ECONOMIC CONSEQUENCES OF MILK QUOTA PURCHASE AND RENTING OF MILK QUOTA ON FARM LEVEL

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Abstract

Dairy farmers with combined milk and beef production face complex decisions regarding optimum milk yield, slaughter age for bulls, calving age for heifers, disposal of farm land etc. The linear programming model TINE Optimal was developed to assist farmers in the decision making process. Application of the model on two case farms demonstrates that farmers with a moderate milk yield per cow can increase their profitability significantly by increasing milk delivery. Such farms have a high production potential which can be utilized when the quota program is abolished. However, this development will reduce inland beef production, requiring national initiatives to maintain self sufficiency. It is also demonstrated, the effect of increased milk delivery on profitability depends on farm conditions. Before increasing milk delivery, farmers should carefully identify possible bottlenecks in their production system, and the effects on heifer breeding and beef production should be taken into account. Comparing quota purchase and renting of quota demonstrates that renting of quota is more profitable at the current price level.

Key words: Dairy, profitability, linear programming, rent of milk quota

Introduction

In Norway there has been a debate regarding by how much the farm gross margin will increase when farm milk delivery is increased (Breines 2005, Flaten 2005). The two authors draw quite different conclusions. While Breines (2005) claims that gross margin will increase by 2.40 NOK per litre extra milk delivered, Flaten (2005) reports an increase of only 0.60 NOK per litre under identical conditions. Trading in milk quotas in Norway is regulated by the government. Quotas can be bought either in the private market or from the government. In the private market the price is agreed upon between buyer and seller, while the price for buying quota from the government is administratively fixed at 3.50 NOK per litre of milk. Usually there is a surplus demand in the market administered by the government, and the number of litres available for each buyer is thus limited. Prices farmers are willing to pay for quotas vary a lot between different counties. From 2009 on farmers are also allowed to rent milk quotas from other farmers for a minimum period of five years.

Norwegian dairy farming policy is determined in annual negotiations between the farmers unions and the government. Product prices are part of this negotiation. In order to reach several widely accepted political goals such as maintaining the cultural landscape and keeping up the establishment in rural areas, the government pays subsidies. Subsidies vary with farm size and geographical location, and are assigned per head of cows and young stock, per ha roughage grown and per unit of milk and beef produced. Although Norway is not member of the EU, the Norwegian dairy sector is affected by farming conditions in the EU. Most of Norway`s dairy imports come from the EU. A tariff is applied to all imported dairy products. At the time of writing the prices of some imported products are so low that they only equal Norwegian prices even after tariff is added. They thus represent an upper limit for the prices Norwegian dairy farmers can charge for their products. If quota abolition leads to decreased milk prices in the EU, this will constrain the prices Norwegian dairy farmers can charge for their products. Switzerland has already abolished milk quotas, and the EU will abolish them from 2015 (IFCN, 2008). Until then quotas will be increased by one percent per year. Even though Norway has its own agricultural policy, it is likely that these changes in the EU will affect Norwegian agricultural policy, at least in the long run.

For a dairy farmer increasing milk quota is an important strategic investment (Harrison, 1999), and profitability depends on how much the gross margin will increase. Possible consequences regarding the short run fixed costs also have to be addressed. In Norway most of the beef is produced from dairy herds. This joint production, together with a relatively complex system of subsidies, makes it a difficult task to determine the enterprise combination to maximize profit. Farmers frequently ask extension workers in TINE how much they can afford to pay for buying or renting additional milk quota. For TINE it was necessary to develop a tool for calculating the economic consequences of increased milk quota. The purpose of this paper is to increase understanding of the economic consequences of increased milk delivery at the farm level. Possible nationwide consequences are also addressed. A linear programming farm model is developed and applied to calculate the financial consequences of buying or renting milk quota. First theory regarding milk quotas is presented. Second the main activities in the empirical model are described. Finally the financial consequences of purchasing or renting milk quotas are calculated.

Quota programmes play an important role in agricultural policy and have generated an extensive literature. The standard theory of the effect of quota on asset values in agriculture is expressed by Dawson (1991), Colman (2000) and Alvarez, Arias & Orea (2006). A number of empirical studies have computed potential gains from removing restrictions on quota transferability or by changing the quota exchange (Ewasechko & Horbulyk 1995; Boots, Oude Lansink & Peerlings 1997; Bogetoft, Nielsen & Olesen 2003).

Here it is assumed that the dairy farmer maximizes short run profit. In the long run all costs must be covered, whereas in the short run a profit above variable costs only need be made, and some costs can be treated as overheads (Colman 2000). A milk quota adds a constraint to the optimizing behaviour of the producer, which can be written as

$$\max \pi = p_i y_i - c_i (y_i, w_i, x_i) \qquad [1]$$

$$\text{s.t. } y_i \leq Q_i$$

where π is the profit of producer i, y_i is the output, p_i is the output price, w_i is the input price vector, x_i is the vector of short run fixed inputs, $c\,(\cdot)$ is the variable cost function, and Q_i is the milk quota. A maximizing problem with constraints can be solved by forming the Langrangean function:

$$L = p_i y_i - c_i (y_i, w_i, x_i) + \lambda_i (Q_i - y_i) \qquad [2]$$

where λ_i is the Langrangean multiplier. The first- order conditions can be obtained by differentiating expression [2] with respect to output. Assuming that farmers produce near the quota constraint the relevant first order condition becomes

$$p_i - MC(y_i, w_i, x_i) - \lambda_i = 0$$

where $MC = \partial C(\cdot)/ \partial y$ denotes marginal cost. The optimal value of λ_i is the shadow price of the quota for producer i. The Lagrangean multiplier measures the change in the objective function (profit) when the quota changes by one unit. It can be described as the marginal profit and is expressed as

$$\lambda_i = p_i - MC(Q_i, w_i, x_i)\ .$$

Marginal cost is unobservable. A method to calculate it is to first estimate a cost function, and then obtain the marginal cost curve by taking the derivative of costs with respect to milk production.

In Norway most of the beef is produced in dairy herds, and cows are used for both milk and meat production. Beef is mainly produced from bull calves from dairy cows. In such combined dairy and beef herds, the decision variables are highly interrelated, and some of them are depicted in Table I.

Data and empirical model

In order to determine by how much the gross margin increases with higher milk production under different farm conditions, a farm model named TINE Optimal was developed. TINE Optimal is a single period linear programming model formulated by the author. In the model a short time horizon is assumed, such that the capacity of buildings and machinery is fixed. Current activities in the model are given in Table I.

Table I. Activities in TINE Optimal

Cows- milk yield per cow	**Heifers- calving age**	**Sheep**	**Roughage**
Cow 5000-10000 kg milk Beef- cows with bulls and heifers	Replacement heifers 24- 28 months Heifers sold live or purchased **Bulls- selling/ buying age** From baby calf 14 days old to bulls slaughtered at 19 months	Ewes fed during winter **Acreage use** Pasture Grass Cereal crops Other crops	Roughage, home-grown, sold or purchased

The model maximizes the gross margin included subsidies subject to the farming constraints, the most significant being land area, milk quota and cowshed capacity. Cows, bulls and heifers are modelled by linear approximation to the production function. Feeding regimes are calculated in accordance with the new Nordic feed evaluation system Norfôr Plan (Volden, 2006). Both cows and young stock are fed only concentrate and roughage. It is possible to choose between three different qualities of roughage; low, medium and high.

Heifers for replacement or sale are modelled with different calving ages, and are fed with roughage and concentrate. Models for beef cows and sheep are also included. Farm land can be used for roughage, grazing or other crops. In order to calculate the economic consequences as milk delivery increases, parametric programming is applied.

Labour is not included in the model. The reason is firstly that we wish to keep the model as simple as possible. Secondly, in practise the farmer assesses the working hours required for the different model solutions. The farmers` final decision as to which solution to choose is based both on model results and practical judgement of workload, possible investment and other features of each alternative. However in the case of buying or renting additional milk quota in this paper, additional workload necessary is included before calculating profitability.

Two case studies based on real farms are used to illustrate the economic consequences of increased milk delivery and the purchase or renting of quota. Farm A has a milk quota of 130.000 litres. Both farms have stanchion barns. For this reason the maximum milk yield per dairy cow on farm A is 8500 kilos, and on farm B 8000 kilos. The difference is due to lower roughage quality and less roughage quantity per cow on farm B. Farm B is situated in a more rural area, and has a milk quota of 119.000 litres. Increased milk yield per cow is planned at the beginning of the lactation.

Milk quota is a durable input. If milk quotas are abolished, as in the EU from 2015 on, dairy farmers are free to increase their production, and quota will have no value. It is difficult to predict how long the quota system in Norway will last. It is reasonable to expect that an abolition of milk quotas would be announced well ahead of the time it becomes operative. Due to the uncertainty regarding longevity of the quota system, profitability is calculated for a period up to eight years in this paper. In accordance with the EU directive yearly milk quota per farm is increased by one percent from 2010 until 2015.

Investment in milk quotas is not a deductible expense in Norway but increased milk income is taxable. In this paper the increased income is considered a marginal return, and the tax rate is 28 percent. This figure represents a reasonable marginal income tax rate for a dairy farmer, and it also equals the general tax rate on capital income.

Investment in milk quota increases the hours worked as the number of dairy cows increases, at least in the short run. In order to estimate the marginal work load due to increased milk production, figures from NILF (2002) are used. Quota purchase might also necessitate additional investments, such as refurbishment of the cowshed. If that is the case then their costs must be included. However, in the two examples reported in this paper, no such additional investments were required.

Calculating net present value requires a decision about the appropriate interest rate. In this paper the interest rate is three percent reduced by 28 % before calculating the net present value. In the case of rent of quota, the rent is subtracted from the additional gross margin and the residual is reduced by 28 percent.

Results

In Table II below the corresponding TINE Optimal solutions for farms A and B before and after the purchase or rent of quota are shown.

Table II. TINE Optimum solutions for farms A and B with both existing and new milk quotas

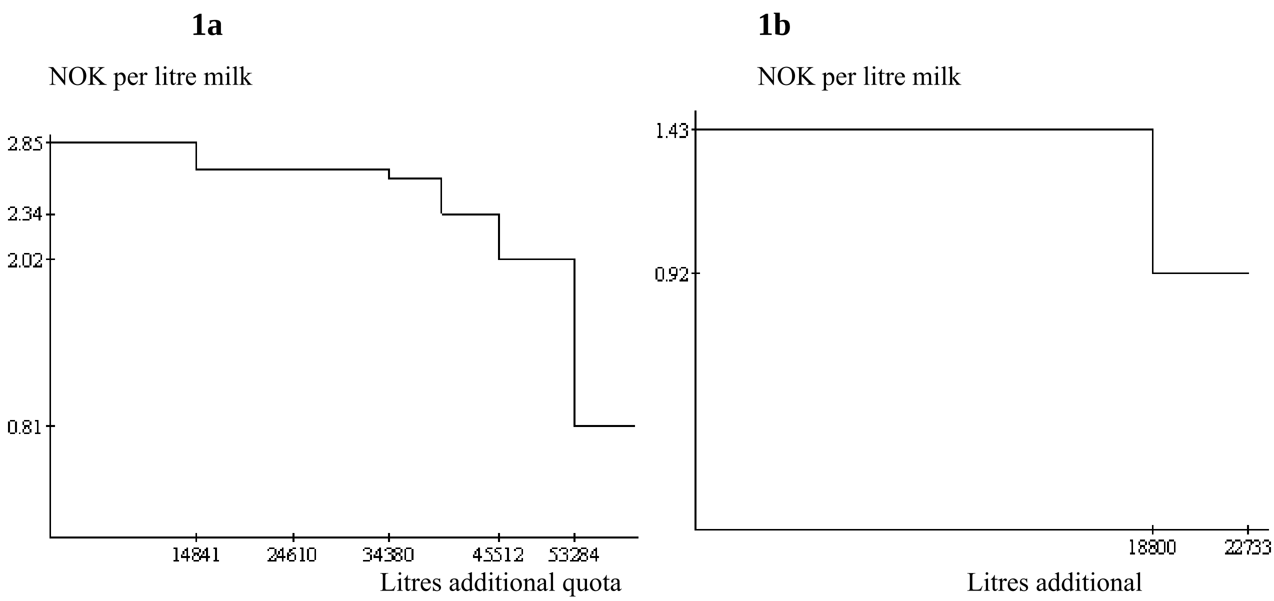
Production	Farm A existing quota	Farm A new maximum quota	Farm B existing quota	Farm B new maximum quota
Milk quota, litres	130.000	183.284	119.000	137.800
Gross margin incl. subsidies, NOK	735.758	872.881	608.937	635.770
No of dairy cows	21.6	24	16.4	19
Milk yield per cow, kilo	6.770	8.500	8.000	8.000
No of heifers raised	13	14.1	7.4	8.6
No of bulls 3 months old, sold	0	0	0	0
No of bulls 3 months old, purchased	0	0	9.4	1.3
No of bulls 13 months old sold	0	13.6	16.8	9.9
No of bulls 19 months old sold	13	0	0	0
Beef from bulls, kilo	4.081	3.861	4.534	2.668
No of sheep	0	0	30	30
Roughage, purchased FUm	18.561	25.363	20.938	25.108

On farm A, TINE Optimal suggests a solution with an average milk yield per cow of 6770 kilos from 21.6 cows. In the model replacement heifers older than 18 months use idle cow places on both farms. Initially all cow places on farm A are used for cows and heifers, and the model therefore suggests the increased milk production should be met by increasing the milk yield per cow. The milk yield per cow is increased before the maximum number of cows is reached, demonstrating that the argument in Knutson et al. (1997) that the solution should always be adjusted to practical farming conditions. As long as heifers are allowed to use idle cow places, all bulls should be slaughtered at the age of 19 months. This ensures high carcass weight and high beef production. The heifers calve when they are 24 months old. All farm land is used for roughage production, and the farmer has to buy some supplemental roughage due to high roughage intake.

On farm B the model suggests an average milk yield of 8000 kilos per cow, and 2.6 idle places for cows are occupied by replacement heifers. Due to lack of roughage and cowshed space, the model shows all home produced bulls and 9.4 purchased bull calves should be fed intensively and slaughtered at 13 months. The heifers calve at 24 months of age. In addition

30 sheep are included in the optimum solution, partly because they do not compete with cattle for cowshed space. All farm land is used for roughage production but some roughage is purchased each year.

TINE Optimal was then used to calculate the consequences of increased milk production on gross margin included subsidies. Figure 1 shows the increase in gross margin per litre milk with increased milk production on farms A and B.



quota

Figure 1. Increase in gross margin including subsidies per litre milk delivered on farm A (Figure 1 a) and farm B (Figure 1b) as the milk quota increases.

On farm A gross margin increases by 2.85 NOK per litre up to 14.841 litres additional milk quota (Figure 1a). At that point the milk yield per cow has increased to 7500 kilos on 21 cows. The most significant change in profitability takes place between 34.380 and 53.284 litres extra quota. At 34.380 litres additional quota, the milk yield per cow reaches its` maximum of 8.500 kilos per cow. From now on cow numbers have to be increased to produce more milk. Replacement heifers which earlier were placed on idle cow places, now start occupying space for bulls, and an increasing number of bulls are being slaughtered at 17 months of age. As milk production increases, the demand for cows increase, and thereby the number of replacement heifers. At 45.512 litres of extra quota the number of cows is increased to 23.1, increasing the need for heifers further reducing space and thereby lowering slaughter age for bulls to 15 months. As quota continues to increase, the slaughter age for bulls is gradually reduced to 13 months at 53.284 litres extra quota, where the cow number reaches its maximum of 24. From now on only one way to increase gross margin remains, namely by replacing milk from cows fed to calves by purchased milk powder. When all milk fed to calves is substituted by milk powder, the shadow price of quota drops to zero. The substitution of raw milk by purchased milk for calves is represented by the short line segment to the right in Figure 1a, from 53.284 litres on and to the right.

In contrast to farm A, on farm B the gross margin including subsidies increases by only 1.43 NOK per litre milk for the first 18.800 litres (Figure 1b). From then on the increase in gross margin falls to 0.92 NOK per litre milk up to a maximum of 22.733 litres extra quota. On farm B, increased milk production is met solely by increasing the number of cows. This requires more replacement heifers. Heifers displace bulls, and the number of purchased bulls for fattening therefore gradually falls, while keeping the slaughter age constant at 13 months. With 18.800 litres extra quota, dairy cows occupy almost all cow places, and displaced heifers reduce the number of purchased bulls to 1.68. At this point the quantity of beef from bulls is reduced to 1.796 kilos. Milk income has increased, but a substantial part of the increased income is offset by reduced income from beef. As can be seen from Table II beef production is significantly reduced as the milk production reaches its maximum. An increased quantity of concentrate due to more cows is outweighed by less concentrates for bulls. The cost for purchased roughage increases, lowering the gross margin. As milk production reaches its maximum, the model gradually switches from raw milk for baby calves to purchased skimmed milk powder. At 22.733 litres supplementary quota all cow places are occupied by dairy cows, and milk production can no longer be increased with existing cowshed capacity. The shadow price of quota is zero. The 30 sheep on farm B are present also in the new equilibrium solution (Table II).

There are several reasons why the increase in gross margin is lower on farm B than on farm A. First of all the cows milk yield potential is already fully realised on farm B, given the disposable quantity and quality of roughage. Secondly, space for bulls and heifers over six months of age is a more scarce resource on farm B than on farm A. In fact, gross margin on farm B can be increased just as much by increasing the number of places for heifers and bulls, as by increasing the number of cow places. This illustrates the complex interdependencies between the different animal groups in a cattle herd. A bottle neck in one part of the dairy operation can affect the overall profitability of the whole operation. Purchase or rent of additional milk quota is thus not a sufficient condition in order to increase profitability. Thirdly, cattle on farm B compete with sheep regarding roughage, reducing the profitability of keeping one extra cow or bull as compared to farm A.

In order to calculate the profitability in quota investment, both the government quota price, NOK 3.50 per litre, and the average buying price in the private market in Rogaland in April 2009, NOK 5.50 per litre, are applied. To be comparable it is assumed that both farm A and B buy the maximum additional quota that farm B can produce at the highest gross margin, 18.800 litres (see Figure 1b). Above this level the shadow price is reduced. The investment takes place in year 2009, and additional quota can be utilized from 2010 on. Farm B needs between two and three extra cows in order to fill the new quota. The farmer can buy heifers or cows, or reduce the number of culled cows. In the paper meat income from cows is reduced on farm B in year 0. Apart from the annual quota increase of one percent, the cash flow remains constant from year 1 to year 8. One might argue that the cash flow should increase. However, statistics for dairy farms from NILF over the years 1996 to 2007 show only minor changes in net farm income (NILF, 2008). Net present value is calculated by subtracting the annual after tax payments discounted to the year of investment, from the invested amount.

Profitability is calculated using the net present value method (NPV). The mathematical procedure for calculating NPV can be expressed by the formula: $NPV = FV / (1 + i)^n$, where *FV* stands for future sums of money under consideration; *n* equals the number of years over which discounting will take place; and *i* is the interest rate. In this paper FV represents the annual net increase in gross margin due to quota purchase. If NPV is positive, the investment yields a higher dividend than the required rate of return, and the investment is profitable. Correspondingly, an investment with a negative NPV is not profitable.

In Figure 2a and 2b net present values for farms A and B are calculated for the two quota prices and different depreciation periods.

2a. **2b.**

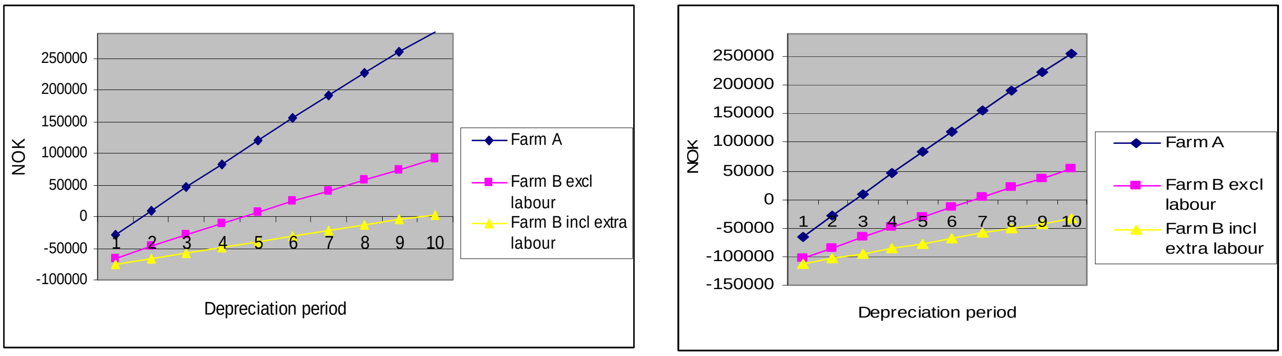


Figure 2. NPV for quota investment on farm A and farm B with different depreciation periods. Quota price is NOK 3.50 in Figure 2a, and NOK 5.50 in Figure 2b.

On farm A, for quota investment to be profitable at a price of NOK 3.50, the depreciation period must exceed two years (Figure 2a). For farm B, for the quota investment to be profitable at the same price, the depreciation period must exceed five years if extra labour costs are excluded, and 10 years if they are included (Figure 2a). In the case of a milk quota abolition in year 6 (year 2015), quota purchase remains profitable on farm A at both price levels. However, on farm B, quota investment yields a small positive net present value in year 6 only when additional labour is not included (Figure 2a). With the higher quota price, the depreciation period on farm A must exceed three years for the investment to be profitable (Figure 2b). On farm B however, a quota price of NOK 5.50 yields a negative NPV at least within a depreciation period of 7 years, even when additional labour costs are excluded (Figure 2b).

In order to compare quota investment and renting of quota on farms A and B, accumulated gross margin less rent and tax is given in Figure 3.

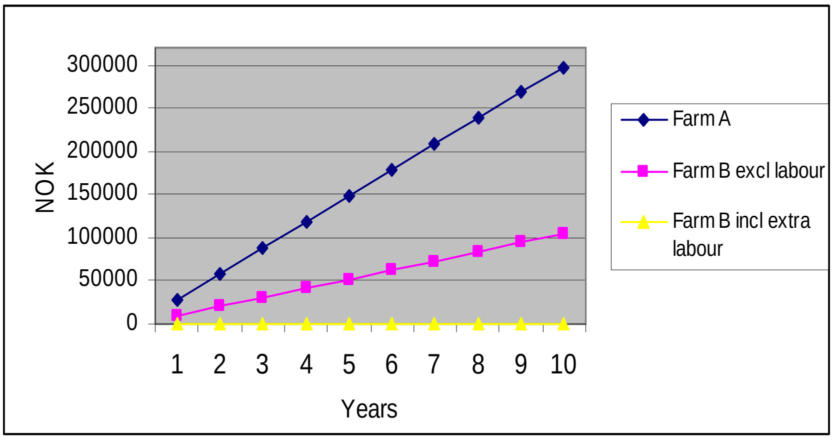


Figure 3. Yearly accumulated gross margin less rent and tax on farm A. Rent price 0.5 NOK per litre milk.

Comparing Figures 2 and 3 demonstrate that for farm A renting of quota is a highly competitive alternative to buying quota. Considering the period until 2015 renting of quota is a more profitable alternative than buying. In addition renting quota on a five year contract implies less financial risk and appears to be a more flexible option than buying quota. On farm B renting of quota is also more profitable alternative than buying, however when additional labour costs are included, renting is not profitable on farm B.

Discussion and conclusion

The results for farm A illustrate that farmers with idle production capacity have a strong incentive to increase milk production. Thus it is not surprising that the demand for milk quotas in Norway has been high. The results for farm A are in line with the example by Breines (2005). Initially farm A has idle milk yield capacity per cow and no competing livestock (sheep). In this situation, the model shows that it is profitable to have a relatively low milk yield per cow combined with a high slaughter age and slaughter weight for bulls. The results from this study are consistent with those obtained by Flaten (2001). With heifers occupying space not required by cows, increased milk quota is filled by increasing the milk yield per cow. This finding demonstrates that the results by Knutson et al. (1997), suggesting that the number of cows should be increased before the milk yield, do not always hold under practical farming conditions.

Factors like land scarcity, alternative use of land and the subsidy scheme influence optimal plans. Subsidies influence optimum milk yield per cow (Flaten, 2001). With limited space for cows, or if the cowshed needs replacement, high yielding milk production systems become profitable.

The results for farm A illustrate that some farms have a high potential for producing additional milk, which can be utilized once the quota program is abolished. But as is clearly demonstrated on both farms, the increased milk production comes at the cost of reduced beef production from bulls. In the long run, a substantial increase in milk yield per cow and number of cows per farm reduce national beef production. In order for Norway to be self-contained in beef, raising a herd of beef cows might be required.

The results for farm B however demonstrate that on farms with initially well utilized production and milk yield capacity, the economic effect of purchasing or renting additional milk quota is significantly smaller. Thus, the findings for farm B are more in line with the example used by Flaten (2005). Farm B starts in a position with roughage scarcity, no idle places for cows, and fully utilized milk yield capacity from dairy cows. Farm B also purchases bull calves at three months old and thus has a higher utilization of the cowshed.

Increased milk yield per cow requires high farming skills and a high cow yield potential, as well as high roughage quality. If, for example, the roughage quality on farm A had been bad, the milk yield would not have exceeded 7500 kilos per cow. Increased milk yield on farm A also requires that the total feed ration is balanced with respect to all nutrients, especially protein, otherwise the effect of increased quantity of concentrate per cow will be reduced. To obtain the desired milk yield increase, it is important to choose the right feeding strategy. This implies that feeding surplus energy must be avoided, and that the concentrate is carefully adapted to the milk yield and the roughage quality. Furthermore it is crucial to plan increased milk yield per cow well ahead of a new lactation. If farm A had tried to increase the milk yield per cow in mid lactation, it would have been much less effective.

Labour constitutes a considerable part of the costs in dairy farming. Inclusion of labour costs in TINE Optimal would have made it profitable to fill the quota on farm A with fewer cows, all other factors kept unchanged (Flaten 2001). The shadow price of the milk quota would have been reduced, and thus the profitability of milk quota investment or rent.

In this paper only short run consequences of quota purchase and increased milk production are considered. In the short run, returns only need cover variable costs. However, in the longer run, the cowshed will need refurbishment or enlargement and the fixed costs to be covered. Furthermore it is assumed that both farms have sufficient liquid assets at their disposal. If that is not so they might get stuck in a liquidity trap. It is also assumed in the paper that the farmers are able to fill the purchased milk quotas. However, Colman (2000) reports that a large number of dairy farmers achieve a poor match between available quota and production. Producing under quota will lengthen the payback time and thus reduce the profitability on both farm A and B.

In the introduction it was stated that there had been a debate as to how much the gross margin will increase with increased milk quota or milk delivery. The overall conclusion from the two examples is that this depends heavily on the current farm situation, a result which is in line with both Colman (2000) and Bogetoft et al. (2003). Before purchasing or renting quota, it is crucial that the farmer examines carefully how existing production will be affected by the additional quota. There exists no standard answer which fits all dairy farmers, and the consequences need to be calculated for each individual farm.

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