

Working Paper No. 2/01

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for dairy products**

by

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SNF Project No. 2625
“Markeds- og produksjonsregulering i jordbruket”

The project is financed by the Research Council of Norway

FOUNDATION FOR RESEARCH IN ECONOMICS AND BUSINESS ADMINISTRATION
BERGEN, January 2001
ISSN 0803-4028

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Abstract:

The Norwegian dairy policy is based on price discrimination. Monopoly profit is passed on to the farmers by raising the average price of milk. This procedure increases milk production, and involves cross-subsidization. Using a numerical model of the Norwegian agricultural sector we show that substantial efficiency gains may be achieved by deregulating the dairy sector, mainly due to the elimination of exports. It is estimated that a transition to cost based pricing may increase the economic surplus by 2.6 billion NOK, which is 22% of value added in agriculture.

Keywords:

Norwegian dairy policy, price discrimination, cross-subsidization, deregulation, numerical model

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1. Introduction

The dairy sector is heavily regulated and subsidized in nearly all industrialized countries. According to an estimation for 1994 (OECD, 1996), total support to the dairy industry measured in producer subsidy equivalents (PSE) amounted to 61% of the total value of production as an OECD average. As a comparison, the average percentage PSE for all agricultural commodities was 42%. Dairy sector support is especially high in countries like Japan, Switzerland, Iceland and Norway, with PSE-rates above 75%. New Zealand is the only OECD country with an insignificant level of support.

Although the exact policy instruments and institutional arrangements may vary, there are some common features characterizing the dairy policy in most OECD-countries. Firstly, market price support accounts for a substantial part of total support. As a principal rule domestic market prices are supported by a combination of import barriers and intervention arrangements where product surpluses are purchased at established floor prices, like the Dairy Price Support Programme in the United States or the national intervention boards in the EU. To get rid of surplus dairy products, export subsidies are used. Many countries also apply production quotas to limit surplus production of milk.

Secondly, price discrimination between different uses of the milk is common. In the United States, for example, the Federal milk marketing order system implies price discrimination between fluid and industrial milk, and in the United Kingdom the recently abolished Milk Marketing Boards set prices on milk to the dairies according to end use. As price discrimination leads to unequal profitability between products, receipts from sales are usually pooled and the farmers are paid a single price adjusted for composition and quality.

As we will thoroughly explain in the next section, the Norwegian dairy policy has strong parallels to the general OECD dairy policy. It is based on price discrimination. Monopoly profit is passed on to the farmers by raising the average price of milk. This procedure increases milk production, and involves cross-subsidization. Using a numerical model of the Norwegian agricultural sector, the main purpose of this paper is to estimate the national welfare losses induced by this policy. We show that substantial efficiency gains may be achieved by deregulating the dairy sector.

2. The Norwegian dairy policy

Most of the regulations in the Norwegian dairy sector are based on a law from 1930, which cleared the way for an organized processing and marketing of dairy products through a dominating cooperative owned by the milk producers.¹ On behalf of the government, the dairy cooperative was given the responsibility to regulate the dairy market in order to ensure all milk producers, regardless of localization, a reasonable and stable price of milk.

Today, nearly all milk farmers are members of the dairy cooperative, and the cooperative resembles a monopoly in the end marked, protected by prohibitive import barriers². Thus, in order to raise the farmgate price, the cooperative is in a position to price discriminate between different uses of the milk (e.g. drinking milk, cheese, butter and milk powder) and between different markets (domestic and foreign). This price discrimination is, however, restricted by price caps on the final products.

The dairy cooperative is a non-profit organization, and the revenue gained by price discrimination is therefore shared by the farmers, i.e. the owners. Two main methods of revenue sharing are discussed in the economic literature, depending on whether the cooperative pays the farmers a price according to net marginal revenue product (NMRP) or net average revenue product (NARP) (see e.g. Helmberger, 1964 and Taylor, 1971). With reference to the Norwegian dairy sector, Figure 1 illustrates the difference between these two methods.

[Figure 1]

In panel a domestic demand for drinking milk is represented by D_A , while D_B in panel b is the demand for other domestic uses of milk (cheese, butter, milk powder, etc.). D_B is assumed to be more elastic than D_A . MR_A and MR_B are the corresponding marginal revenue curves. P_E is

¹ Regulations for the benefit of cooperatives, were also introduced in other countries in the 1930s, e.g. in the United States (see Ippolito and Masson, 1978). Cooperatives were promoted by two reasons: First, to offset the monopsony power local buyers of milk obtained due to high transportation costs, and second to raise and stabilize the raw milk price, which in many countries almost collapsed during the depression in the 1930s. To raise the raw milk price, different kinds of price discrimination schemes were introduced, taking advantage of the relatively inelastic market for fluid milk products.

² The import tariffs, resulting from the Uruguay Round of Multinational Trade Negotiations (GATT, 1993), are in the range of 250-400 per cent. Minimum access opportunities equal to 5 per cent of domestic consumption in the base period, are established at lower tariffs.

the export price. If the cooperative were free to set domestic prices, it would sell A units of milk as drinking milk at a price P_A and B units of milk for other domestic uses at a price P_B . Any milk produced in excess of A+B would be exported. However, the cooperative is facing price caps \bar{P}_A and \bar{P}_B . In panel c the stepwise curve labelled NMRP is the constrained aggregate net marginal revenue product curve. S is the farmers' supply curve of milk, including subsidies paid directly to the farmers. We assume that the cooperative has constant marginal costs in inputs other than milk, for simplicity normalized to zero.

In order to maximize farmers' surplus, subject to the price caps \bar{P}_A and \bar{P}_B , the cooperative has to purchase C units of milk from the farmers, of which \bar{A} and \bar{B} units should be sold in the two domestic markets and the remainder ($C - \bar{A} - \bar{B}$) in the export market. To limit the production to C, the cooperative cannot pay the farmers more than the price P_{NMRP} , which is equal to the cooperative's net marginal return. This means that the cooperative profit, $(\bar{P}_A - P_{NMRP})\bar{A} + (\bar{P}_B - P_{NMRP})\bar{B}$, has to be divided between the farmers independently of delivered quantity (see e.g. Staatz, 1987).

The Norwegian dairy cooperative, however, pays the farmers a price according to the net average revenue product (NARP), which means that all revenue gained by price discrimination is passed on to the farmers in the form of an increased price of milk. Thus, the farmgate price of milk is a weighted average of the net return obtained in different markets. Referring to Figure 1, this principle results in a farmgate price, P_{NARP} , given by the intersection of the farmers' supply curve, S, and the solid curve, NARP, defined as:

$$NARP = \alpha_A \bar{P}_A + \alpha_B \bar{P}_B + (1-\alpha_A-\alpha_B) P_E$$

where α_i , $i = A, B$, is the share of total production sold in the i^{th} domestic market.

As Figure 1 illustrates and which will be demonstrated empirically in section 3.3, NARP pricing results in higher production than NMRP pricing, \bar{E} . In the absence of price caps NARP would be given by the dotted curve in panel c, resulting in an even higher production, E. The surplus production is exported at a price lower than the marginal costs in production, which means that the farmers as a group can do better by choosing NMRP pricing. In the case of Norway, about 16% of the total milk production is exported at a loss (see section 3.3).³

³ As a means to limit the surplus production of milk, a production quota system is applied at the farm level, but the total production level still exceeds by far the quantity necessary to maximize the farmers' surplus.

This loss is financed through the higher price imposed on domestic consumers. The government does not directly participate in the financing of export subsidies through budgetary outlays.

The price discrimination inherent in both NMRP pricing and NARP pricing leads to a net welfare loss illustrated by the triangles β and γ in panels a and b, whereas NARP pricing leads to the additional loss of producer surplus equal to the area δ in panel c.

Price discrimination, exploiting differences in demand elasticities between different final products, leads to unequal profitability between different lines and local dairies. NARP pricing is a way of pooling revenues and costs in such a way that all dairies have the same ability to pay for the farmers' milk. Obviously, this method involves cross-subsidization. As will be shown empirically in section 4, domestic products like butter and milk powder are cross-subsidized by drinking milk and cheese, while foreign consumers are cross-subsidized by domestic consumers. Furthermore, small dairy companies in rural areas, unable to exploit economies of scale and with high transportation costs, are cross-subsidized by bigger companies closer to the consumers and farmers.

A regulatory system based on cross-subsidization is threatened by cream skimming from entrants (private dairy companies) preferring to supply the most profitable products or markets and leaving the incumbent (the cooperative) to supply the less profitable. Until recently, cream skimming from private dairies has been avoided by different kinds of institutional entry barriers⁴. However, as a part of a new milk marketing scheme introduced in June 1997, most of the institutional entry barriers have been removed⁵. To avoid cream skimming in a market with no institutional entry barriers, dairies producing profitable products are obliged to pay a levy in proportion to the number of units produced, for example per litre drinking milk produced. This levy is, i.a., used to subsidize unprofitable products, export, small regional dairies and transport.

⁴ It was almost impossible for entrants to get milk supplies from farmers since all the existing milk farmers were members of the cooperative and legally unable to change dairy company. Milk supplies from new farmers were also ruled out as a result of a closed quota system. Potential entrants in the dairy sector were therefore obliged to buy milk from the cooperative, which would be their rival in the end market. Another severe barrier to competition was the cooperative's dual role as competitor in the market place on one side, and administrator of the pool system on the other side.

⁵ By repealing the law which made it difficult for farmers to change dairy company and by introducing tradeable production quotas at the farm level, the new marketing scheme makes it easier for entrants to receive supplies from the farmers. The scheme also facilitates competition by moving the administrative responsibility for the pool system from the cooperative to a separate marketing board («Omsetningsrådet»).

The main objective of the new milk marketing scheme is to strengthen competition in the dairy sector by removing institutional entry restrictions. As such the scheme is a response to the general criticism that monopolies tend to have low efficiency, and also a response to results of economic research that suggest cooperatives are less efficient than other organization forms (Porter and Scully, pp. 511-12, 1987). However, the new milk marketing scheme implies no major change in the practice of cross-subsidizing export and some domestic products by imposing a levy on other domestic products, especially drinking milk. The only change in this respect is that the previously implicit levies and subsidies have been made explicit. Hence, the issue of welfare losses due to price discrimination and cross-subsidization, is just as relevant as before the reform.

3. The model

3.1 Description

In order to estimate the efficiency loss due to the Norwegian dairy policy, we will use a price endogenous, partial equilibrium model which includes the most important products and factors in the Norwegian agricultural sector. It is a partial equilibrium model in the sense that input prices as well as export prices are determined outside the model and treated as given. However, domestic linear demand functions for the main agricultural products are included, hence the name price endogenous (see McCarl and Spreen, 1980).

A short description of the model is presented in the appendix.⁶ In this section we focus on some important details regarding the model representation of the dairy sector. Seven dairy products or aggregates are modelled: Cow milk, goat milk, cheese, brown cheese⁷, butter, milk powder and drinking milk. The first two are intermediary products delivered from milk farms to dairies.⁸ The remaining products are aggregates delivered from dairies to wholesale

⁶ The model is designed to perform policy analyses, and has as such been used by the Norwegian Ministry of Finance and the Norwegian Ministry of Agriculture. A detailed description of the model is given in Brunstad et al. (1995a).

⁷ Brown cheese is a traditional Norwegian product produced by boiling down milk and whey. Most of the goat milk is used for this product.

⁸ At the farm level, milk production is represented by about 75 model farms of varying size (from 6 to 200 cows) and location (9 production regions), each characterized by fixed input and output coefficients.

or retail dealers.⁹ Cow and goat milk are converted into dairy products by four different dairy processes or model dairies. The model dairies are characterized by fixed conversion coefficients for milk into each product. The conversion coefficients and processing costs for each model dairy are presented in Table 1. Note that all model dairies have butter as a by-product.

[Table 1]

The domestic demand functions are linearized to go through the price/quantity combination of the base year (1990) using the following demand elasticities: cheese and brown cheese (0.5), butter (1.0), milk powder (1.0) and drinking milk (0.3). These elasticities correspond to the common assumption that the demand for drinking milk is less elastic than the demand for butter, milk powder and cheese, and are roughly in line with several existing studies. Cross-price effects are neglected as we use broad product aggregates which hardly are close substitutes in consumption, except for cheese and brown cheese.

3.2 The base solution: Net average revenue product pricing

Using the model, we have simulated the actual agricultural policy in Norway by implementing the actual system of subsidies and import barriers in the base year 1990.¹⁰ In the simulation we assume perfect competition in all sectors but the dairy sector. In the dairy sector we allow the cooperative to practise price discrimination between different uses of milk and between different markets. This price discrimination is restricted by the price caps applied to the final products in 1990. Furthermore, we assume that the net revenues gained by price discrimination is passed on to the farmers in the form of an increased farmgate price of milk (NARP pricing).

⁹ The most important product, drinking milk, is an aggregate of fluid milk of different fat content, cream and yoghurt.

¹⁰ At the farm level, the Norwegian agricultural policy is based on different kinds of subsidies. First, there are substantial budget transfers in the form of general price subsidies, regionally differentiated price subsidies, subsidies differentiated by farm size, acreage and headage payments, disaster payments, transport subsidies, structural adjustment measures etc. Second, support is also given in the form of tariffs. Third, a system of tradeable production quotas gives regional protection. It should also be noted that the subsidies favour small farms in scarcely populated areas. Consequently, the Norwegian agricultural policy is to a large extent directed at rural employment and protection of the family farm. For a detailed description of the Norwegian agricultural policy, see OECD (pp. 52-61, 1990).

The results of this simulation, which is called the base solution, are presented in Column 2 of Table 2, and may be compared to the actual situation in the base year 1990, reported in Column 1 of Table 2. It appears that the simulation of the actual policy gives results which are close to the observed situation. Observe that the level of support given to Norwegian agriculture is extremely high (19.2 billion NOK or 2.5 billion USD). Since agriculture employs about 85,000 man years, the support per man year is about 225,000 NOK (30,000 USD). Apart from grain, Norway is self sufficient or has a surplus in agricultural products. For dairy products there is a considerable surplus. As will be demonstrated in section 3.3, exports of cheese and butter correspond to about 290 million litres of cow milk (16% of the cow milk production).

[Table 2]

3.3 Net marginal revenue product pricing

To demonstrate the difference between the two methods of revenue sharing discussed in section 2, we have simulated the market solution with NMRP pricing. As explained in section 2, NMRP pricing implies that the revenue gained by price discrimination is allocated to the members independent of delivered quantity. Compared to the base solution, which assumes NARP pricing, Column 3 of Table 2 shows that NMRP pricing results in lower milk production, higher cooperative profit, higher surplus to producers and lower total budget support. To be more specific, cow milk production is reduced by about 290 million litres (-16%), as exports of cheese and butter are eliminated.¹¹ This is due to the fact that export prices are way below production costs, in spite of substantial subsidies at the farm level.¹² Consequently, when the cross-subsidization inherent in the NARP pricing strategy is abolished, the dumping of dairy products stops. The domestic consumption of dairy products is unaltered, as we assume the same price caps.

The elimination of exports raises cooperative profit by 1.1 billion NOK. This amount, which in Figure 1 is illustrated by the shaded rectangles in panel a and b, should be allocated to

¹¹ A small quantity of butter is still exported, which is due to the fact that butter is a by-product from the production of drinking milk, cheese and milk powder.

¹² Average prices on dairy products exported from Norway are: cheese (16.85 NOK), brown cheese (31.03 NOK) and butter (9.77 NOK). The production costs, including subsidies, are: cheese (37.25 NOK), brown cheese (38.66 NOK) and butter (22.81 NOK); see section 4, Column 5 in Table 3.

the members. If allocated equally to the about 29,000 milk farms, each farm will receive approximately 38,000 NOK, which illustrates that the farmers can do substantially better by choosing NMRP pricing.

As shown in Table 2, the switch to NMRP pricing has limited effects on other agricultural sectors. The production of coarse grains is, however, reduced by 8% due to lower demand from the milk sector. The production of beef and veal is also negatively affected (-5%), as beef and veal are largely produced in combination with milk. Due to cross-price effects between meat products, the production of sheepmeat and pigmeat increases slightly as a response to higher prices on beef and veal.

The overall increase in economic surplus is 2.1 billion NOK, of which 0.8 billion NOK is due to higher producers' surplus, while 1.3 billion NOK can be explained by lower budget support, mainly because of lower milk production and fewer farms. Note that the increase in producers' surplus is closely related to the raise in cooperative profit. Domestic consumption and prices, and thus consumers' surplus, are largely unaltered.

An obvious question to ask is why the farmers fail to choose NMRP pricing. One possible explanation could be that the cooperative's objective is to be as big as possible without losing money, rather than to maximize the total surplus of the member farmers. According to a public choice approach, this may be the goal of a firm's management or the goal of altruistic or idealistic farmers.¹³ A second possible explanation is that surpluses from NMRP pricing must be allocated to the members as lump-sum transfers, which may be difficult to achieve. A final reason not to choose NMRP pricing, could be potential ratcheting effects inherent in the yearly negotiation system between the government and the farmers' organizations concerning the subsidy level. If the milk farmers' income increase strongly over time due to a transition to NMRP pricing, it is reasonable to believe that the government will respond by withdrawing subsidies.

4. A deregulated dairy sector

We have demonstrated that exports of dairy products are unprofitable and give rise to substantial welfare losses. In this section, we focus on additional efficiency losses caused by

¹³ See Bateman, Edwards and LeVay (1979a, b) and LeVay (1983) for more detailed discussions of alternative objectives of cooperatives.

Harberger distortions in the domestic market. We assume free competition, and consequently obtain prices which are equal to marginal costs. Import restrictions are maintained, which means that we focus on an internal deregulation. At the farm level, we assume that the government subsidies are the same as in the base solution.

The exact framing of the deregulation is beyond the scope of this paper, but removal of institutional entry restrictions and government interventions in the product market are basic conditions. As explained in section 2, institutional entry restrictions have already been removed as a part of the new milk marketing scheme, but interventions in the product market are still present in the form of levies and subsidies.

The results of the experiment are presented in Column 4 of Table 2 and in Table 3. As we observe from Table 3, cross-subsidization in the base solution does not only apply to exports, but even to butter and milk powder in the domestic market as well. Deregulation of the dairy sector means an increase in the domestic prices of butter and milk powder by 12% and 60% respectively. Furthermore, Table 3 shows that most of these subsidies are financed by levies imposed on cheese and drinking milk in the domestic market. In the base solution, these two products are overpriced by 12% and 32% respectively. Naturally, the consumption of cheese and drinking milk increases as a result of the transition to cost based pricing, while the consumption of butter and especially milk powder decreases.

[Table 3]

Compared to the base solution, cow milk production is reduced by 357 million litres (-20%), of which 290 million litres stem from the elimination of exports (see section 3.3), while the remaining reduction is due to a lower domestic demand when the price discrimination is eliminated.

As a result of deregulation, the economic surplus increases by 2.6 billion NOK, while total agricultural support decreases by 2.9 billion NOK. The increase in economic surplus is a measure on the efficiency loss inherent in the present system with price discrimination and cross-subsidization. Nearly 80% of this efficiency loss (2.1 billion NOK) can be attributed to exports, while the remaining efficiency loss (0.5 billion NOK) is caused by distorted pricing in the domestic markets.

Consumers and taxpayers are the main gainers of the deregulation. As a result of lower domestic prices on drinking milk and cheese, and despite higher prices on milk powder and butter, the consumers' surplus increases by 1.6 billion NOK. The taxpayers gain 1.5 billion

NOK, mainly because of lower milk production and fewer farms, and thereby lower total subsidies to the milk farmers. The producers' surplus decreases by 0.5 billion NOK because of the decline in the milk production.

An objection to our model simulation is that deregulation will hardly lead to free competition and cost based pricing. Although institutional entry barriers are removed, there are many kinds of technical and strategic entry barriers which may continue to hamper competition, such as economies of scale, sunk costs and transport costs.¹⁴ The industry norm is, as noted by Sexton (1990) and Tennbakk (1995), that cooperatives coexist with other firms in markets that are structural oligopolies or oligopsonies. Thus, the estimate in this section should be interpreted as the maximum gain by deregulating the dairy sector.

5. Concluding remarks

Norwegian dairy policy is based on price discrimination. Monopoly profit is passed on to the farmers by raising the average price of milk. This procedure increases the milk production of the farmers, and involves cross-subsidization. Model simulations presented in this paper show that substantial efficiency gains may be achieved by deregulating the dairy sector. It is estimated that a transition to cost based pricing may increase the economic surplus by 2.6 billion NOK, which is 22% of value added in agriculture. Elimination of exports explain nearly 80% of this efficiency gain, while the remaining gain is due to elimination of Harberger distortions in the domestic market. Cow milk production is reduced by more than 350 million litres (-20%).

Cooperatives which set prices according to NARP without restricting the farmers' supply, are often seen as procompetitive forces in the economic literature. The surplus that is retained as profits in an investor owned firm (IOF), is passed on to the farmers in the cooperative by raising the price of raw milk. In response they increase their production and the cooperative supplies more than an otherwise identical IOF. In oligopoly and oligopsony

¹⁴ Since the introduction of the new milk marketing scheme, three private dairies have expanded production rapidly. However, they still have low market shares, especially at the farm gate level (about 1%). The highest market share is in the wholesale market for cheese (about 10%). Other entrants have tried to enter the market, but have failed. The entrants accuse the cooperative of predatory pricing.

situations, cooperatives may thus, as noted by Helmberger (1964), Cotterill (1987) and Sexton (1990), play an important yardstick role in moving output and price levels closer to those of perfect competition. However, this paper illustrates that the outcome may be adverse if the cooperative is allowed to price discriminate between domestic and export markets. In this case the cooperative tends to behave just like a monopolistic IOF in the domestic end market, but, unlike an IOF, it also generates surplus production that is exported at a price below the marginal costs of production.

A final question, when evaluating the regulations, is whether there are social benefits to outweigh the substantial costs of the current policies. There are several alleged benefits of regulation, spanning from the original objectives in the 1930s, namely to raise and stabilize milk prices and offset monopsony power, to current objectives related to rural employment and farm incomes. However, at the present market conditions it is hardly probable that these benefits justify government interventions of the magnitude described in this paper. The regulations may have been relevant at the time when they were passed, i.e. during the depression in the 1930s, but they are now out-of-date due to technological development and structural change. For example, farmers' bargaining power towards dairy companies has increased due to lower transportation costs and better conservation methods. The rationale for price stabilizing interventions in the market is also weakened, partly because the farm level production has become more predictable, and partly because technology makes it easier to transfer milk products in time (storage) and space (trade). Regarding rural employment, it might be argued that deregulation will have a negative effect on agricultural employment in rural areas, estimated to about 11,600 man-years (-22%).¹⁵ However, it is well established that the most efficient way to achieve rural employment is by means of general income support to all inhabitants or general wage subsidies to all industries in a particular region (see e.g. Winters 1989-1990), and not by support confined to a single industry. If the authorities still want to pay specific support to agriculture, production neutral support is more efficient than price support of the kind used in the Norwegian dairy sector.

¹⁵ See Brunstad, Gaasland and Vårdal (1995b) for a more detailed discussion of issues regarding rural employment, using the same simulation model.

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Appendix

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 labour and capital, it must be interpreted as a long run model. A more technical description of the model is given in Brunstad et. al (1995a).

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 are: land (four different grades), labour (family members and hired), capital (machinery, buildings, livestock) and other inputs (fertilizers, 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 modelled with fixed input and output coefficients, based on data from extensive farm surveys carried out by the Norwegian agricultural economics research institute. 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 linearized to go through the observed price and quantity combination in the base year (1990). 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 are derived from the demand for the final products for which they are inputs. Exports take 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.

Different types of objective functions are used, dependent on what kind of market structure that is simulated. When assuming perfect competition total economic surplus (consumers' surplus, producers' surplus and importers' surplus) of the agricultural sector is maximized. When simulating the market structure of the dairy sector, only producers' surplus and importers' surplus are maximized (subject to price caps on the final products). In either case the maximization is performed subject to demand and supply relationships and the imposed restrictions. Which restrictions are included depends upon what kind of simulation that is attempted. 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.

Table 1: Production processes in the dairy sector

Product	Process			
	Cheese and brown cheese	Brown cheese	Milk powder	Drinking milk
Cow milk (litre)	-11.302	-8.705	-4.607	-1.041
Goat milk (litre)	-0.319	-1.494		
Cheese (kg)	1			
Brown cheese (kg)	0.250	1		
Butter (kg)	0.145	0.155	0.076	0.007
Milk powder (kg)			1	
Drinking milk (litre)				1
Processing costs (NOK)	16.34	13.44	8.87	2.01

Table 2: Production, support, economic surplus and main input levels in Norwegian agriculture.

	The actual		The base		Net marginal		A deregulated	
	situation	solution	revenue	pricing	dairy	sector		
	(NARP pricing)		(NMRP pricing)					
Production (P) and net imports (I):								
(million kg)	P:	I:	P:	I:	P:	I:	P:	I:
Cow milk *)	1836.8		1840.0		1551.1		1483.8	
Goat milk	26.5		21.9		17.3		17.5	
Cheese	65.6 (-23.6)		68.7 (-25.2)		43.5		46.2	
Brown cheese	18.4 (- 3.6)		17.1 (- 4.0)		13.1		13.4	
Butter	25.6 (- 9.4)		22.2 (- 5.3)		18.2 (- 1.3)		15.1	
Milk powder	34.2		30.4		30.4		12.1	
Drinking milk *)	740.0		740.0		740.0		812.2	
Beef and veal	81.5 (- 6.3)		79.0		75.2		75.0	
Pigmeat	82.2 (- 1.5)		79.7		80.5		80.6	
Sheepmeat	22.7 (- 1.5)		25.8		27.3		27.3	
Coarse grains	822.5 (171.9)		772.5 (171.9)		707.2 (171.9)		691.9 (171.9)	
Wheat	151.3 (222.7)		145.5 (218.2)		147.1 (220.7)		147.1 (220.7)	
Potatoes	340.9 (- 6.2)		342.0		340.4		340.4	
Eggs	50.5 (0.5)		52.1		52.2		52.2	
Total employment:								
(1000 man-years)	85.3		71.6		62.3		61.0	
Remote areas	54.3		51.8		41.7		40.2	
Central areas	31.0		19.8		20.7		20.8	
Total land use:								
(million hectares)	0.95		0.70		0.64		0.63	
Total economic surplus:								
(billion NOK)			9.7		11.8		12.3	
+ Consumers' surplus			20.2		20.2		21.8	
+ Producers' surplus			1.1		1.9		0.6	
- Taxpayers' expenses			11.6		10.3		10.1	
Cooperative profit:								
(billion NOK)		≈0			1.1		0	
Total support:								
(billion NOK)	19.2		19.0		17.8		16.1	
Border measures	7.6		7.4		7.5		6.0	
Budget support	11.6		11.6		10.3		10.1	

*) Million litres

Table 3: Domestic consumption (million kg or litres) and wholesale prices (NOK per kg or litre)

Product	Domestic consumption			Domestic wholesale prices		
	The base solution	A deregulated dairy sector	Percentage change	The base solution	A deregulated dairy sector	Percentage change
Cheese (kg)	43.5	46.2	+ 6.2	42.36	37.25	- 12.1
Brown cheese (kg)	13.1	13.4	+ 2.3	39.98	38.66	- 3.3
Butter (kg)	16.9	15.1	- 10.6	20.42	22.81	+ 11.7
Milk powder (kg)	30.4	12.1	- 60.2	13.68	21.95	+ 60.5
Drinking milk (litre)	740.0	812.2	+ 9.8	6.56	4.44	- 32.3

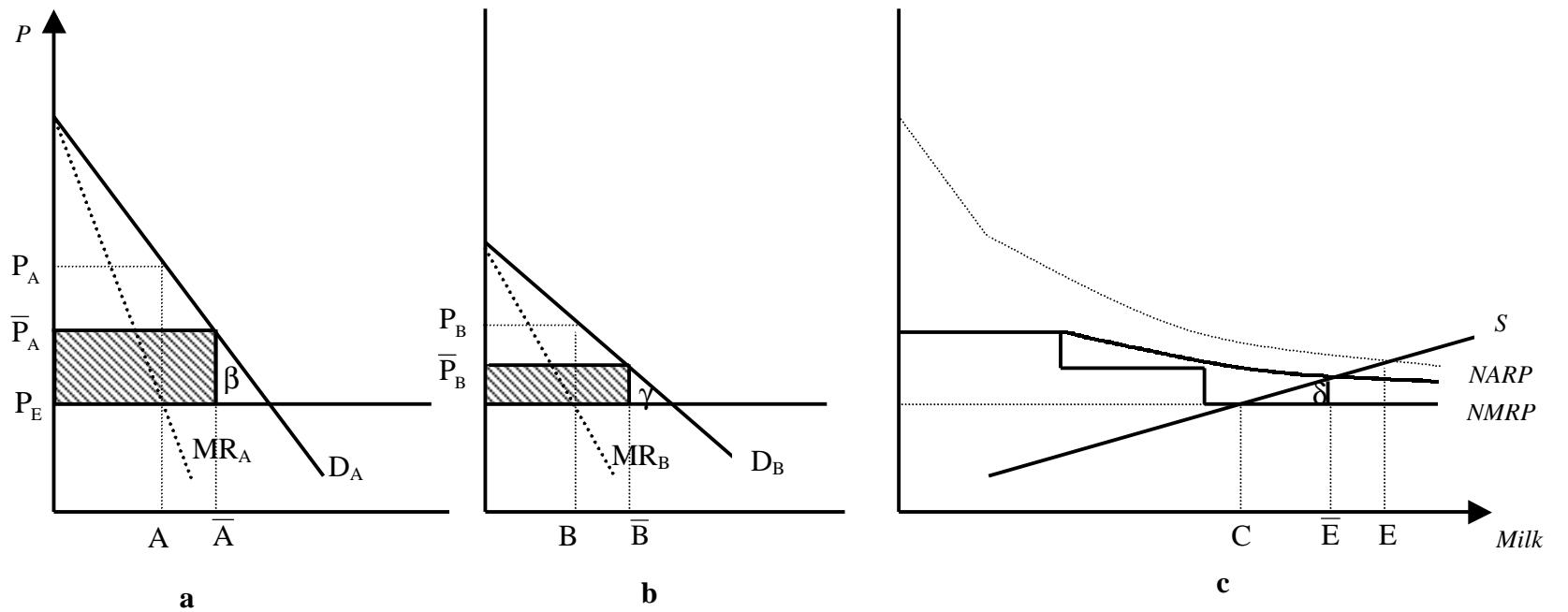


Figure 1: *Methods of revenue sharing: NMRP versus NARP*