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# The profitability of seasonal mountain dairy farming

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**Abstract.** The economics of seasonal production of cheese in the mountain is compared with keeping the cows at the farm, investing in a common pasture, or in co-operative dairy farming on rural Norwegian dairy farms. The comparison is based on a linear programming (LP) model supported with Stochastic Dominance with Respect to a Function (SDRF). Mountain dairy farming involves free ranging cows on alpine pastures for about 70 days. The contents of polyunsaturated fatty acids, CLA and various antioxidants in the milk increase when cows graze alpine species rich pastures affecting the health properties, processing properties, chemical content and possibly also the flavour of dairy products. Seasonal mountain cheese production is found to be generally preferable to the other alternatives. The risks are partly related to price but also to yield and output as well as to policy since the profitability depends strongly on subsidies and premiums, and exemption for farm-processed milk in the quota. Investments in farming co-operatives were unprofitable due to less subsidy payments. The effects of calving time, introducing fertilized pastures or night pens, and supplementary feeding to extend the mountain period and sustain milk yields are examined. The premium price for "mountain products", animal welfare, and farmer co-operation on marketing are discussed.

**Keywords.** Linear programming – Mountain dairy products – Stochastic dominance – Risk analysis.

***La rentabilité de la production laitière en montagne***

***Résumé.*** *L'intérêt économique de la production de fromage en montagne norvégienne est comparé au maintien des vaches sur l'exploitation, à l'utilisation de pâturages collectifs, ou à l'utilisation de coopératives laitières agricoles. La comparaison est faite avec un modèle de programmation linéaire (PL) basé sur la « Dominance Stochastique avec Respect de la Fonction » (SDRF). L'élevage laitier de montagne est basé sur le libre accès des vaches à des pâturages de montagne durant environ 70 jours. Les teneurs du lait en acides gras polyinsaturés, CLA et divers antioxydants augmentent quand les vaches pâturent des prairies riches en espèces de type alpin. Ceci a un impact sur les propriétés sanitaires, la transformation fromagère, la composition chimique et peut-être la flaveur des produits. La transformation fromagère est en général préférée à une autre utilisation du lait. Les risques sont en partie liés aux prix, mais également au niveau de production laitière et aux politiques publiques, le résultat économique des fermes dépendant avant tout de l'importance des subventions et de la non prise en compte dans les quotas du lait transformé en fromage. Les investissements dans les structures coopératives sont peu rentables car peu subventionnés. Nous avons étudié l'incidence de la date de vêlage, de l'utilisation de pâturages fertilisés et de parcs de nuit, d'une alimentation supplémentaire pour prolonger la période de production en montagne et maintenir la production de lait. L'importance de la surprime pour les « produits de montagne », du bien-être animal et de l'intérêt des coopératives pour la commercialisation des produits sont discutés.*

***Mots-clés.*** *Programmation linéaire – Produits laitiers de montagne – Dominance stochastique – Analyse des risques.*

## I – Introduction

Seasonal mountain dairy farming in Norway, based on grazing by milking cows on natural ranges, developed as a strategy for using large mountainous grazing areas while the agricultural area in the valley was limited. Mountain dairy farming has declined substantially over time. Roughly 57 thousand dairy cows (21% of the national herd) grazed outlying pasture in 2004. In the most important alpine dairy region Valdres, 74% of the cows grazed mountain ranges in 2007. Typical farms have from 10 to 20 cows, raise the calves, and are located at 400-700 m altitude with the alpine summer farm at 800-1100 m. The cows graze 70 days from the end of June and ca. three weeks before and one month after in the valley. They are free ranging daytime and supplementary fed concentrates. Small-scale local processing concentrate on sour cream and cheeses, but most of the milk is delivered to a dairy plant. The mountain milk is richer in polyunsaturated fatty acids regarded as beneficial to human health, i.e. the ω3 fatty acids and conjugated linoleic acid (CLA) compared to milk from both pasture and indoor feeding, and low in saturated fatty acids. A governmental support motivated by concern for cultural, historical and biological values was introduced in the 90s.

This paper is about the economics of dairy farming in mountain areas, and its objective is to compare and discuss the relative profitability of alternative systems to clarify whether local processing in the mountain has a future as a niche in the larger dairy production. The examined systems are: (i) retaining the cows on farmland pasture (FP); and (ii) maintaining or developing a mountain farm dairy business (MF). We have investigated production of 500 kg of sour cream (sold fresh) out of 5 tons of milk, or manufacturing a hard white cheese out of 20 tons. The whey is made into "brown cheese" by boiling and adding cream. Farm-processed milk is exempted in the milk quota and surplus whey and skim milk is used for feed. By investing in a (iii) Common pasture (CP) farmers would save work in the grazing season while by establishing a (iv) Farming cooperative (FC) substantial work can be saved throughout the year.

## II – Materials and methods

A linear programming (LP) model representing small dairy farmers in the area has been developed. The LP technique is based on constrained optimization, reproducing the reality of farmers who maximize income while facing several constraints. The mathematical model is:

$$\text{Max } Z = c'x \text{ subject to } Ax \leq b,\ x \geq 0$$

where Z is the farmer's objective function i.e. total gross margin (TGM) minus variable costs; x is a vector of activity levels determined in a solution; c' the vector of marginal net returns per unit of each activity, and b a vector of constraints. The yields as well as amount of fertilizers were stipulated based on research at Bioforsk Løken. Standard values for feed requirements were employed. The feed for milk is distributed according to a lactation curve and calving on October 15 or March 15. Protein requirements are specified according to Madsen *et al.* (1995). The milk quota allows for ca. 15 cows, and processing would permit between one and five more cows. Space for cows can be obtained by selling baby-calves instead of finished bulls. All prices reflect 2010-conditions. Farmers are paid a premium per ha of farmland and animal premiums. The average milk price is NOK 5.06 per kg, with supplementary payments in the summer. For the hard cheese we assume NOK 235 a kg and subtract the variable costs of electricity, packaging, rennet etc. As for the "brown cheese", the price is NOK 159 a kg after subtracting NOK 40 for firewood for cooking. Surplus whey and skim milk are valued as feed.

The fixed costs are stipulated based on 36 farm records (Asheim *et al.,* 2010). A fixed annual direct payment to milk producers, split among the members of a FC, is incorporated. Investments for a small production of cream encompass a cream separator, churner and a cold storage chamber. A facility for hard cheese would need water purifying equipment and a formal approval by the Food Safety Authorities. The investments for the CP consist in a milking barn (25 years), milking machines and equipment. For the FC, we investigate 60 cows and Automatic Milking System (AMS). Based on the records the available family work time is set to 2,801 h, plus 290 h for MF

(October) and 350 h (March) for moving the animals to and from the mountain, overhead work with processing etc. The CP work time saving is assumed to constitute half of overhead work and work with the animals after accounting for some work at the CP. Similar savings are assumed throughout the year for the FC. We assume 1.5 h per portion (200 l) of milk for cream, including cleaning of equipment and sale. Manufacturing the hard cheese would require 3.5 h for 200 l, and boiling of "brown cheese" 3 h for 170 l whey.

The model was specified and solved in Excel and stochastic simulation conducted in Simetar© (Richardson *et al.*, 2008), incorporated the solver. The stochastic variables encompass the farm yields assumed to be normally distributed with 10% standard deviation (SD). Moreover, for each per cent yields increase above expected yield, the energy and protein values were lowered by 0.2% due to delayed harvesting. The prices of concentrates and milk are normally distributed with SDs 15% and 10%. For the mountain cheeses and cream, a 10% price increase is possible while minimum is the price obtained for industrial products. This has been modelled as GRKS functions. The stochastic outputs of cream, hard cheese, and "brown cheese" incorporate risks of *i.a.* "misfermentation". Regarding the outlook for agricultural subsidies, premiums and other direct support we have used a GRKS function with a maximum of +10%, a most likely outcome of –30%, and a minimum of -50%. We also assume a 50% chance that the milk quota will be abolished over the period, however unless fresh milk and cheeses can be imported without customs farm milk production will then be constrained by farm building capacity, deemed to be 20% higher. This has been modelled using a Uniform function. All investments are depreciated assuming 3% real interest rate and a 1/3 chance it will go down to 2% or increase to 4%.

## III – Results and discussion

If farmers choose to retain the cows at the farm roughly half the farm area will be used for pasture, the other half for winter feed and renewal. The mountain agricultural area is used for silage which is baled and transported to the farm (Table 1). Compensation per h for seasonal mountain farming by delivering the milk is slightly lowered due to extra work. Mountain farming as "a way of life", might be a reason for this choice. Extending the mountain period by feeding does not improve the economy (data not shown), however processing a small amount of sour cream to be sold directly improve the farm profit per h to NOK 110. The "break even" price seems to be about half of the sale price. Unsold sour cream can be processed into butter and the skim milk is sometimes made into Cottage cheese or the autochthonous cheeses "Gamalost" or "Pultost", a young, semi-hard cheese with caraway (*Carum carvi*). However, the market is limited due to short durability and pasteurization might be needed.

**Table 1. Model solutions for FP compared with MP without processing, processing 5 tons into cream or 25 tons into cheese, and with the CP and FC alternatives. March calving**

| | FP | MP | MP 5 t | MP 20 t | CP | CF |
|---|---|---|---|---|---|---|
| Farm silage (pasture), ha | 9.2 (9.9) | 15.5 (3.7) | 15.3 (3.8) | 14.7 (4.5) | 16.6 (2.5) | 10.8 (8.4) |
| Mountain silage (pasture), ha | 6.0 (0) | 0 (6.0) | 0 (6.0) | 1.6 (4.4) | 0 (6.0) | 6.0 (0) |
| Dairy cows, heads | 14.9 | 14.9 | 15.7 | 18.7 | 14.9 | 14.9 |
| Gross output, incl. support, NOK | 926,006 | 962,477 | 1,017,078 | 1,434,618 | 926,006 | 873,855 |
| Support mountain farming, NOK | 0 | 32,000 | 32,000 | 32,000 | 0 | 0 |
| Gross Margins, NOK | 520,284 | 565,714 | 598,411 | 1,031,242 | 532,699 | 472,989 |
| Fixed costs and hired work, NOK | 224,602 | 237,388 | 250,705 | 354,396 | 230,970 | 308,384 |
| Farm profit, NOK | 295,682 | 328,326 | 347,706 | 676,846 | 301,729 | 164,606 |
| Farm profit per h, NOK | 106 | 104 | 110 | 215 | 108 | 77 |

The hard cheese production makes the highest profit as our basic prices are about 65% higher than needed to break even. A considerable amount of work has to be hired. A common storage for cheese from several farms would lower work with turning, which could be mechanized. Co-operation on marketing cheese sold off-season is also possible. Branding of mountain products like in some European countries (Santini, 2013) are available to farmers under the Norwegian "Matmerk" system. The CP seems to improve the economy slightly and more so if some support for mountain farming can be obtained. Particularly farmers giving priority to vacation during the summer should consider the CP. Due to loss of subsidies and substantial investments the FC seems uncompetitive in spite of substantial work time savings.

The cumulative distribution functions (CDF) of farm profit in Fig. 1 show that the MF-cheese production alternative is more risky with a wider range in the solutions however, the considered risks still places MF-cheese on the upside of the others. The probability of a farm profit above NOK 200,000 is estimated to 0.41 for the FC, compared with 0.94 for the CP and 0.91 for the FP alternative. For FC the chances of a negative result is somewhere between zero and one per cent. An analysis of SDRF gave the following preferences: (i) MP 25 tons; (ii) MP 5 tons; (iii) MP March (milk); (iv) CP March; (v) FP March; and (vi) FC March. The ranging was the same for risk neutral decision makers (RAC = 0) and extremely risk averse decision makers (RAC = 4) (Anderson and Dillon, 1992).

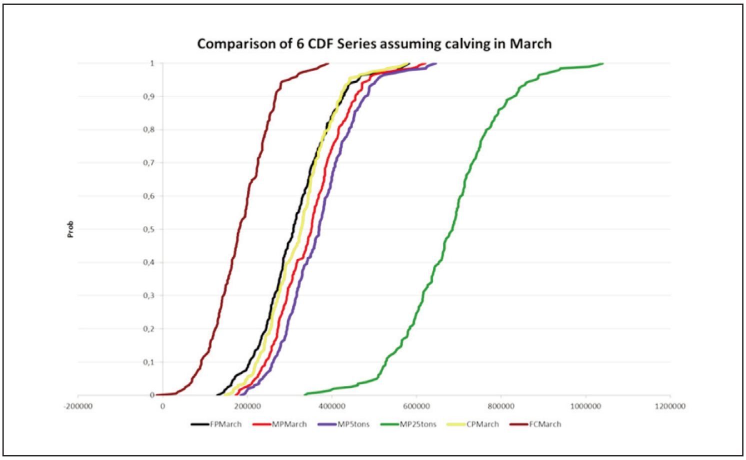


**Fig. 1. The CDFs of farm profit for the systems, simulating the stochastic variables 200 iterations.**

## IV – Conclusions

Smaller family dairy farms should consider maintaining the seasonal dairy business activity if they need to find more employment since the activity pays about similar wage per h as retaining the cows at the farm. Alpine pasture products are typically richer in PUFAs regarded as healthy and important to prevent cardiovascular diseases and have a lower content of unfavourable, saturated fatty acids, but this is not reflected in the price paid by the dairy. The study indicates that developing the mountain processing business might be a profitable and not particularly risky strategy. This is partly due to the support for such production but also due to the high market prices obtained for mountain products and exemption for farm processed milk in the quota. Marketing and co-operation on marketing might become critical for a long run mountain business development.

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