Regional Aspects of Agriculture

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Abstract

Prevention of depopulation in remote areas has traditionally been an important political goal in Western-European societies. This may be rationalized as follow: If the density of the population in an area drops to very low levels, the cost of providing basic infrastructure may become prohibitively high. As long as total depopulation is undesirable, this is an argument for keeping the population density above some critical level. The most efficient way of achieving this goal would seem to be some general income support to all inhabitants in remote areas or a general wage subsidy to all industries and not support confined to a single industry. This paper introduces a method for incorporating information on the willingness to pay for regional activity in the objective function of a price-endogenous, mathematical programming model for the agricultural sector of Norway. Optimal levels of support, production, land use and activity in various regions are calculated. Our conclusion is that regional preferences do not affect the national activity level of agriculture, but affect the distribution of the activity level between regions.

Keywords: agricultural policy, optimal regional policy, applied general equilibrium model, public goods, WTO-conform rules

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1 Introduction

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 (cf. Winters, 1989-1990; OECD, 2001). What implications these externalities should have for national agricultural policy, is a less settled 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, many high cost countries use 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.

This paper offers an empirical contribution to the multifunctional aspect of agriculture. In Brunstad et al. (1995a) 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 percent. In Brunstad et al. (2005) we added landscape preservation as an argument and discussed optimal policy when food security and landscape preservation are simultaneously taken into account. We found a high degree of complementarity between these public goods in the sense that supplying one of them more or less automatically would lead to supply of the other.

In this paper, we consider rural viability. To what degree is rural employment and settlement a public good that can justify agricultural support, and what policy instruments are efficient? Based on a discussion of these issues within the model framework of Brunstad et al. (2005), we implement rural viability as the third public good, besides landscape preservation and food security, and consider how the optimal policy and production pattern change. Complementarities in the supply of the public goods are investigated, e.g. are the same policy instruments efficient with respect to more than one public good, and which public good seems to be dominant.

Note that the focus is on high cost countries like Norway. At pure free-trade equilibrium with no subsidies, essentially no food would be produced domestically. The levels of agricultural public goods would, therefore, also be close to zero.

In section 2, we demonstrate some basic principles on landscape preservation, rural viability and food security. In section 3, these principles are elaborated into a richer model. A willingness to pay function for landscape preservation and rural viability are incorporated into a sector model for the agricultural sector in Norway. In section 4, the model is employed to discuss the optimal policy and supply of public goods when cost complementarities are considered. Section 5 offers concluding remarks.

2 Public Goods in Agriculture

In this section, we argue that agriculture in certain respects provides services to the community that have the character of public goods.

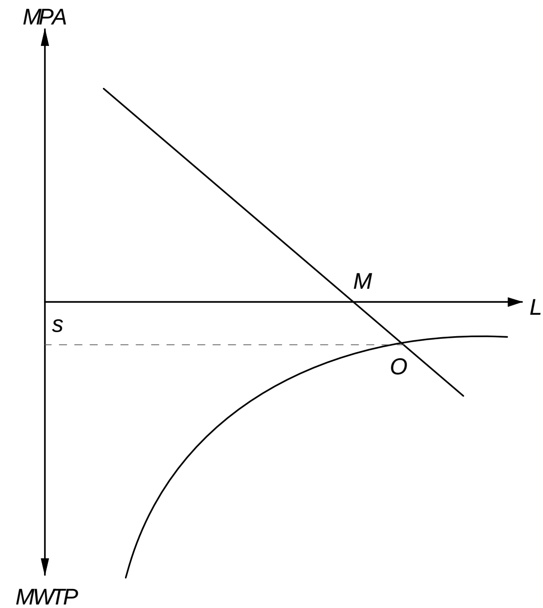
2.1 Landscape Preservation

Compared to the competitive equilibrium, a positive valuation of the agricultural landscape is an argument for increasing the activity in the agricultural sector. How much the activity should increase depends on the willingness to pay, *WTP*. This point is illustrated in Figure 1. The horizontal axis represents land use, *L*, which is a measure of the level of agricultural activity. In the upper half of the figure, the marginal profitability of agriculture, *MPA*, is pictured. *MPA* is derived under the assumption that no government support is given, and that perfect competition prevails in the domestic as well as in the international market. Since we are looking at a small country, this means that commodity prices are determined by the world market. Naturally, *MPA* decreases with land use. In competitive equilibrium *MPA* is zero, marked as point *M*. In the lower half of the figure we have drawn the marginal willingness to pay, *MWTP*, for landscape preservation. *MWTP* is large when the agricultural activity is low (agricultural landscape is scarce), and diminishes with increased agricultural activity. The optimal solution is found where

$$-MPA = MWTP,$$

marked as point *O*. To reach this point a subsidy per unit of land equal to *s* is called for.

Figure 1 **Optimal Level of Landscape Preservation**



For the exact formula for willingness to pay, we follow Lopez et al. (1994) and assume:

$$WTP = E[LP]^{\varepsilon_1}. \qquad (1)$$

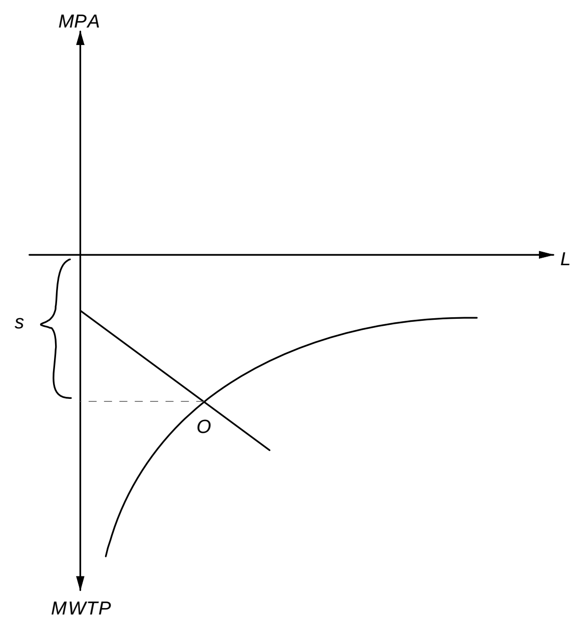
E (>0) is a constant, *LP* is an index of amenity enhancing agricultural land which we assume is equal to the use of land for agricultural production, *L*. ε_1 reflects the marginal willingness to pay for landscape preservation. If we assume ε_1<1, the function (1) is concave. Based on (1), *MWTP* is simply:

$$MWTP \equiv \frac{\partial WTP}{\partial L} = \varepsilon_1 EL^{\varepsilon_1 - 1}.$$

Figure 2 illustrates the case where agriculture is unprofitable even at low activity levels. The agricultural sector in some highly industrialized countries such as Finland, Norway, Switzerland, and Japan, can serve as examples. Without support, agriculture will vanish.

Due to positive external effects, some farming will still be desirable from the society's point of view. At lower levels of land use, total *WTP* clearly exceeds the necessary support. The optimal size of agriculture is marked as *O*.

Figure 2 **Unprofitable Agriculture**



2.1.1 Regional Aspects of Landscape Preservation

Lopez et al. (1994) estimated (1) based on information from four U.S. communities. They also controlled for size of population and income; i.e:

$$WTP_i = B_i LP_i^{\varepsilon_1} P_i^{\varepsilon_2} Y_i^{\varepsilon_3} \tag{2}$$

Here i is an index over communities, P is population, and Y is income per capita. If landscape is a public good, ε_2 should be positive. A pure public good implies $\varepsilon_2 = 1$, while a pure private good requires $\varepsilon_2 = 0$. Finally, we would expect the income elasticity to be rather high, implying ε_3 to be well above 1.

Lopez et al. (1994*)* arrived at the following estimates: $\varepsilon_1 = 0.172$, implying that the marginal willingness to pay is strongly decreasing, $\varepsilon_2 = 0.796$, implying that landscape is rather close to being a pure public good, and $\varepsilon_3 = 3.877$, confirming that the income elasticity is high. However, it is important to note that even if these estimates confirm prior beliefs, they are based on only four communities, and should therefore be used with considerable care.

2.2 Prevention of Depopulation in Remote Areas

Prevention of depopulation in remote areas has traditionally been an important political goal in Norway. This may be rationalized as follows. If the density of the population in an area drops to very low levels, the cost per capita of providing basic infrastructure may become prohibitively high. This means that prevention of depopulation in remote areas is an example of a local public good.[1]

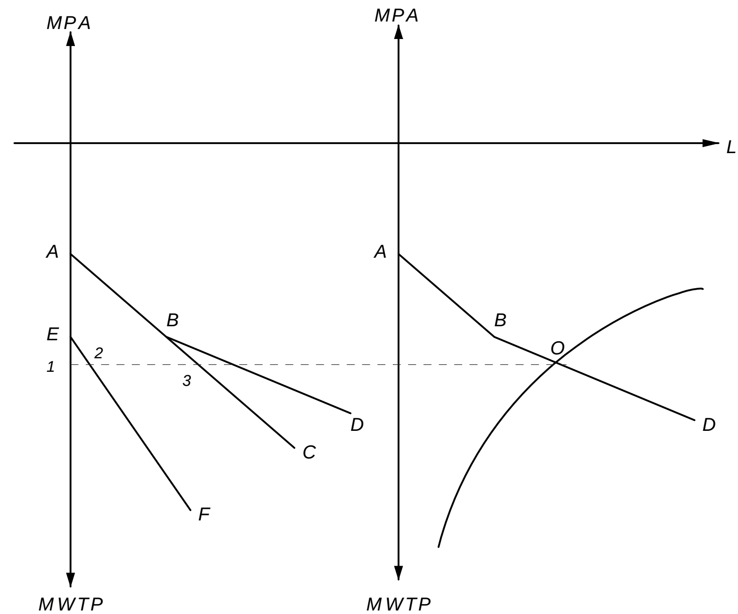
As long as total depopulation is undesirable, this is an argument for keeping the population density above some critical level. The most efficient way of achieving this goal would be some general income support to all inhabitants in remote areas or a general wage subsidy to all industries, and not support confined to a single industry. Indeed, Winters (1989–1990: 251) writes: "The equation of rural with agricultural has been a major fallacy in thinking about the long-term future of rural communities. However, in many remote areas agriculture is the only source, or one of very few feasible sources, of employment. For this reason the goal of maintaining population in remote areas may possibly justify some wage support to agriculture in remote areas. Subsidizing the use of labor in agriculture for this reason will of course also help to achieve food security even if the latter goal could be achieved in a more efficient way by supporting agriculture closer to the large population centres."

Figure 3 illustrates the effect of introducing a subsidy of labor in remote areas. The left part of Figure 3 gives the assumed production technology. We have two regions: A semi-urban region where agriculture is relatively productive. The marginal profit curve is drawn as *ABC*. Then, we have a rural region with less productive agriculture and a marginal profit curve *EF*. The marginal profit curve for the nation is *ABD*.

[1] *According to OECD (2001: 84): "The value of preventing an increase in the costs of providing local public services is a local public good since the benefits are non-excludable and non-rival only within certain geographical boundaries".*

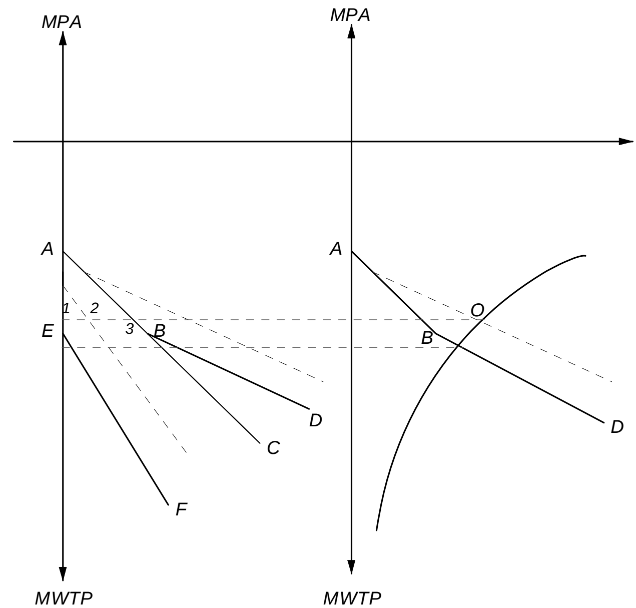
Without support, agriculture will vanish. In the right part of Figure 3 we have illustrated the optimal solution. Note that we have assumed the agricultural landscape to be a national good.

Figure 3 **Optimal Division Between Land Use in the Semi-Urban and Rural Region**



In Figure 4, we have added a subsidy on rural labor. This shifts the rural profit curve upwards, as shown by the dotted line. The aggregate profit curve shifts accordingly, and the new optimal solution is marked as *O*. We see that the aggregate activity level in agriculture increases. However, the subsidy given directly to land *(MWTP)* is reduced. Consequently, the agricultural activity in the semi-urban region (which is solely based on land subsidies) declines. The increase in the agricultural activity in the rural region is therefore larger than this decline.

Figure 4 **The Effect of a Subsidy on the Use of Rural Labor**



2.3 Food Security

Given the choice between foreign products at world market prices and domestic agricultural products at cost prices, Norwegian consumers would, to an overwhelming extent, choose cheaper foreign products, and most of the industry would be wiped out. This may cause problems for the population if a crisis should arise. Blockade in connection with war or international conflict is the traditional example of a crisis. Lately increased risk of ecological crises, man-made disasters like the Chernobyl fall-out and a pandemic have also been used as examples.

Global food security is defined as:

Pr [(world production + world stocks) ≥ world needs] ≥ π.

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, that is formulated as:

Pr [(domestic production + domestic stocks + imports + aid) $\geq$ 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. in line with the situation during the World War II. This traditional argument for national food security seems to be outdated due to strong defense alliances and the way modern warfare is pursued. Nevertheless, it seems unwise to totally dismiss the need for a minimum of activity within the agricultural sector in order to soften negative effects from unknown crises in the future.

A more rational argument concerns the 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 more moral reasons that most countries should contribute to the global production potential. As agreed upon by a vast majority of economists, this is not an argument for national self-sufficiency. 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 will take the view that Norway at least should have the capacity to feed its own population if a crisis occurs.

3 An Agricultural Model with Public Goods

To quantify costs of providing public goods as well as cost complementarities, we need to elaborate the basic principles put forward in the previous section into a richer model. As a point of departure, we use a sector model for the agricultural sector in Norway.[2] This model is extended by incorporating a willingness to pay function for landscape preservation and rural viability.

3.1 The Core Model

The model, which 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 while 3 are related to crops.

Domestic supply is represented by about 400 "model farms." Each model farm is characterized by Leontief technology, i.e. with fixed input and output coefficients. However, production can take place on small farms or larger more productive farms. Consequently, there is an element of economies of scale in the model.

As specified in Figure 5, the country is divided into nine regions, each with limited supply of different grades of land.[3] This introduces an element of diseconomies of scale because, *ceteris paribus*, production will first take place in the best regions. Inputs needed to produce agricultural products are land, labor (family and hired), capital (machinery and buildings), concentrated feed, and an aggregate of other goods. Domestic demand for final products is represented by linear demand functions.

The objective function is an economic surplus (consumer's surplus plus producer's surplus) of the agricultural sector and this surplus is maximized, subject to demand and supply relationships, policy instruments and imposed restrictions. The solution

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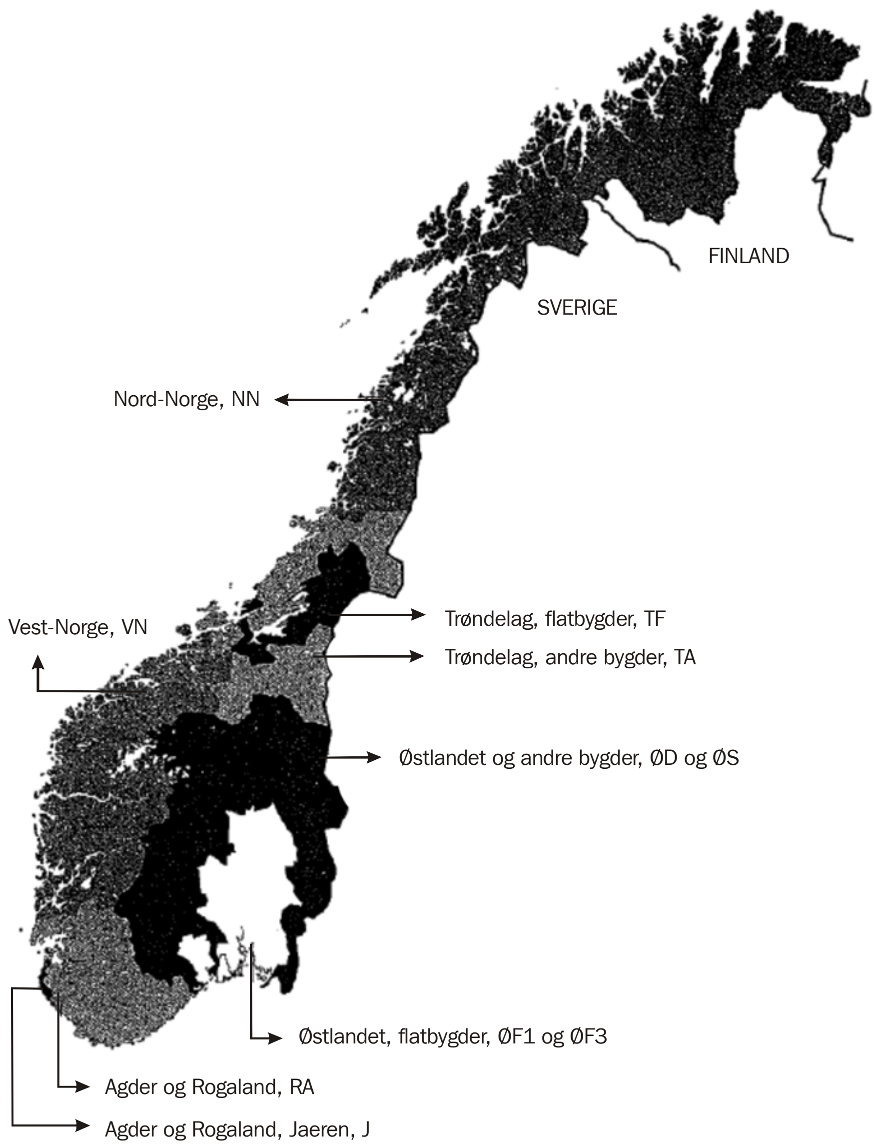
[2] *An early version of the model is described in Brunstad and Vårdal (1989), but the model has been considerably improved since then. A technical description of the model is given in Brunstad et al. (1995b). Details are given in Gaasland et al. (2001). The model is constructed in order to perform policy analyses, and has as such been used by the Norwegian Ministry of Finance and the Norwegian Ministry of Agriculture.*

[3] *Using the acronyms specified in Figure 5, the nine regions are: 1) ØF1 and ØF3, 2) ØD, 3) ØS, 4) J, 5) RA, 6) VN, 7) TF, 8) TA, 9) NN.*

to the model is found as the prices and quantities that achieve equilibrium in each market. A broader description of the model is offered in Appendix 1.

Figure 5 **The Regions in the Agricultural Model**



3.2 Public Goods

3.2.1 Landscape Preservation

Landscape preservation is taken into account by adding the willingness to pay function (2) to the economic surplus as defined in the previous paragraph. The parameters used is specified in section 2.1 (see also Brunstad et al., 1999).

3.2.2 Willingness to Pay for Rural Viability

In Norway, firms have to pay a pay-roll tax on labor. This pay-roll tax differs between regions. In central regions firms have to pay 17 percent. Firms in rural regions are exempted from pay-roll tax. We take the differentiated pay-roll tax as an estimate of the society's willingness to pay for rural viability. This is then incorporated into the model by subsidizing the use of labor in the rural regions by 17 percent.

3.2.3 Food Security

It is difficult to measure the need for food in the case of a crisis. The closest we come is to specify a crisis menu. Table 1, which is taken from a government report (NOU, 1991: 142), gives an example. This menu provides 2600 kcal per person per day, and also gives sufficient vitamins, minerals and proteins. Compared to normal consumption the menu involves higher consumption of vegetables in proportion to animal products. Consumption of milk, meat and eggs is reduced, while the consumption of grain and potatoes is upheld or increased. In addition, the crisis menu makes allowance for the fact that consumption of fish, of which Norway has a huge export surplus, can be considerably increased. The crisis menu shows the minimum annual quantities of agricultural products that must be available for consumption in times of crisis. Stockpiling and remaining import possibilities will make it possible to reduce production below this level.

Production in normal times does not have to be equal to the necessary production during a crisis (see Gulbrandsen and Lindbeck, 1973, Chapter 7). Some switching of production in the time of crisis would be possible. A crucial condition for switching of production is, however, that the necessary factors of production are available, especially tilled land but also agricultural skills, animal material and capital equipment.

We first employ the agricultural model to calculate how much acreage and labor is needed to produce the quantities of food required by the crisis menu. These levels, calculated to be 56 and 29 percent of the base levels, must be kept continuously available in order to be prepared to produce the crisis menu if the needs arise.

4 Model Experiments

The model is calibrated to reproduce the actual situation in the base year 1998 as closely as possible, by including the actual support and tariff regime. In this year, total support amounted to 73 percent of the value of production in agriculture (OECD, 2003). Nearly half of the support was market price support, generated by high import tariff. The rest of the support were payments based on output (15 percent), area planted or animal numbers (12 percent) and input use (25 percent). The support was only to a minor degree targeted on provision of public goods, e.g. in terms of requirements for landscape preservation or the agricultural production systems.

Column 1 of Table 1 presents the base solution. In spite of climatic disadvantage, production is high. Norway is self-sufficient in most products, and for dairy products there is even a surplus which is dumped on the world market. The exception is grain. The arctic climate does not permit sufficient quantities of high quality grain for bread-making. To sustain these high activity levels, substantial support is necessary (NOK 15.3 billion or €1.83 billion).[4] Since agriculture employs about 59,700 man-years, the support per man-year is about NOK 255,000 (€30,700).[5] The support rates are regressive with regard to farm size and favor agriculture in rural and less productive areas. Therefore, small-scale farming appears in most parts of Norway.

A simulation (not reported) where all existing support to agriculture, except for giving 17 percent support to the use of rural labor, results in almost zero agricultural

[4] *We have used the exchange rate 1€ = 8.30NOK, which was the exchange rate that gave approximately purchasing power parity between Norway and EU in 1998.*

[5] *Both total support and employment figures are somewhat lower than the actual ones. Support per man year, on the other hand, is approximately correct.*

activity. Column 2 of Table 1 gives results of a simulation where landscape preservation is the only policy objective. Landscape preservation is implemented in the model as described in section 3.2. The simulation assumes free trade and no subsidies, except those endogenously generated by the model to internalize the marginal willingness to pay for the amenity value of pasture and tilled land. Compared to the base solution, the activity in the agricultural sector is substantially reduced, especially production and employment (18 percent of the level in the base solution). Nevertheless, the computed level of land use is only 44 percent of the present level. Necessary support, in the form of acreage subsidies, is NOK 3.0 billion, or about one fifth of the support in the base solution.

In the parentheses in column 2, we give the results when an additional 17 percent rural labor subsidy is included. We see that the effect on the produced commodities is small. However, the aggregate use of labor increases 10 percent. And we see the same features as pointed out in the connection with Figure 4: a decline in the employment in central agriculture, while the employment in rural agriculture increases.

In the next simulation, reported in column 3, we add food security to landscape preservation. We observe that it is optimal to have a production in normal times that differs from the requirements of the crisis menu. Grain production is reduced and is far below the levels required by the crisis menu. Relative more of the acreage is applied to milk, meat and egg production. Also, for meat there has been a switch to land intensive production techniques. Extensive production of sheep meat absorbs parts of the land now used for grain production. If a crisis occurs, animal production will gradually have to revert to grain production while grain stocks are running down. Agricultural support decreases to NOK 7.7 billion, or about half of the base solution. That means that food security and landscape preservation can be provided at a considerably lower cost than is the case today. 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 57 and 64 percent 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 spectrum of inputs than landscape preservation.

Finally, we look at the simulation where rural employment is subsidized. We see almost no effect on the aggregate activity. However, the division between the activity level in central versus rural areas is heavily affected.

Table 1 **Production and Main Input Levels in Norwegian Agriculture**

	Base solution	**Landscape preservation and (rural employment)**	**Landscape preservation, food security and (rural employment)**
Production (Mill.kg/ltr)			
Milk	1671.5	79.2 (79.2)	838.0 (838.0)
Beef and veal	82.1	68.1 (73.3)	95.5 (101.3)
Pork	100.1	-	13.0 (13.0)
Sheep meat	23.0	-	15.0 (15.0)
Eggs	43.8	-	17.0 (17.0)
Wheat	210.5	36.2 (35.3)	32.1 (30.0)
Coarse grains	1021.3	68.4 (71.0)	259.2 (245.0)
Potatoes	298.0	344.8 (343.0)	342.9 (341.1)
Land use (mill. hectares)	0.85	0.37 (0.39)	0.54 (0.57)
Tilled land	0.31	0.04 (0.04)	0.09 (0.08)
Grazing and pastures	0.54	0.33 (0.35)	0.45 (0.49)
Employment (1000 man-years)	59.7	10.7 (11.3)	33.0 (33.0)
Rural areas	40.1	7.0 (8.9)	17.0 (21.1)
Central areas	19.6	3.7 (2.5)	16.0 (11.9)
Total support (billion NOK)	15.3	3.0 (3.2)	7.7 (7.9)
Border measures	6.7	-	-
Budget support	8.6	3.0 (3.2)	7.7 (7.9)
Composition of budget support			
Area planted or animal number	35%	100%	58%
Other input use	52%	-	42%
Output	13%	-	-

5 Conclusion

This paper introduces a method for incorporating information on the willingness to pay for regional activity in the objective function of a price-endogenous, mathematical programming model for the agricultural sector of Norway. Optimal levels of support, production, land use and activity in various regions are calculated. Our conclusion is that regional preferences do not affect the national activity level of agriculture, but affect the distribution of the activity level between regions.

Appendix 1

The model is a partial equilibrium model of the Norwegian agricultural sector. For given input costs and demand functions, market clearing prices and quantities are computed. Prices of goods produced outside the agricultural sector or abroad are taken as given. As the model assumes full mobility of labor and capital, it must be interpreted as a long-run model. A technical description of an earlier version of the model is given in Brunstad et al. (1995b).

The model covers the most important products produced by the Norwegian agricultural sector, in all 14 final and 9 intermediary products. Most products in the model are aggregates. Primary inputs in the model are: land (four different grades), labor (family members and hired), capital (machinery, buildings, livestock) and other inputs (fertilisers, fuel, seeds, etc.). The prices of inputs are determined outside the model and treated as given.

Supply in the model is domestic production and imports. Domestic production takes place on the model's approximately 400 different "model farms." The farms are modeled with fixed input and output coefficients, based on data from extensive farm surveys carried out by the Norwegian Agricultural Economics Research Institute, a research body connected to the Norwegian Ministry of Agriculture. Imports take place at given world market prices inclusive of tariffs and transport costs. Domestic and foreign products are assumed to be perfect substitutes. The country is divided into nine production regions, each with limited supply of the different grades of land. This regional division allows for regional variation in climatic and topographic conditions and makes it possible to specify regional goals and policy instruments. The products from the model farms go through processing plants before they are offered on the market. The processing plants are partly modelled as pure cost mark-ups (meat, eggs and fruit), and partly as production processes of the same type as the model farms (milk and grains).

The domestic demand for final products is represented by linear demand functions. These demand functions are based on existing studies of demand elasticities, and are linearised to go through the observed price and quantity combination in the base year (1998). Between the meat products there are cross-price effects, while cross-price effects are neglected for all other products for which the model only assumes own price effects. The demand for intermediary products is derived from the demand for the final products for which they are inputs. Export takes place at given world market prices.

Domestic demand for final products is divided among 5 separate demand regions, which have their own demand functions. Each demand region consists of one or several production regions. If products are transported from one region to another, transport costs are incurred. For imports and exports transport costs are incurred from the port of entry and to the port of shipment respectively. In principle restrictions can be placed on all variables in the model. The restrictions that we include can be divided into two groups:

1) Scarcity restrictions: upper limits for the endowment of land, for each grade of land in each region.
2) Political restrictions: lower limits for land use and employment in each region, for groups of regions (central regions and remote areas), or for the country as a whole; maximum or minimum quantities for domestic production, imports or exports; maximum prices.

In the model, the economic surplus (consumer's surplus plus producer's surplus) of the agricultural sector is maximized. This maximization is performed subject to demand and supply relationships and the imposed restrictions. Those restrictions depend on the type of simulation. The solution to the model is found as the prices and quantities that give equilibrium in each market. No restrictions must be violated, and no model farm or processing plant that is active, must be run at a loss.

Appendix 2

The crisis menu provides sufficient vitamins, minerals and proteins for the yearly subsistence needs of the population. If we take into account that there exist ample quantities of sugar through stock piling, the menu also provides sufficient calories for the population. The palatability of the diet is reflected in a concern for minimizing the difference between the crisis and the normal menus. Compared to normal consumption, the menu involves higher consumption of vegetables in proportion to animal products. Consumption of milk, meat and eggs is strongly reduced, while the consumption of grain and potatoes is kept at a relatively high level. In addition, the crisis menu makes allowance for the fact that consumption of fish, of which Norway has a huge export surplus, can be considerably increased.

Table A1 **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*	335

Note: Average consumption (product units) in the period 1995-99 (Gaasland, 2003).

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