasley *et al.* (1986) and Foster *et al.* (1982), have calibrated the following willingness to pay function for the amenity value of the agricultural landscape:

$$\text{WTP} = BL^{e1}P^{e2}y^{e3}$$

where L is a quantity index for landscape amenity, here assumed equal to cultivated area, P is population, y is income per capita, and B is a scaling parameter. From economic theory one would expect the marginal willingness to pay for the landscape amenity to be diminishing, implying that $0 < e1 < 1$, and also that the willingness to pay should be income elastic,

[5] Not available

meaning that e3 > 1. Furthermore, if the landscape amenity were a pure public good, like the famous lighthouse example, e2 = 1, implying that the per capita willingness to pay is independent of population size.

In fact the elasticities were calibrated to: e1 = 0.172 - marginal willingness to pay for the landscape amenity is strongly diminishing; e2 = 0.796 - landscape amenity is close to a pure public good, but some crowding effect is present, and e3 = 3.877 - landscape amenity is highly income sensitive. Even if the empirical foundation of these estimates is extremely meager, amounting to four observations from US counties, they are within the ballpark of "acceptable" figures, albeit the income elasticity may seem unreasonably high.

Obviously, it is hard to model all the attributes that enhance the value of the agricultural landscape, like openness, variation, biodiversity and type of agricultural technique. We follow Lopez *et al.* (1994) and assume the following willingness-to-pay function for landscape preservation:

$$WTP = \Theta L^{\varepsilon}$$

Where Θ (>0) is a constant. In our approach, the amenity value of tilled land, *T*, is allowed to differ from that of grazing and pasture, *G.* The aggregate for landscape preservation is postulated by the following CES function:

$$L = \Lambda\left[\alpha_G G^{(\kappa-1)/\kappa} + \alpha_T T^{(\kappa-1)/\kappa}\right]^{\frac{\kappa}{(\kappa-1)}}.$$

Following Brunstad *et al*. (1999), the parameters Θ, Λ, α_G and α_T are calibrated to estimates of amenity benefits taken from Drake (1992) who makes a similar distinction between tilled and arable land. Based on Lopez *et al*. (1994), the elasticity of scale, ε, is set equal to 0.172. This means that the marginal willingness to pay is strongly decreasing for rising levels of *L*. Moreover, the elasticity of substitution between pasture and tilled land, κ, is assumed to be equal to 3.0, reflecting a relatively high degree of substitution.

Adding this willingness to pay function to the model and removing all tariffs and subsidies other than those generated by the MWTP, we get the hypothetical figures for Norwegian agriculture which are presented in the second column of the table 1.

Compared to the actual support regime (column 1), the activity in the agricultural sector is substantially reduced, especially production and employment (16% of level in the base solution).

Naturally, since land use enters into the WTP function it declines less than the other indicators. Nevertheless, the computed level of land use is only 43% of the present level. Land intensive grazing, i.e. extensive sheep farming, keeps up better than grain production on tilled land. Necessary support, in the form of acreage subsidies, is 3.3 billion NOK, or about one fifth of the support in the base solution.

4. Food security

The ability to provide food under all contingencies is referred to as *food security*. Food security can, following Ballenger and Mabbs-Zeno (1992), be defined on a global, national and individual level.

Global food security is defined as:

$$Pr\ [(\text{world production} + \text{world stocks}) \geq \text{world needs}] \geq \pi.$$

Pr symbolizes probability, π is the minimum acceptable likelihood and ‘needs’ is the necessary consumption. This means that the sum of world production and stocks in every year must exceed the necessary consumption by a minimum acceptable likelihood.

National food security, formulated as:

$$Pr\ [(\text{domestic production} + \text{domestic stocks} + \text{imports} + \text{aid}) \geq \text{domestic needs}] \geq \pi,$$

is less restrictive since consumption can be based on imports and aid from other countries. Therefore, even if global food security is below reasonable limits, rich countries like Norway will normally have enough purchasing power in world markets to secure a sufficient share of world production. The same logic applies to individual food security, which can be secured if a person has enough income or purchasing power, even if the nation’s food supply is insufficient.

It follows that if global food security is fulfilled, then national and individual food security is a matter of distribution or poverty relief. A special case is a blockade in connection with war, that rules out distribution between countries (infinite import prices), e.g. as in the situation during World War II. This traditional argument for national food security seems to be outdated thanks to strong defence alliances and the way modern warfare is pursued. Nevertheless, it seems unwise to dismiss totally the need for a minimum of activity within the agricultural sector in order to diminish the negative effects of unknown crises in the future.

A more rational argument concerns global food security. Some kind of ecological crisis or man-made disaster (like the Chernobyl fall-out) is less likely to be detrimental to global food security if production capacity is spatially diversified throughout the world. Although rich countries would be able to finance the high food import bill under adverse situations, it can be argued, for ethical reasons, that most countries should contribute to the global production potential. As agreed by a vast majority of economists, this is not an argument for national self-sufficiency.[6] Import tariffs and production subsidies are not only costly, but may also impair the purchasing power and food security in countries with comparative advantage in food production, e.g. many developing countries. It is, however, an argument for keeping necessary factors of production available with a minimum distortion on trade. In the forthcoming simulations, we take the view that Norway should at least have the capacity to feed its own population if a crisis occurs.

Gulbrandsen and Lindbeck (1973) attacked the self-sufficiency goal stressing that production in normal times does not have to be equal to production during a crisis. Some switching of production when the crisis has arisen, will be possible. The crucial condition for switching of production is, however, that the necessary factors of production are available, especially agricultural land, but also skills, livestock and capital equipment. Then, according to what could be termed the *Gulbrandsen-Lindbeck principle* a rudimentary measure of food security could be obtained if there are enough acreage, labour (i.e. agricultural skills) and livestock available to produce a crises menu containing sufficient nourishment to feed the population. The point is not that this basket of goods *should actually be produced*, but that sufficient quantities of the agricultural inputs should be *available* so that the crises menu *could be produced.* Of course to the extent that actual production deviates from the menu, this can only happen after some necessary period of transition, to prepare for which some stockpiling would also be necessary.

[6] Using an index of national food security, Sumner (1990) showed that trade barriers are detrimental to food security in most conceivable situations, mainly due to adverse effects on real income. Beghin *et al*. (2003) showed that the welfare costs for South Korea of pursuing food self-sufficiency (trade barriers) are substantial, and that food security can be achieved at much lower costs using more targeted policy instruments. An improved international trading environment, i.e. for agricultural products, is considered to stimulate economic growth, and thus strengthen food security, in developing countries that depend heavily on agriculture, see e.g. Anderson and Morris (2000), Davis *et al*. (2001) and Sumner (op.cit).

For Norway such a crisis menu has actually been computed in an official report to the government, see NOU (1991). The crisis menu is given in table 2 below.

Table 2. *Crisis menu compared to actual consumption in the base year 1998 (million kg per year)*

	Consumption 1998	Crisis menu
Grains	463	335
Potatoes	309	461
Cow milk	1400	853
Meat	247	63
Eggs	44	17
Fish	72[7]	335

In line with the Gulbrandsen-Lindbeck principle, we first employ the agricultural model to calculate how much land and labour is needed to produce the quantities of food required by the crisis menu. These levels, calculated to be 56 per cent and 29 per cent of the base levels, must be kept continuously available in order to be prepared to produce the crisis menu if the need arises. In addition to keeping land and skilled labour available, livestock has to be available for meat and milk production. This limits the extent to which the current production of animal products can be reduced relative to the crisis menu. This is taken care of by assuming that the production of meat, cow milk and eggs must not fall below the levels of the crisis menu. Furthermore, if a crisis occurs, current import of grain will have to be replaced out of stocks for the time that is needed to cultivate the land such that sufficient grain can be produced. In Brunstad *et al*. (1995a) the stockpiling costs were estimated to be negligible compared to the production cost of grain.[8]

In a second run of the model we impose the quantities derived above as minimum restrictions. The necessary subsidies then follow from the shadow prices.

In column 3 of table 1 we present the hypothetical figures for the Norwegian agricultural sector when all tariffs and subsidies other than those necessary to implement the

[7] Average consumption (product units) in the period 1995-99 (Gaasland, 2003).

[8] The computation was based on the assumption that 4 years were needed to make enough land available to supply the quantity of wheat and coarse grain required by the crisis menu. Consequently, the necessary stocks needed to be twice the current level of imports.

Gulbrandsen-Lindbeck principle are removed. We can see that food security can be provided at a considerable lower cost than is the case today. Agricultural support decreases to 5.5 billion NOK, or about one third of the base solution. The support follows endogenously from the constraint on food security, and is, thus, targeted at the underlying factors of the food security production function, i.e. acreage, skilled labor and livestock. Employment and land use decline to 29% and 56% of the base line levels. Compared to the landscape preservation scenario, however, activity levels are higher, especially production and employment, but also land use. This reflects the fact that food security requires a wider specter of inputs than landscape preservation.

5. Cost complementarities

Assume now that we want both landscape preservation and food security. This brings us to the concept of jointness in production. In general, joint production exists if the production of two or more outputs is interlinked in some way, e.g. through technical interdependencies or non-allocable inputs (see Boisvert, 2001). Jointness gives rise to cost complementarities, also referred to as economies of scope, which means that it is more expensive to produce the outputs separately than together. For agricultural public goods, jointness is mainly related to the existence of non-allocable inputs. By definition, it is difficult to determine a non-allocable input's contribution to each output. In agriculture, land is the most obvious non-allocable input since land enters into the production of both landscape preservation and food security, as well as private goods. But also labour and livestock have such characteristics. Besides being key inputs in food production, these inputs contribute to food security and they affect the amenity value of the landscape.

In our final model simulation we include *both* the WTP function for the amenity value of the cultural landscape *and* the minimum restrictions derived from the Gulbrandsen-Lindbeck principle. The result of this simulation is presented in column 4 of table 1.

The necessary support for providing both public goods is only 40% of the costs of the actual support scheme (column 1). In the base solution tariff support and budget support proportional to output accounts for more than 50% of total support. However, as the jointness of private agricultural products and the public goods is due to non-allocated inputs, support should be targeted at the inputs and not at the products, which is indeed the case in column 4.

We also see that the necessary support for jointly producing both public goods is much less than the sum of the support needed to produce each one of them separately. The percentage extra costs of producing optimal levels of the two public goods separately, compared to joint production, is more than 80 per cent. This reflects the existence of complementarities between the two public goods: Due to common inputs, support to obtain a desired level of food security also reduces the costs of keeping up the cultural landscape.

6. Concluding remarks

Without support, the levels of agricultural public goods like food security and landscape preservation will fall short of the demand in high cost countries like Norway, Finland, Iceland and Switzerland. However, as demonstrated in this paper using Norway as a case study, the current level of support is well out of proportion from a public goods perspective. Furthermore, the present support, stimulating high production levels, is badly targeted at the public goods in question. Since agricultural land is a major component of both food security and landscape preservation (as well as in the production of private goods), thus giving rise to a high degree of cost complementarity, it would be more efficient to support land-extensive production techniques, than production *per se*. With optimal policy instruments, the simulations show that at most 40 per cent of the current support level can be defended by the public good argument. Naturally, production and trade will also be affected by support to sustain public goods, but, as illustrated by the simulations, to a far lesser extent.

Finally, it should be noted that our analysis only considers food security and landscape preservation. In principle, there may be other public goods that could affect the optimal policy, e.g. biodiversity, animal health, preservation of rural lifestyle or occupation of land for territorial defence.

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