The Profitability of Seasonal Mountain Dairy farming in Norway

Rentabilität der Almwirtschaft in Norwegen

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Abstract

In this paper the economics of seasonal production of cheese in the mountain in Norway is investigated and compared with keeping the cows at the farm, investing in a common pasture or in co-operative dairy farming. The comparison is based on calculations in a linear programming (LP) farm model supported with Stochastic Dominance with Respect to a Function (SDRF) for risk analysis. Mountain dairy farming involves free ranging cows on natural pastures for about 70 days. The contents of polyunsaturated fatty acids, CLA and various antioxidants in the milk increase when cows graze alpine pastures affecting its processing properties, and flavor and chemical content of dairy products. Seasonal mountain cheese production is found to be generally preferable to the other alternatives for risk neutral as well as risk-averse decision makers. This is due to a higher price for mountain products, subsidy payments for mountain farming, and exemption for farm processed milk in the national milk quota. The risks are partly price risks but also yield and output risks as well as downside political risks since the profitability depend strongly on subsidies and premiums, and exemption for farm-processed milk in the milk quota. Investments in farming co-operatives were unprofitable due to less subsidy payments compared to individual farmers. 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.

Key Words

linear programming; mountain dairy products; stochastic dominance; risk analysis; range pastures

Zusammenfassung

In diesem Beitrag wird die Rentabilität der Produktion von Almkäse im eigenen Betrieb untersucht und mit gemeinsamer Weide und in einer Betriebsgemeinschaft in Norwegen verglichen. Der Vergleich basiert auf Berechnungen in einem linearen Programmierungsmodell, unterstützt durch Stochastic Dominance with Respect to a Function (SDRF) für Risikoanalyse. Die Almwirtschaft beinhaltet ein Verfahren mit Kühen auf Almen an ungefähr 70 Tagen. Der Anteil von mehrfach ungesättigten Fettsäuren, konjugierte Linolsäuren (CLA) und verschiedenen Antioxidanten erhöht sich, wenn die Kühe auf einer Alm weiden. Dadurch verändern sich die Verarbeitungseigenschaften der Milch sowie der Geschmack und die chemische Zusammensetzung von Milchprodukten. Der Beitrag zeigt, dass die Rentabilität der Almwirtschaft für risikoneutrale und risikoscheue Entscheidungsträger generell besser und den alternativen Verfahren vorzuziehen ist. Eine wichtige Rolle spielen Preisrisiko, Risiko in Bezug auf die Milchleistung und politisches Risiko, da die Rentabilität der Milchproduktion sehr stark von Beihilfen und Subventionen abhängt. Politisches Risiko findet sich zudem in der Tatsache, dass auf der Alm verarbeitete Milch von der Milchquote ausgenommen ist. Investitionen in eine landwirtschaftliche Betriebsgemeinschaft waren unrentabel. Dies erklärt sich zum großen Teil aus den degressiven Beihilfesätzen im Vergleich zu Einzellandwirten. Der Einfluss der Abkalbezeit, das Zuführen von Mineraldünger auf Almweiden und die Verlängerung der Zeit auf der Alm durch zusätzliche Fütterung werden untersucht. Darüber hinaus wird der Einfluss eines Preiszuschlages für Almprodukte, Tiergesundheit und die gemeinschaftliche Vermarktung von Almprodukten diskutiert.

Schlüsselwörter

lineares Programmieren; Milchprodukte; stochastische Dominanz; Risikoanalyse; Almwirtschaft

1 Introduction

Seasonal mountain dairy farming, based on grazing by milking cows on natural ranges, has a long tradition in many mountainous countries across the world. In Norway, the mountain farming system developed as a strategy for using large mountainous grazing areas while the agricultural area in the valley was limited. Butter was the main product for sale. Farmers also used firewood for cheese-making and cleared forest-land was harvested for haymaking which, together with grazing, had a profound effect on the rural landscape (REINTON, 1957; SKARSTAD et al., 2008). Rangeland grazing is still common, but the share taken by cattle declined from 58% in 1939 to 29% in 2004 (ASHEIM and HEGRENES, 2006). Roughly 57 thousand dairy cows utilized outlying pasture in 2004 constituting ca. 21% of the Norwegian dairy cow population.

Currently seasonal mountain dairy farming is common only in parts of support zone 5 covering the central mountain chain in south and mid Norway with approximately 55% of the dairy cows. In the most important alpine dairy region Valdres, 74% of the cows grazed on mountain ranges as recent as 2007 (SKARSTAD et al., 2008). Typical farms have from 10 to 20 cows and raise surplus calves for replacement or sale, using the Norwegian Red Cattle, a combined meat and milk breed. However, even here the farming families tend to concentrate the calving period and keep mainly dry or low yielding cows on the mountain ranges (ASHEIM et al., 2010). Local processing has a limited extent, and concentrate on sour cream and cheeses, most of the milk is delivered to a dairy plant. In southern Norway, such farms are located at 400-700 m altitude with the alpine summer farm at 800-1,100 m. It is quite common to have cultivated land both places. The period on natural mountain pastures is about 70 days from the end of June. The cows graze in the valley for about three weeks before and one month after the mountain period (ASHEIM, 1985). The animals are free ranging daytime and supplementary fed concentrates to sustain the yield.

It is well known that the plant biodiversity of pastures influences the chemical content of the pasture milk (HARSTAD and STEINSHAMN, 2010). Particularly the composition of fatty acids changes and amount of terpenes (i.e. α-tocopherol, carotenoids and terpenoids) in the milk increase when cows graze rich and diverse species in pastures at high altitude (COLLOMB et al., 2002; KRAFT et al., 2003; LEIBER et al., 2005; AGABRIEL et al., 2007). The milk is typically rich in polyunsaturated fatty acids (PUFAs) regarded as beneficial to human health, i.e. the ω3 fatty acids and conjugated linoleic acid (CLA), and low in saturated fatty acids. The chemical changes in the milk are partly explained by a high number of dicotyledon herbs in mountain pastures which contain a high number of terpenes compared to monocotyledons such as grass species in Poaceae (MARIACA et al., 1997; CORNU et al., 2001; SICKEL et al., 2012). The chemical changes also affect the colour and texture of processed products, and probably also the flavour (HAUSWIRTH et al., 2004; INNOCENTE et al., 2002; BUGAUD et al., 2001; COULON et al., 2004; VERDIER-METZ et al., 1998; CHILLIARD and FERLAY, 2004).

Studies by NORUM (1966) and ASHEIM (1985) showed that summer mountain farming was more profitable than retaining the cows at the farm only when the resources of farmland were limited, otherwise farmers should rather expand the area in the valley. However, local processing and a premium price for mountain products were not considered in those studies. The mountain milk is mostly collected by a tank lorry and mixed with other milk. Moreover, the milk collection from many small farms is expensive, and subsidies for in-transport amounted to NOK 450 million (€ 58 million) in 2011 (BUDGET COMMITTEE FOR AGRICULTURE, 2012). A governmental support scheme for seasonal mountain dairy farming, motivated by concern for cultural and historical as well as landscapes and biological values (MINISTRY OF AGRICULTURE AND FOOD, 1997), was introduced in the middle of the 1990s. It was later followed by exemption for farm-processed milk in the national milk quota. The mountain period has to be at least eight weeks and, unless processed, four weeks with milk deliveries. The support is sufficient to cover additional work and costs of keeping up the mountain milking barn and chalet (ASHEIM et al., 2010), particularly for farms with autumn calving, but not more.

According to the guidelines of EUROMONTANA (2010), apart from the mountain origin, consumers expect mountain products to: respond to high (industrial) standards of hygiene, have a link to the cultural identity of local communities, be produced from raw mountain materials, connected to specific cultural areas, support local employment, and produced with traditional methods by small-scale producers, ensuring their authenticity. Mountain product retailers in six European countries ranked taste, environment, local origin and health as the four most important characteristics whereas branding was considered the least important characteristic (SCHØLL et al., 2010). A study cited by EUROMONTANA (2010) revealed great variation in prices of mountain products depending on quality, the nature of competing products and the place where it is marketed.

Dairy farmers have to form their opinion regarding future development of the production. This article is about the economics of dairy farming in mountain areas, and its objective is to compare and discuss the relative profitability of alternative systems involving an individual entrepreneurial or family, approach. We think targeting consumer expectations with "a packaged production system" involving all the aspects of assigned properties of mountain products from local peculiarity, taste, environment and health, animal welfare etc. is worth being examined for producers with mountain pasture milk. To our knowledge such a comparison of milk deliveries with local processing and a premium price for mountain products has not been conducted before. Dairy farmers may also opt for a co-operative strategy together with one or more neighbours. A comparison is relevant to clarify whether local processing in the mountain has a future as a niche in the larger dairy production or farmers rather should opt for mainstream production systems.

The examined systems are: 1) *Retaining the cows on farmland pasture* (FP) in the valley which can be advanced under different calving times, from the fall (October) to late winter (March). The alternative system 2) *Maintaining or developing a mountain farm dairy business* (MF) is based on a combination of natural and fertilized pastures. Farmers may deliver the milk or process some of it. For calving in March, we have investigated a small production of 500 kg of sour cream out of 5 tons of milk, or manufacturing 2,000 kg of a hard white cheese out of 20 tons. The cream has to be sold fresh while the hard cheese is stored for at least three months before marketing. On the summer farm, the whey is made into "brown cheese" by boiling for several hours before adding cream. The amount of "brown cheese" is 1,000 kg and 500 kg cream would be needed. Surplus whey and skim milk is used for feed. The alternative *3) Common pasture* (CP) established in the mountain would require investments in a milking barn but would allow farmers more leisure and to concentrate on field work and grass harvesting. Finally, by establishing a *4) Farming co-operative* (FC) in the valley substantial work can be saved. Dry cows, heifers and the young stock may still use natural pastures for these alternatives.

2 Method and Materials

2.1 Model Structure

The quality of any model is determined by how well it captures the reality of the situation it is to represent as well as on the chosen parameters. The LP technique, used in this study, is based on constrained optimisation that can be said to reproduce the reality of farmers who strive to maximize their income while facing several constraints. It has frequently been applied to identify optimal farming systems (e.g., JANSSEN and VAN ITTERSUM, 2007). In LP models several activities, and production techniques can be considered simultaneously and within the model constrains, and the effects of changing technical specifications and biological responses or right hand side parameters, can easily be assessed. We think the technique can be used to compare the four ways of dairy farming in mountainous areas in the study, however, for the model to properly capture the essential aspects of the problem investigated we need to emphasize working out realistic and complete assumptions regarding the relevant activities and constrains of farming in such areas.

The mathematical model of a primal LP problem (LUENBERGER, 1984):

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

Here Z is the farmer's objective function i.e. total gross margin (TGM), total return from livestock production, government payments, minus variable costs; x is a vector of activity levels to be determined in a solution; c' the vector of marginal net returns per unit of each activity. The fixed costs in each run are subtracted from the computed TGM to arrive at farm profit. A is the matrix of technical coefficients showing resource requirements by the activities; b is the vector of right-hand side values of resources such as land, farm labour and milk quota, and balances such as feed, relating to the constraints of the model. The problem is to identify the composition of activities resulting in the maximum objective function value, not violating any constraints, or involve any negative activity levels.

The land activities are given in Table 1, and animal processes in Table 2. Separate processes were set up for government farm area payments and for supplying a variety of purchased concentrate feeds. If farm family labour is not sufficient, a process for hired labour allows farmers to contract work. The vector b of right-hand side values constrains the activities to the available fixed assets of farmland, farm pasture or mountain areas, used as meadows or pasture, and to available farm labour in the year and in the grazing season. Constraints also account for crop rotation, use of manure, herd replacement as well as government area payments and a farm milk quota. The feeding constraints match feed produced or purchased with animal needs for energy, protein and maximum and minimum roughage DM in both the indoors and grazing seasons. In the prevailing farming system, cows are let out to graze after the start of vegetation growth, represented by June 8. The cows graze until September 27 (111 days). From June 25 to September 5 (72 days), they may graze in the mountains, possibly extended to 90 days with feeding.

The fixed costs were derived from farm accounts. The model employs account data from dairy farms in the mountainous areas of south Norway (representing zone 5) collected from the database of the Norwegian Agricultural Economics Research Institute (NILF, 2008) for the years 2006-08. The 20 farms with seasonal mountain milk production in the database were compared with 16 farms from the same municipalities that were retaining the cows in the valley. The fixed costs are higher with seasonal mountain production due to the additional milking barn and chalet in the mountain. The data were split in two groups, enabling assessment of workload of seasonal mountain farming according to time of calving as described in ASHEIM et al. (2010). Differences regarding investments in e.g. mountain production facilities, and general governmental supports, such as the support scheme for seasonal mountain dairy farming, were included. The model, consisting in 30 activities and 29 constraints, was specified and solved in an Excel spreadsheet using the standard solver (Frontline Systems, Inc.) supported by the add-in Simetar© (RICHARDSON et al., 2008) for risk assessment.

The specific advantages of Excel are that it is widespread, easy to use, and many researchers are familiar with it. For larger models, depending on number of

Table 1. DM yields in kg/ha, kg N/ha, and AAT in g/FEm of silage, hay and pasture growth of the leys and seeding years according to application of manure and mineral fertilizer (NPK)

Fertilizers, tons manure or NPK	**Farm yield** kg DM/ha	**NEL**[a] MJ/kg DM	**Total N-use** Kg N/ha	**AAT**[a] g/kg DM
Silage 2 cuts				
Spring: 30 t + 25-2-6 or 18-3-15	2,840	5.66	115	0.077
Summer: 20 t + 25-2-6 or 18-3-15	2,100	5.93	80	0.080
Silage and pasture				
Spring: 30 t, + 25-2-6 or 18-3-15	2,840	5.66	115	0.077
Summer: 20 t + 25-2-6 or 22-2-12	1,080	6.42	70	0.085
Hay and pasture				
Spring: 30 t + 25-2-6	3,550	5.24	125	0.073
Summer: 22-2-12	650	6.42	60	0.085
Ryegrass pasture				
Spring, summer: 50 t + 25-2-6	4,260	6.76	99	0.088
Renewal				
Spring: 50 t	2,570	5.93	81	0.080
Farmland pasture				
Spring, summer, fall: 22-2-12	3,330	6.42	170	0.085
Permanent pasture				
Spring, summer, fall: 22-2-12	2,290	6.42	140	0.085
Mountain silage/pasture				
Spring: 18-3-15	3,430	5.66	140	0.077
Pasture regrowth	200	6.42	20	0.085
Mountain permanent pasture				
Spring: 18-3-15	1,880	6.42	110	0.085
Mountain natural pasture[c]				
Summer	-	5.93	0	0.077

[a]NEL = net energy lactation (VAN ES, 1978)
[b]AAT = amino acids absorbed in the small intestine (MADSEN et al., 1995)
[c]Yield/ha is not considered.
Source: own calculations based on VAN ES (1978), MADSEN et al. (1995) and BIOFORSK (2012)

decision variables, constraints, and total number of formulas, the standard solver might have to be replaced. However for smaller matrixes, less than 100 constrains, and where the objective and constraints are linear functions of the decision variables, one can be confident of finding a globally optimal solution.

2.2 Land Use, Forage Production and Yields

The area of farmland is set to 25.2 ha (average of the 36 farms above) out of which we have assumed 1.5 ha of permanent pasture in the valley and 6 ha of cultivated grassland in the mountain. The net yields and fertilizer use for the grassland processes are given in Table 1. The parameters were DM yield, net energy for lactation (NEL), and amino acids absorbed from the small intestine (AAT) according to MADSEN et al. (1995). The yields as well as amount of fertilizers were stipulated based on experiences at Løken Research Station in Valdres. The manure produced indoors is used in the valley due to the transportation costs. Processes for silage or pasture are worked out using either manure or mineral fertilizers. The fertilizing effect of surface spread manure is 1.0 kg N, 0.5 kg P and 2.5 kg K per ton. The N-value increases to 1.6 kg when the manure is mixed into the soil (BIOFORSK, 2012).

Grass swards are renewed in the spring after ploughing and conventional cultivation for seedbed preparation without a companion crop. A seed mixture of timothy (*Phleum pratense*), meadow fescue (*Festuca pratensis*) and red clover (*Trifolium pratense*) suitable for the local climate was assumed. One herbicide treatment to control annual weeds and 50 tons of animal manure and 4 tons of lime is applied per ha. The silage crop is mowed, wilted a few hours (to 25% DM), and baled (800 kg). The costs include nutrients, machinery for field operations, custom hiring for baling, and renewal for the sward establishment or annual ryegrass pasture. Leys are reseeded after seven years, mowed once in the year of establishment, and twice in later years.

2.3 Livestock Feeding Requirements

Standard values for feed requirement (NILF, 2010) were employed (Table 2). The feeding requirements for cows consist in feed for maintenance, growth, fetus and production of milk, depending on yield. The herd replacement rate is 0.35. The growth and maintenance feed requirements is assumed to be constant, whereas the feed for fetus increases gradually over

Table 2. Requirement for energy, protein and DM for cows, baby-calves, heifers and bulls with calving on October 15 or March 15 and milk yield 6,656 kg per cow

	Calving time October 15		**Calving time March 15**	
	Indoors	Pasture	Indoors	Pasture
Cows, live-weight 550 kg				
Energy, NEL	27,896	8,313	23,815	12,934
Protein, kg AAT	410	117	345	182
Roughage DM_{Max}, kg	2,540	1,110	2,540	1,110
Roughage DM_{Min}, kg	1,972	518	1,684	773
Calves, live–weight 56 kg				
Energy, NEL	48	-	48	-
Protein, kg AAT	0.3	-	0.3	-
Roughage DM, kg	4	-	4	-
Heifers, live-weight 485 kg (24 months)				
Energy, NEL	12,686	8,847	14,711	6,822
Protein, kg AAT	168	116	192	93
Roughage DM_{Max}, kg	3,374	1,860	3,374	1,860
Roughage DM_{Min}, kg	1,121	689	1,300	532
Bulls, live-weight 590 kg (18 months)				
Energy, NEL	15,228	4,700	17,012	2,915
Protein, kg AAT	199	61	219	42
Roughage DM_{Max}, kg	3,089	744	3,089	744
Roughage DM_{Min}, kg	807	220	902	136

Source: own calculations based on VAN ES (1978), MADSEN et al. (1995)

62 days before calving. The feed for milk is distributed over 10 months of milk production assuming a standard lactation curve for all times of calving for the annual milk yield of 6,656 kg[1]. The feed for the young stock is summarized from birth to sale or transfer. Table 2 summarises the estimates of energy, protein and roughage DM intakes, assuming calving on October 15 or March 15.

The need for energy during the grazing period is considerably higher for cows calving in March compared to October whereas the opposite is the case for heifers (Table 2). Minimum protein requirements measured in kg AAT are specified according to MADSEN et al. (1995). The feeding requirements may be met with silage, hay and concentrate indoors, and by pasture and concentrate outdoors, however, we have a minimum of 173 MJ of hay for calf diet feed and 1449 MJ of a special calf concentrate for the young stock. As hay is considerably more expensive than silage, farmers will only provide the minimum amounts. In the MF alternative, the amount of natural pasture is constrained to 41.4 MJ a day for cows calving in March and 34.5 (October). As for cultivated pastures a minimum of 20.7 MJ (March) and 6.9 MJ (October) is assumed due to use of night pens.

2.4 Prices and Other Farm Premises

The prices of farm inputs and outputs, some of which are reproduced in Table 3, are set to reflect 2010-conditions. The exchange rate was 1 € = 8.00 NOK in 2010. The costs of fertilizers and baling are most important, representing 75% of the variable costs for silage. Operating field machinery costs (not shown) include repairs, diesel and lubricants per hour for various field operations. The coefficients for variable labour requirements are assumed constant, irrespective of the scale of these activities. The concentrate mixtures are FF80 and FP45 indoors or FF80 and FE90 on pasture. Farmers are paid a premium per ha of farmland and animal premiums depending on number of animals on January 1. Bulls borne in January or March obtain the grazing premium the first summer. Moreover, the premium per cow has a lower rate for higher numbers. Hence, the farming co-operative, considered as one farm, will have lower support.

The returns from the cow activities include sale of milk, culled cows, and premium payments. The average price of the milk is NOK 5.06 per kg, and milk quality payments, due to protein content, somatic cell or bacterial count and odour or taste, are assumed similar across production systems. Any differences in colour and texture and flavour of the mountain milk is not reflected in the milk price from the dairy. Farmers are also supplementary paid for milk delivered during the summer, NOK 0.68 per kg for June and July, and NOK 0,98 per kg for August and September, whereas NOK 0.25 is subtracted in the other months. Cost of milk for processing, valued at the seasonal price is subtracted. Based on a judgment of the information from farmers (Lars Hamarsbøen, pers. comm.) we have assumed NOK 86 as an average price per l sour cream when selling 500 kg. Variable costs of electricity, boxes for packaging, and starter culture (NOK 6 per l) are subtracted. For the hard cheese (Geir Harald Fodnes, pers. comm.), we assume NOK 235 a kg and subtract the variable costs of electricity, packaging, and rennet etc. assumed to constitute 35 NOK a kg. We also subtract 6% storage losses for the white cheese. As for the "brown cheese", the price is NOK 159 a kg after subtracting NOK 40 for firewood for cooking. The cream is valued as above and surplus whey and skim milk are valued as feed.

The fixed costs for maintenance and depreciations of farm buildings as well as machinery depreciations, administration and management etc. are based on inflated numbers from the records. A fixed annual direct payment to all milk producers in the country (NOK 84,800) is incorporated. This payment is split among the members of a co-operative farming operation. The costs of maintenance of the mountain milking barn, including machinery and tank, and chalet has been estimated by inflating the farm account data.

2.5 Investments and Work Time According to Production System

All investments are depreciated using the Payment (PMT) function in Excel to calculate annual costs including capital recovery over the useful lifetime, assuming a real interest rate of 3%. Investments for a small production of cream and butter involve a cream separator, churner and a cold storage chamber or a refrigerator for direct sale, estimated to NOK 30,000 (12 years). The cream is made sour in plastic containers using a starter culture. Public requirements are minor since a small scale cream production does not involve substantial risks for food contamination. The storage life of sour cream is 35 days when kept at

[1] The curve is stipulated based on calving on November 10 and 106 kg of raw milk production in five days followed by 396 kg in the rest of November. Monthly milk production is 883, 818, 709, 752, 665, 622, 554, 523, 491, and 137 kg in the months from December to September (10 days) and 61 days dry period.

Table 3. Economic parameters, prices, and government farm payments

Parameter	Value (NOK)	Parameter	Value (NOK)
Receipts		*Other expenses*	
Milk price[a]	5.06/l	Seeds and herbicides	359/ha
Hard cheese, net price	200/kg	Fertiliser 22-2-12	3.15/kg
"Brown cheese", net price	159/kg	Fertilizer 25-2-6	2.82/kg
Sour cream, net price	80/l	Fertilizer 18-3-15	3.40/kg
Bulls, 18 months	13,361/bull	Lime[f]	1,630/ton
Selling heifers[b]	12,406/heifer	Diesel	10.92/l
Baby calves	1,659/calf	Cost of labour	124/h
		Custom baling, incl. wrapping and transport	180/bale
Livestock expenses[c]		*Governmental payments*	
F-Elite 90 (6.69, 116)[d]	3.22/kg	Grassland, 1-20 ha	3,990/ha
F-Calf conc. (6.35, 101)[d]	3.35/kg	Grassland, > 20 ha	2,410/ha
F-Protein 45 (6.90, 230)[d]	4.89/kg	Dairy cows, 1-16	3,500/cow
F-Favør 80 (6.69, 107)[d]	3.03/kg	Dairy cows, 16-25	1,744/cow
F-Elite 90 (6.69, 116)[d]	3.22/kg	Dairy cows, > 25	556/cow
Other costs for cows[e]	3,211/cow	Other cattle	787/head
Other costs baby calves[e]	354/calf	Relief payment cows[g]	2,413/cow
Other costs bulls[e]	1,645/bull	Relief payment, other cattle	513/head
Other costs heifers[e]	1,365/heifer	Cattle, grazing	350/head
Fixed costs		Cattle, mountain grazing	300/head
Mountain barn and chalet	9,470/year	Basic milk production	84,800/year
Farm buildings	240,475/year	Mountain milk production	32,000/year

[a] The basic price is NOK 4.67 plus rural support 0.39. The price is lowered by NOK 0.26/l for deliveries in October to May and increased by 0.7/l in June and July and by 1.0/l in August and September.
[b] Value when surplus heifers are sold. Herd replacement is 0.35 heifers per cow.
[c] Price for commercially available concentrate mixtures Felleskjøpet, 2010 (adding 10% for freight etc.)
[d] in parentheses: NEL in MJ/kg and AAT g/kg
[e] consist in milk replacer for young cattle, minerals, veterinary costs medicine, insemination, etc.
[f] Limestone is applied at a rate of 4 t/ha in the meadow replacement year.
[g] in addition NOK 1,142 for the first 8 cows in total 9,136/year
Source: NILF (2010)

0-4 degree Celsius. A larger production of hard cheese would also include water purifying equipment and need a formal approval by the Food Safety Authorities. Investments are set to NOK 250,000 (20 years) and NOK 150,000 for equipment (12 years) based on Geir Harald Fodnes (pers. comm.). An old facility is assumed used for the "brown cheese" since the public requirements are less strict for "brown cheese" due to boiling. The milk quota, based on the average farm accounts, will allow for ca. 15 cows per farm enterprise when all the milk is delivered. Processing would allow the farmer to have between one and five more cows and require more space for cows. However, space can be saved by selling baby-calves instead of finished bulls. The investment for establishing the CP consist in NOK 200,000 in a milking barn (25 years), 220,000 for milking machines and equipment (12 years) and 110,000 for miscellaneous equipment (20 years), based on similar equipment as in ASHEIM (1985). For the FC, we investigate 60 cows and Automatic Milking System (AMS) based on STOKSTAD and NÆSS (2009). They found a cost of NOK 4,764 (including 1 m^3 of storage for manure) per m^2 arriving at NOK 110,000 per cow (20 m^2) when adjusted for inflation.

The supply of family labour on dairy farms, unless involved in milk processing, is set to 2,801 h, based on recorded average work time in the farm accounts. The work need for many farm tasks not directly allocable to specific production activities (overhead labour) is estimated to 2,096 h for the FP, based on a study by JERVEN (1986) for dairy farms of this size. As for MF, we assume, based on the farm accounts, that the overhead work will be 290 h higher in case there is calving in October and 350 h in March. The extra time involves moving the animals to and from the mountain, extra time to gathering cows, and the overhead work with processing and driving back and forth for harvesting crops, and feeding bulls at the farm site. This is matched with a similar higher supply of family labour for the MF alternatives. Regarding the CP alternative, work-time saving is assumed to constitute half of overhead work and work with the animals during the pasture season after accounting for some work at the CP. Similar savings is assumed throughout the year for the FC alternative. Based on information from Lars Hamarsbøen, (pers. comm.) 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. The work required for boiling of "brown cheese" would be 3 h for 170 l whey.

2.6 Stochastic Variables

The yields of roughage and pasture are assumed to be normally distributed with 10% standard deviation (SD). Negative values are set to 0. This is modelled in Simetar by multiplying the energy yield parameters by the formula MAX(0;NORM(1;0.1)). Moreover, for each per cent yields increase above expected yield, the energy concentration and AAT values have been lowered by 0.2%. This can be due to delayed harvesting and is modelled using an if-function. We assume the price of concentrate is normally distributed with 15% SD.

The price of milk is normally distributed with SD=10%. Regarding the seasonal milk price payments, we presume an additional 10% is a maximum, and a decline by 30% is the most likely value. However, it can go down to 0. This has been modelled as a GRKS function. The outlook for agricultural subsidies, area and animal premiums and other direct support are particularly difficult to assess. We have ended up with a GRKS function with a maximum of an additional 10%, a most likely outcome of –30% and a minimum of -50% over the life span of the investments. Norwegian subsidy payments are high and we consider the downside risks to be substantial. We also consider it possible that the milk quota will be abolished over the same period, however unless fresh milk and cheeses can be imported without customs farm milk production will then be constrained by the building capacity, deemed to be 20% above the quota. This has been modelled using a Uniform function with a 50% chance of no change and 50% chance of 20% increase. As for the mountain produced cheeses and cream, a 10% price increase is possible while the minimum would be the price obtained for similar industrial products. Since the cheeses and the cream are fermented, we think the risk of a serious food contamination followed by a closure of the operation by the food authorities can be ruled out. The stochastic output of cream is GRKS(475;500;525), hard cheese GRKS(1600; 2000;2050), and "brown cheese" GRKS(900;1000; 1050) incorporating risks of i.a. "misfermentation" leading to unsellable products. The basic interest rate is 3% and we assume a 1/3 chance it will go down to 2% and 1/3 chance it will increase to 4%.

3 Results and Discussion

3.1 Retaining the Cows on Farmland Pasture at the Farm Site (FP)

Roughly, half the farm area is 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. Annual ryegrass for pasture is not profitable. Ryegrass would be more beneficial in the last part of the grazing season when the quality of the farm pasture deteriorates and this has not been considered. Table 4 gives information on the economic performance of this system.

Clearly it will improve the farm economy to have calving in the late winter increasing farm profit by ca. NOK 15,000 compared with the calving in October, or from NOK 100 to 106 per h. Apart from the higher milk price, less silage will be needed, and some silage area is replaced with pasture. If the farmer can provide natural pastures near the farm for cows calving in October he will obtain extra support for that and lower his costs and the difference compared to calving in March becomes less significant (data not shown). However, if he or she wants to take advantage of the high milk prices during the summer months calving time in late winter or early spring and well-kept pastures would be needed. Particularly if calves are partly suckling or fed fresh milk during the first 8 weeks this period of calf rearing should be over before the high milk prices in the summer. Many smaller dairy farms may prefer to have low or no milk production during the summer due to field work, maintenance, and vacation etc. and try to concentrate calving in the fall and enforce drying up the cows in late summer.

Table 4. Model solutions for the farm pasture (FP) alternative according to calving time, assuming no farm milk processing

Calving time	October	March	Spread
Land use and livestock			
Silage, hay, pasture and renewal, ha	9.8	9.2	9.5
Infield pasture, ha	9.4	9.9	9.7
Silage mountain area, ha	6.0	6.0	6.0
Pasture mountain area, ha	0	0	0
Dairy cows, heads	14.9	14.9	14.9
Financial results (NOK)			
Gross output, farming	672,999	700,875	692,448
Government area payments	90,799	90,799	90,799
Animal and relief payments	141,552	134,333	134,333
Variable costs			
Forages	180,538	176,499	178,451
Concentrates	147,035	157,728	152,354
Miscellaneous, livestock	71,495	71,495	71,495
Gross margin, incl. support	506,282	520,285	515,280
Hired work	75,809	75,063	75,424
Fixed costs	149,539	149,539	149,539
Farm profit	280,934	295,683	290,317
Farm profit per h	100	106	104

Source: Lp Model calculations

3.2 Maintaining or Developing a Mountain Farm Dairy Business (MF)

Seasonal mountain farming is most easily conducted by delivering the milk directly to a dairy. There can be several reasons for doing so for some summer weeks; one is the extra support, another is farming as "a way of life" or as a combination of work and leisure. Seasonal mountain farming seems comparable economically to retaining the cows at the farm (Table 5). This is mainly due to the extra support, which is more than needed to maintain the alpine production facilities. Farm profit increases roughly by NOK 30,000 relative to the same alternatives in Table 4. However, overall compensation per h seems roughly unaffected due to more work. All the agricultural area in the mountain is used for pasture in these alternatives. Extending the period in the mountain to e.g. 90 days by feeding bales of silage does not seem to make any sense from an economic point of view (data not shown). If there are larger resources in the mountain or cows can have more natural pastures that question may come up, however the driving forces are towards shorter time in the mountain.

Developing the seasonal mountain dairy business by processing a small amount of sour cream, mainly to be sold directly from the mountain chalet, seems to improve the farm profit by ca. NOK 20,000 compared to delivering the milk. The number of animals increases slightly but raising the bulls is still possible and profitable. Average earning per h rises to NOK 110 from 104. The "break even" price for the cream seems to be NOK 41 per l or about half of the price achieved, however it seems difficult to make a considerable profit unless more can be sold. For comparison industrial produced sour cream sells in supermarkets for around NOK 50 per l. The sour cream not sold can be processed into butter, and may achieve a better price than the standard industrial produced butter, but hardly enough to make much profit. A better way to improve the economy would be to diversify with more products in case of too few customers. The skim milk, currently valued as feed, is sometimes made into cottage cheese or the autochthonous cheeses "Gamalost" or "Pultost", a young, semi-hard fermented cheese with caraway (*Carum carvi*). Production of cottage cheese or "Pultost" might improve the bottom line, but the market is limited due to short durability and pasteurization might be needed.

The cheese production makes the highest profit, our basic prices are considerable (about 65%) higher than needed to break even. Assuming a new facility for the "brown cheese" would not alter this conclusion. Industrial produced cheeses such as "Jarlsberg" sell for around NOK 120 a kilo while the "brown cheeses" are

Table 5. Model solutions for the mountain pasture (MP) alternative according to calving time without milk processing, and processing 5 tons into cream or 25 tons into cheese

Calving time	No milk processing October	 March	Cream March	Cheese March
Land use and livestock				
Silage, hay, pasture and renewal, ha	16.6	15.5	15.3	14.7
Infield pasture, ha	2.5	3.7	3.8	4.5
Silage mountain area, ha	0	0	0	1.6
Pasture mountain area, ha	6.0	6.0	6.0	4.4
Dairy cows, heads	14.9	14.9	15.7	18.7
Financial results (NOK)				
Gross output, farming and processing	677,469	705,345	753,174	1,159,324
Government area payments	90,799	90,799	90,799	90,799
Animal and relief payments	141,552	134,333	141,105	152,495
Support for mountain farming	32,000	32,000	32,000	32,000
Variable costs:				
Forages	208,254	199,931	198,097	200,128
Concentrates	114,171	125,337	145,471	126,008
Miscel. livestock	71,495	71,495	75,099	77,240
Gross margin, incl.support	547,900	565,714	598,411	1,031,242
Hired work	79,917	78,379	88,682	162,835
Fixed costs	159,009	159,009	162,023	191,561
Farm profit	308,974	328,326	347,706	676,846
Farm profit per h	100	104	110	215

Source: Lp Model calculations

around NOK 85. A considerable amount of work has to be hired, but cheese production still seems to be profitable. Extending the mountain season by feeding bales of silage or hay should be considered. As much cheese is sold directly in the mountain key questions are whether sales could be extended in a longer mountain period and whether prices could be sustained as the milk will be based on some silage and less use of natural pastures likely attractive to these customers. The processing in the mountain is based on unpasteurized milk, and farmers are generally skeptical to use bales of silage in such systems. Hay could be needed.

In the current market it seems possible to sell much of the farm mountain cheeses directly without much sales efforts. However, if the mountain production should increase more efforts would have to be devoted to sales and marketing. In that case a question is whether it would be worthwhile to undertake investments in a common storage for similar cheeses from several farms. This also would lower work with turning the cheeses which could then be mechanized. Cheeses may still be labeled with specific farm identification numbers. Co-operation on marketing cheeses sold off-season is also possible and might be easier to undertake from a common storage. Moreover, branding might become more important. Branding has been successful in some European countries where the EU has established labels dealing with protected denomination of origin (PDO), Protected Geographical Indicator (PGI), or Traditional Specialty Guaranteed (TSG). According to SANTINI et al. (2013) four European countries, France, Italy, Switzerland and Spain (in Galicia) have a direct protection in regulation related to mountain products. The best protection is provided by Switzerland, generally the protection is weak in the other countries.

Similar approvals are also available to Norwegian farmers under the "Matmerk" system, but this has not yet been much developed for mountain cheeses. Clearly common marketing and mountain labelling is an area where Norwegian dairy farmers could take advantage of experiences from European countries. However, branding is not considered the most important characteristic by retailers (SCHØLL et al., 2010). According to RYTKÖNEN and GRATZER (2010) whether the product should be marked under a label is perhaps not so important, the key will be the actions undertaken by the entrepreneurs.

Table 6. Model solutions for the common pasture (CP) and farming co-operative (FC) alternative according to calving time, assuming no farm milk processing

	Common pasture		Farming co-operative		
Calving time	October	March	October	March	Spread
Land use and livestock					
Silage, hay, pasture and renewal, ha	17.7	16.6	11.3	10.8	11.1
Infield pasture, ha	1.5	2.5	7.8	8.4	8.1
Silage mountain area, ha	0	0	6.0	6,0	6.0
Pasture mountain area, ha	6.0	6.0	0	0	0
Dairy cows, heads	14.9	14.9	14.9	14.9	14.9
Financial results (NOK)					
Gross output, farming	672,997	700,875	620,847	648,724	640,297
Government area payments	90,799	90,799	90,799	90,799	90,799
Animal and relief payments	141,552	134,333	141,552	134,333	134,333
Variable costs					
Forages	197,593	188,572	164,572	160,533	162,485
Concentrates	121,589	133,240	158,144	168,838	163,464
Miscellaneous, livestock	71,495	71,495	71,495	71,495	71,495
Gross margin, incl. support	514,671	532,699	458,987	472,990	467,985
Hired work	75,084	71,186	75,084	71,186	71,186
Fixed costs	159,784	159,784	237,198	237,198	237,198
Farm profit	279,803	301,729	146,705	164,606	159,601
Farm profit per h	101	108	69	77	74

Source: Lp Model calculations

The production of bulls will decrease in this alternative as baby-calves are sold at an age of between four and five weeks and raised elsewhere. Steers are uncommon and seem to be out of the question if buildings are needed during the winter. Production of intermediate calves between five or seven months of age when slaughtered should be considered. Such calves could be fed skim milk or whey and be ready at the end of the grazing season.

3.3 Common Pasture (CP) or Farm Co-operative (FC)

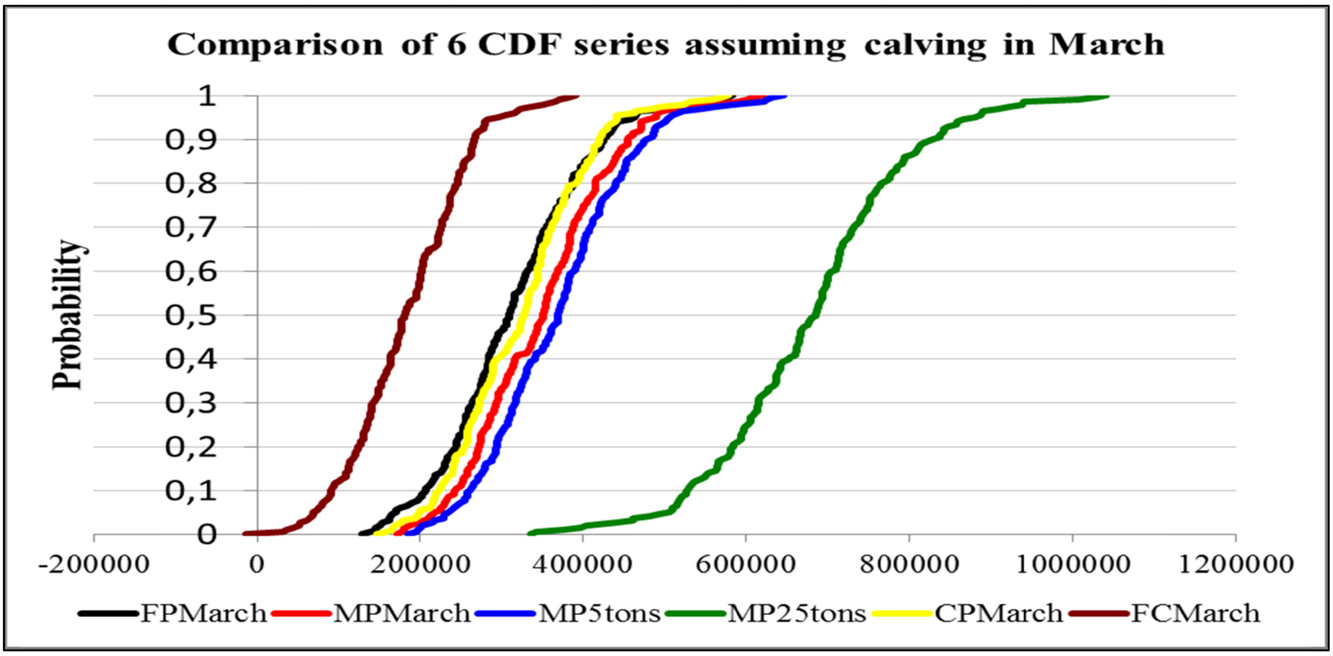
Using the mountain area as a common pasture together with the cows from some neighboring farms seems to improve the economy slightly compared to the farm pasture or delivering the milk in the mountain pasture alternative (Table 6). Farmers giving priority to vacation during the summer should consider the CP alternative, particularly if some support for mountain farming can be obtained for the CP. The mountain farmland is used as pasture, however by using bales of silage or more annual ryegrass pasture it should be possible to extend the mountain period. The farm co-operative seems to be the less competitive in spite of substantial work time savings. The reason for this is mainly the loss of subsidies. The alternative also involves substantial investments in buildings and AMS. If subsidies are paid equal to individual farms and some savings due to less use of old farm buildings are accounted for, it might be better than individual farming, however, not as profitable as the cheese production under MF. It should be possible to combine the CP and FC, however, a mobile AMS should then have to be considered.

3.4 Risk Assessment

The cumulative CDFs of farm profit for a sample of the systems, simulating the stochastic variables with 200 iterations, and incorporating the solver, are displayed in Figure 1. An analysis of Stochastic Dominance with Respect to a Function (SDRF) gave the following preferences 1) MP 25 tons, 2) MP 5 tons, 3) MP March, 4) CP March, 5) FP March, and 6) FC March. The ranging was the same for risk neutral decision makers (RAC=0) and extremely risk averse decision makers (RAC=4)[2].

[2] A rough classification of risk aversion coefficient (RAC) has been offered by ANDERSON and DILLON (1992): risk neutral (RAC=0), hardly risk averse (0.5), somewhat risk averse (1), rather risk averse (2), very risk averse (3), and extremely risk averse (4).

Figure 1. The cumulative CDFs of farm profit for a sample of the systems, simulating the stochastic variables 200 iterations and incorporating the solver



Source: calculations in Lp Model supported with Simetar©

The results indicates that for smaller dairy farmers developing the seasonal mountain processing business might be a considerably more profitable strategy than delivering the milk from the mountain or retaining the cows at the farm site. The large mountain cheese-production alternative is more risky with a wider range in the solutions, but generally, the risks seem to be on the upside of the others. More specific risks in the MP 25 tons alternative are such as declining product quality and authenticity. The milk processed in the mountain is not pasteurised. A risk of diseases due to food contamination due to e.g. bad hygiene have been ruled out in our analysis, since it will mainly affect the production of fresh cheeses and not fermented cheeses. Pasteurization of the raw or skim milk is an option for producers of such products. For individual farmers much of that risk is transferred to the dairy industry by selling fresh milk to them. Also over expansion and declining prices is a risk in the processing alternatives.

The probability for a farm profit above NOK 200,000 is estimated to 0.41 for the farm co-operation (FC) alternative. This compares with 0.94 for the common pasture (CP) and 0.91 for the farm pasture (FP) alternative. For the MP alternatives the chances are 0.98 (5 tons) and 0.99 (25 tons). The agricultural policy measures, in particular the national milk quota coupled with exemptions for farm-processed milk, together with the special support for this production system is an important reason for the results. Ample subsidies for smaller farms and de-motivating subsidies for large scale farming co-operatives are also important. However, the downside political risks due to a strong reliance on structural measures in the farm subsidies should not be overlooked. Larger farming co-operatives might become relatively more competitive if the policy measures are lowered.

Similar risk assessment conducted using the farm profit per h resulted in a 0.92 probability of a value less that NOK 160 (€ 20) for the FP alternative compared to values of 0.94 and 0.92 for the MP alternatives without processing or processing of 5 tons, respectively. For the CP and FC alternatives the figures were 0.91 and 0.99 while for the MP processing 25 tons the figure was 0.11. Particularly for the MP processing of 25 tons variation in work needed for cheese making and for marketing could easily have been underestimated, resulting in a too favourable assessment, ref. the discussion above.

Finally, animal welfare implications should be noted as a special advantage of free ranging cows on natural range pastures in the MP system. Generally the differences between the alternatives need to be considered for the whole production system, including the indoor period. Smaller dairy farms may have a tie-stall barn while larger farming cooperatives all have free stall barns. Free stall barns will, however be required for all dairy farms from 2024.

4 Conclusion

Seasonal mountain dairy farming in Norway has declined substantially in recent years representing a threat to biodiversity in mountain semi-natural grasslands. However, pasturing is favorable for animal welfare and alpine pastures may be well suited. Moreover, alpine pasture products are typically richer in PUFAs regarded as healthy and important to prevent cardiovascular diseases. They also have a higher content of α-tocopherol, carotenoids and terpenoids. The color and texture and probably also the flavor of dairy products are affected when cows graze species rich and diverse pastures at high altitude. European consumers expect mountain products to have several attributes considered to be positive such as hygiene, authenticity etc. as cited by EUROMONTANA (2010). Such properties may attract more consumers interested in the dairy products and become an important factor in business development.

Even in areas where mountain dairy farming is still common, the processed amounts are small. However, family farms should consider maintaining the seasonal dairy business activity if they need to find more employment since the activity pays a similar wage per h as retaining the cows at the farm. We find that processing the milk in the mountain may be a viable strategy as its current profitability is better than any of the dairy alternatives examined. This is partly due to the support for such production but also due to the high market prices obtained for cheese and cream produced in the mountain compared to industrial cheese and sour cream. In Norway such cheeses might compete with specialty cheeses, much of which are imported. Specialty cheeses have higher absolute price and expenditure elasticity than standard cheeses and industrial whey cheeses (GUSTAVSEN and RICKERTSEN, 2003). Processing the milk locally enables farmers to take advantage of special mountain milk qualities, valued by many consumers but currently not reflected in the price paid by the dairy company.

Exemption for farm produced milk in the national milk quota is also important as it allows farmers to have more cows. There has not been much focus on the economy of processing mountain milk and farmers may not be aware of opportunities to improve the economy this way. It is possible seasonal mountain farming business will expand until the demand is satisfied. Whether the price can be sustained in a longer run if more farmers elect this option remains to be seen. Marketing and co-operation on marketing might become critical for a long run business development if production increases and the demand situation become more constrained while currently it is not an importunate issue.

Still, many mountain farmers will decide not to enter the milk processing business or select other alternatives for different reasons. The economy of Norwegian dairy farming is policy determined and farmers need to consider those when planning their production. The current structural payments will be lowered when small farmers join together and this can make investments in a large scale farm co-operative unprofitable. We thus find that dairy farmers in mountainous areas with 10-20 cows and a quota around 100 thousand l are better off by continuing in the current way of farming unless the time saved has a substantial alternative value. Market opportunities should not be overlooked, and farmers may improve the situation by moving the time of calving to late winter or spring to take advantage of a higher milk price during the summer. But that will be at the costs of a higher opportunity value of the family workforce in the summer. If the work situation becomes more constrained, particularly in the summer season, a common pasture with some neighbors could be advantageous – particularly if a substantial part of the farming area is in the mountain. In that situation the subsidies on the individual farms could be kept more or less unchanged.

Disclosure Statement

The authors are not aware of any potential conflict of interest including any financial, personal or other relationships with other people or organizations within three (3) years of beginning the work submitted that could inappropriately influence (bias) their work.

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Acknowledgement

The authors are grateful to the Research Council of Norway, the counties of Oppland and Buskerud, and "Valdres Natur og Kulturpark" for funding the study and to Dr. Brian Hardaker for commenting a previous draft of the article.

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