Key Performance Indicators on Dairy Farms

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Abstract

The aim of this paper is to present a method for identifying key performance indicators (KPIs), and to present and discuss a set of such indicators suitable for benchmarking on dairy farms.

Data were collected from the Norwegian Dairy Herd Recording (NDHR) and the Norwegian Dairy Financial Recording (NDFR) databases for 2000 and 2001.

KPIs can be used to recognize differences in economic efficiency between farms. To rank farms according to efficiency two indices are calculated using Data Envelopment Analysis (DEA). One is based on gross margins, and the other on gross margins including subsidies less fixed roughage costs. To identify the correlations between KPIs, principal component analysis and multiple regression are applied.

A total of 26-27 KPIs were detected. Some important KPIs were:
-gross roughage costs (variable and fixed roughage costs)
-milk income minus variable feed costs
-meat produced per cow
-consumption articles (detergents, brushes, flypaper and so forth)
-milk yield per cow
-meat income minus variable feed costs
-livestock purchased
-quota filling
-roughage yield

In general both fixed and variable feed costs, and the difference between milk income and variable feed costs were the most important KPIs.

Keywords: Key performance indicators, benchmarking, efficiency, economic performance, gross margin

Introduction

Background

One of the intentions of this paper is to improve the value of the extension service in dairy production in Norway. The service offered by the extension service may be described as performance benchmarking on farms. Benchmarking compares performance with that of others engaged in a similar activity and learning from the comparisons that follow (Ashworth 2002). Benchmarking requires the measurement of aspects of the production process. These are used to generate quantitative key performance indicators (KPIs), which describe the competitive performance and the production process achieved and used by the average and best farms (Collis & Franks 2003). The quality of the work provided by the extension service is dependent on the relevance of the indicators used.

The general intention of benchmarking is to enable profit to be maximised by optimising inputs and outputs (Collis & Franks 2003). An outcome of benchmarking is the adoption of better practices that in turn should result in improved profit. Sufficient KPIs need to be available to allow the competitive status and the process used to achieve that performance to be identified. The focus is on the initial steps, which provide the necessary background for performing the benchmarking on individual farms.

The task is to find KPIs that;

- measure the level of achievement from a specific resource
- are based upon the economic influence they carry
- contain information about an individual business's strengths and weaknesses
- describe the production process achieved and used by the average and best farms

Suitable farms for comparison must have:

- similar types of farms/enterprises
- similar opportunity regarding portfolio of income sources
- similar sized units

In the next section we briefly discuss related studies. Then we divide our task into its two main components; (i) ranking farms according to performance, and (ii) searching for key factors that determine these rankings. Under (i) we also discuss how our ranking method is related to profit maximization. The data is then presented. Then we describe the methods used, both when ranking farms and when determining key performance indicators. Finally the main results from the study are presented and discussed.

Previous studies

Investigating the differences in farming success is not a new issue. Research over more than 90 years has not come up with a good explanation why results differ between farms (Fox et al. 1993). One reason might be that success can be measured in many ways and by many factors, and farmers put different weight on different factors. Success is therefore a subjective measure (Olsson 1989). Alternatively, success depends on subjective alternative-values of resources used in production.

Fixed costs such as labour costs, interest and depreciation vary a lot between Norwegian dairy farms (Giæver et al. 1995). Low variable costs in general, and more specifically low feeding costs such as concentrate costs, variable roughage costs and costs for other purchased feedstuffs, are important for obtaining a high gross margin (Flaten & Giæver 1998, Rougoor et al 1999, Cunningham et al 1998, McGilliard et al 1989, Williams et al 1987, Pritchard & Smith 1987, Farrar & Franks 1998). In a production system with milk quotas, a reduction in the roughage price will increase the use of roughage and decrease the use of concentrate, and vice versa (Flaten 2001). Pasture use is reported to have a positive effect on variable costs compared to hay and silage (Williams et al 1987). Increased beef production per cow increases profitability (Flaten & Giæver 1998, Hansen et al. 2000). A significant part of the beef production in Norway is from dairy herds. With low profitability in beef production, it is often profitable to reduce the number of bulls to increase milk production through quota purchasing (Flaten et al 2003). In Norway it was possible for farmers to buy milk quota in 2001, but not in 2000.

A moderate level of milk yield per cow can give the highest gross margin per litre of milk under Norwegian conditions (Flaten 2001). Hansen et al. (2000) found no relationship between milk yield and gross margin per litre. Rougoor (1999) reports a negative relationship between milk yield and gross margin per litre, and also a negative effect of large quota per ha and gross margin per litre. Mc Gilliard et al (1990) found an economic optimum at approximately 8200 litres per cow under American conditions, while Pritchard & Smith (1987) report increasing gross margin with increasing milk yield. High milk yield alone does not automatically generate a high net margin (gross margin less fixed costs) (Farrar & Franks 1998). There is little difference in gross margin per litre of milk between groups of farms with different milk yield (Farrar & Franks 1998).

A positive effect of increasing herd size on gross margin per cow is reported by Mc Gilliard (1990), while Hansen et al. (2000) found no such effect. Farrar & Franks (1998) found that the top 25 percent of the farms with respect to gross margin per litre milk were slightly smaller than the average herd size. However, when fixed costs were taken into account, the smaller herds were at a disadvantage because of their relatively high labour input. There is a positive effect on gross margin from good fertility status in the herd (low culling rate due to fertility problems, low age at first calving, high conception rate to first service, short calving interval) (Rougoor et al. 1999, Williams et al 1987, Pritchard & Smith 1987, Dijkhuizen et al 1985, Mourits 2000, Hansen et al. 2000). Reproductive disorders also effect milk yield per cow negatively (Fourichon et al 2000). Gross margin is also positively affected by good health status in the herd (low culling rate due to health problems, few veterinary treatments per cow, low veterinary costs) (Rougoor et al 1999, Hansen et al. 2000, Williams et al 1987) The average yearly loss due to mastitis in Norwegian dairy herds is NOK 0.144 per litre of milk (Forshell & Østerås 2002).

While Hansen et al. (2000) found no significant impact on gross margin from milk quality, a positive impact from low cell count in milk on profitability is reported by Williams (1985). A positive effect on gross margin from high milk price is also reported by Pritchard & Smith (1987).

These studies are based on explaining differences in certain economic variables that we expect are related to profitability. To sum up the following factors might be KPI-candidates under Norwegian conditions:

- low depreciation and interest costs on machinery and buildings
- low feeding costs in general, particularly concentrate costs
- low variable costs in general, including roughage and veterinary/medicine costs
- moderate milk yield

- good fertility status in the herd, with short calving interval
- low cell count in milk
- low culling rate on cows
- low age at first calving
- high milk price.

Efficiency studies applying either data envelopment analysis or stochastic frontier functions typically focus on investigating efficiency changes over time, or the current level of efficiency (Kumbhakar & Heshmati 1995, Bravo-Ureta & Rieger 1991, Thiele & Brodersen 1999, Tauer 2001). However, a literature review shows surprisingly little research undertaken to highlight the underlying causes of efficiency at farm level. Sipiläinen (2004) reports that although profitability and efficiency were related to the size of farms, changes in productivity and efficiency did not necessarily coincide with the growth of farms.

Identifying key performance indicators

KPIs are intended to be tools to understand and explain performance. Before we can identify KPIs, the initial step is to measure farm performance. Our starting point is profitability.

Profitability

The actual profitability of the farms is not recorded in the data sample. The most aggregated economic information in the data source is gross margin including all subsidies and after deducting the fixed cost of roughage production. We have defined this as the “extended gross margin”. When comparing gross margins, one can put to one side some of the disadvantages of small herds, particularly the relatively high use of labour (Farrar & Franks 1998). This enables a more critical examination of the efficiency of milk production in relation to the main variable costs over which the farmer has more managerial control (Farrar & Franks 1998). Additionally it might be argued that gross or net margin, when measured per cow, has less relevance when the ultimate limiting factor is not necessarily hectares of land or cowshed capacity, but the amount of milk that can be produced.

Making farm results comparable

One problem with accounting data, as net income or extended gross margin as indicators of short run profit, is that a large part of the variation is due to the scale of the operation. The amount of fixed factors may explain these differences, but such factors are highly correlated, and it is often difficult to determine the actual contribution to profit from the different fixed factors. Therefore the dependent variable is often a result per unit, i.e. gross margin per litre of milk delivered.

As an alternative we have based the ranking of farms on the ratio between observed efficiency values and optimal efficiency values given the fixed factors as shown below. This ratio can be expressed as the efficiency with respect to short term profitability of firm i (E_i):

$E_i \equiv \frac{\pi_i}{\pi_i^*}$, where the numerator is the observed farm efficiency and the denominator is the optimal farm efficiency. The method allows us to compare farms that are similar with respect to several resource uses, instead of using a ranking dependent on one resource (milk quota) only, as gross margin per litre of milk.

In this paper a particular farm is not benchmarked against its potential. The focus here is on factors that in general are essential in explaining differences in efficiency among farms. *In our definition KPIs are synonymous to causes of differences in economic efficiency*. We therefore use E_i as the dependent variable and try to explain differences between firms to identify central KPI candidates. As pointed out in Hansen and Stokstad (2004) the efficiency indices removes the effect of differences in meat production potential between farms, and therefore makes the results comparable.

Material

Data

Data were collected from the National Dairy Herd Recording (NDHR) and the National Dairy Financial Recording (NDFR) databases for the years 2000 and 2001. The NDFR contain both biological and economic data. Approximately 10 percent of the milk producers in Norway participated in NDFR in 2000 and 2001. Both the NDHR and the NDFR are important tools for the extension services in the dairy companies. In the year 2000, 2110 farms participated in NDFR, and 2021 in 2001. Inclusion criteria in the study population was membership in the NDFR either in 2000 or in 2001. Altogether 195 farms were excluded in 2000, and 110 in 2001. The final study population consisted of 1915 farms in 2000 and 1911 farms in 2001. Exclusion criteria were taking part in a joint operation, or leaving such operations, during the study period. Also farms with obvious irretrievable erroneous recordings, of a kind that might affect the results, were excluded. The reference population consists of all Norwegian dairy farmers. This is the goal population to which the results are related. A comparison of the study population and reference population in 2000 showed that a larger percentage of the farmers in the eastern and middle part of Norway took part in NDFR than in the western and southern parts. Only 3.5 % of the farms in Northern-Norway took part, while the average was 10.5 %. The study population was found to be representative of all Norwegian dairy farms.

Data source, performance

Previous analyses of the economics of dairy farming has been based on calculated gross margin. Data for gross margin including all subsidies, less fixed costs in roughage production, is also included in NDFR since 2000. This measure is more in line with short run profitability, thus we use it as an indicator of short run profitability, and define it as extended gross margin. In order to compare our results with previous analyses, we also use gross margin as a measure of short run profitability to contrast these two measures.

Short run profitability of a farm does not make sense without relating it to use of fixed resources. We have assumed three fixed resources;
i) milk quota, ii) building capacity and iii) acreage in use.

Acreage includes both tillable land and fields used only for grazing. The database does not record building capacity. Therefore the capacity is measured as the average building acreage necessary to keep the number of cattle reported in the NDHR in the beginning and the end of the year. Unfortunately we lack data on use of labour. Such data should either have been deducted from the extended gross margin, or treated as a fixed resource.
Farm management is found to be a crucial factor in explaining farm production- and financial results (Agger, J.F. et al 2004, Olsson R. 1989, Bigras-Poulin et al 1985, Kay et al 1999, Cowen et al 1989). Unfortunately our database lacks data which describe the managerial abilities of the farmer (Rougoor 1999).

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Method

This section is divided in two. First, Data Envelopment Analysis (DEA) used to rank farms, is explained. Then we describe the analysis leading to a regression model that rationalises the variation in ranking of farms.

Data Envelopment Analysis

DEA is used to calculate relative performance of decision-making units. DEA is one way to identify the model farms that perform best, as in Lund & Ørum (1997) and to measure other farms' relative performance given the same use of resources. Ranking of farms by DEA requires that outputs and inputs from the farms are defined. As output we use our proxy for short run profitability (E1 for GM and E2 for extended GM), and inputs are the fixed resources: milk quota, acreage and cowshed capacity. These fixed resources represent key constraints for farms. Farm efficiency indices are explained by a set of economic and production variables. As dependent variables two indices are used:

-E1, based on the profitability measure gross margin
-E2, based on the profitability measure extended gross margin

These are the main variables in this paper.

We calculate product- increasing efficiency. This implies that the efficiency criterion measures the level of short run profitability on the actual farm, compared to the best farms with the same use of resources. The efficiency measures may be calculated with various assumptions regarding returns to scale. Plots of the data show little connection between gross margin per litre of milk and quota size. With no scale- related subsidies or fixed costs included, this is as expected. When computing E1, which is based on gross margin in relation to the three different inputs, we therefore use constant returns to scale. However, when computing E2, which is based on extended gross margin as output, we assume variable returns to scale. In the extended gross margin subsidies are included, and they vary significantly with scale.

The DEA measure used in a two stage process

The computed efficiency values are sensitive to errors in the 'frontier' farms. We assume that these observations are reported without errors and that linear combinations of them represent profit-maximizing behaviour. They are the farms which others are scaled against. A small number of farms are efficient, thus we have made sure that these farms on the frontier represent farms that can be reproduced, for example uses feed that is available to other producers. Further the farms on the frontier were thoroughly checked for missing data, typing errors or obvious erroneous recordings. The DEA-method provides an efficiency score that is easy to relate to for the individual unit. In addition, the initial step in the statistical analysis requires that we can rank farms to study possible nonlinear scale impact. This two-step method allows us to use the main variable of interest (relative performance) as the rank instead of the observed financial result.

Statistical analysis

In order to identify the key performance indicators we build on the ranking obtained in the DEA-analysis. The dataset consists of several variables that are causally dependent. We start out with 86 variables. These variables are financial variables (per litre or cow) used in the calculation of extended gross margin, and production variables regarding feed use/strategy, product quality, health status, fertility and production method. Due to different levels of aggregation in potential explanatory variables, highly correlated variables, large numbers of variables and interaction effects, we have applied principal component analysis (Johnson & Wichern 1992).

Due to the number of independent variables available compared to the number of farms included, it is necessary to divide the dataset for the farm as a whole into item related categories. These are as follows:

- Strategy milk (litres milk delivered, milk yield per cow etc.)
- Animal health
- Feeding and feedstuffs
- Fertility
- Breeding
- Milk quality
- Meat production
- Incomes
- Variable costs and gross roughage costs
- Milk minus feed and meat minus feed

For each of the two dependent variables, the total material was divided in four equal parts related to the quartiles of the efficiency index. The multivariable analysis then was performed in the following steps:

a) The independent variables within each subject were included in a one- way analysis of variance for comparison of the four efficiency quartiles. Variables obviously increasing or decreasing over the quartiles were specially marked for inclusion in the further analysis.

b) Principal component analysis and correlation analysis within each quartile was used to detect the relationship between the independent variables and between the independent and the dependent variables.

c) Within each set of variables listed above, variables with obvious increasing or decreasing trends in the single variable analysis were included in a multiple regression model (Lewis-Beck M., 1980) with the aim of explaining and expressing the dependent variables E1 and E2. In this analysis, both interaction effects and polynomials of second degree were tried.

d) The selected independent variables from each regression model within subjects were then put together in a final multiple regression model aiming to explain and express the dependent variables E1 and E2. Only variables x_i which contribute linearly were included in the final model as a variable x. In addition to a linear impact both interactions and polynominals of second degree were tried. We also included a short list of other possible interaction variables z_k that we suspected had an impact, or are used as relevant indicators even though they fell out in earlier stages. The total model was reduced to the final model by requiring a significance level of 10 % while reducing the model.

e) In order to determine each variables contribution to the overall R^2, a “leave one out” - technique was applied. One variable, including it`s polynomials and interactions, was withdrawn from the full regression model. The reduced model then was run, and the percentage reduction in R^2 used as an expression of the variables total explanatory power. The full model then was re-established, and the same procedure repeated for each variable. Finally the variables were ranked in descending order.

Results

Models predicting E1 and E2 in 2000 and 2001

In Table I below, variables contributing linearly in the final regression model predicting E1 in 2000 and 2001 are shown. Table II gives the results for the final regression model predicting E2. Each variables contribution to the total explanatory power (R^2) of the model is calculated using the leave-one-out technique described above. The contribution to R^2 in percentage terms is reported in Table I and II.

Table I. Explanatory power (R^2) of variables which contribute linearly to explaining E1 in 2000 and 2001. The effects of the interactions each variable takes part in are also included. The direction of the linear contribution is shown in the rightmost column.

Variable	Contribution to R^2 in 2001 %	Contribution to R^2 in 2000 %	Direction of linear contribution (+/-)
Regional subsidy	24.9	26.1	+
Milk minus feed	12.9	22.1	+
Milk yield per cow	7.5		+
Kg meat per cow	7.2	5.2	+
Livestock purchased	6.2		-
Compensations	3.3	4.1	+
Meat minus feed	3.1	4.7	+
Concentrate costs	2.5		-
Age first calving	2.4	2.6	-
Consumption articles	2.1	7.7	-
Variable roughage costs	2.0	2.5	-
Veterinary/medicine costs	1.4	3.2	-
Roughage yield	1.3	6.5	+
Calves from breeding bulls	0.9		+
Gross roughage cost	0.9		+
Livestock subsidy	0.7	2.1	-
Insemination costs	0.7		-
Protein %	0.5		-
Inseminations per cow	0.5		+
Calving index	0.3		+
Production loss mastitis	0.2		-
Mastitis treatments	0.1		-
Quota filling		6.8	+
Summermilk, %		2.3	-
Culled cows		2.1	-
Fertility status		1.4	+
Quality payment		0.6	+
Total	81.6	72.4	

Table II. Explanatory power (R^2) of variables which contribute linearly to explaining E2 in 2000 and 2001. The effects of the interactions each variable takes part in are also included. The direction of the linear contribution is shown in the rightmost column.

Variable	Contribution to R^2 in 2001 %	Contribution to R^2 in 2000 %	Direction of linear contribution (+/-)
Gross roughage costs	21.3	24.5	-
Regional subsidy	10.3	15.1	+
Kg meat produced	7.7		-
Milk minus feed	6.0	9.1	+
Litre milk delivered	5.5		+
Milk yield per cow	5.5		+
Livestock subsidy	4.9	8.5	-
Acreage subsidy	4.0		+
Quota filling	3.0	4.1	+
Consumption articles	2.2	3.0	-
Insemination costs	1.3	0.7	-
Other feedstuffs	1.2	1.4	+
Veterinary/medicine	1.2	1.2	-
Meat minus feed	0.1	2.1	+
Calving index	0.1	0.9	+
Concentrate deviation	0.1	0.4	-
Calving interval	0.1		+
Production loss mastitis	0.1		-
Protein %	0.1		+
Compensations		1.6	+
Hay %		0.8	+
Fat %		0.7	-
Fertility status		0.6	+
Culling other diseases		0.4	-
Age at first calving		0.4	-
Milk fever		0.3	-
Total	74.7	75.8	

The variable fertility status in the two 2000 -models was substituted by five singular components in the 2001-models. One of these components, number of inseminations per cow, enters the E1-model in 2001, and a second, calving interval, enters the E2-model in 2001.

Discussion

In general there is a high degree of accordance between the models in the two years for both E1 and E2. The majority of the variables are identical, and the direction of the contribution of each variable is the same in most cases. Altogether 11 variables from a total of 16 in the E1-model in 2000 also enter the 2001-model. The corresponding numbers for the E1 and E2-models in 2000 are 19 and 12. The relative importance of each variable varies between years. For instance roughage yield has larger influence on E1 in 2000 than in 2001. However, on average there was little difference between average roughage yield on the studied farms in the two years. Both models in 2001 have a larger number of variables and therefore are more complex than the corresponding models in 2000. As a result of this, the contribution from each variable is lower in 2001 compared to 2000. Nearly half the number of variables in the E1-model in 2001 contributed less than 1 % each. Year 2000 was a year with a low profitability in general, due to low product prices, while in 2001 both milk and meat prices increased (NILF 2002). In addition, a minor increase in milk quota was also possible in 2001.

The dependent variable E2 is based on reported gross margin less fixed costs and including direct subsidies related to the resource use. Gross roughage costs is a dominant variable which explains 21.3 % in 2000 and 24.5 % in 2001. Gross roughage cost is a highly aggregate variable which consist of depreciation, maintenance of machinery and roughage store, other fixed roughage costs such as electricity, fuel, machinery insurance and hired labour used in roughage production. The marginal impact of a change in a variable may be measured in the direct impact and the indirect impact, the latter depending on the size of different interaction variables.

Regarding gross margin, the direct and indirect marginal impacts are about the same size and negative. This suggests that to some extent there may be reasons for higher costs, but in general gross roughage cost is a central KPI. Gross roughage cost is also one of the potential variables used to explain variation in E1. Fixed costs in roughage production are not included in the gross margin, however the gross roughage cost enters the final equation in 2001, while the explanatory power is only 0.9 %. A likely explanation for this inclusion is that gross roughage cost is highly correlated with other variables explaining variation in E1.

Comparing fixed costs among farms is not straightforward, and therefore the results have to be interpreted with care. Comparing results require that we make some assumptions regarding comparable labour and capital requirements. Capital can partly substitute for labour, and labour is not included in our study. Including labour in the efficiency index might therefore influence the ranking between farms. Other problems regarded comparing fixed costs refer to which phase the farm and farm family is in, and to natural conditions. Since depreciation is included in the fixed costs, farmers who have made large investments lately are likely to be worse off than farmers who have put their expansion period behind them. Large differences in natural conditions might also effect the level of fixed costs. However, the results tell us that farmers should put effort in keeping their roughage costs low in order to be effective. For a dairy farmer, this stands out as one of the most important subjects to pay attention to. The significance of roughage related fixed costs in dairy production is in accordance with the findings of Farrar & Franks (1998).

Regional subsidy measured in NOK per litre of milk is also an important explanatory variable in all four equations. Regional subsidy paid per litre of milk and kilogram of meat varies between regions, and the value is influenced by the relative amount of meat against milk and the region. Therefore a negative interaction with meat production per cow or variables correlated with meat production per cow is as expected. The intention with this subsidy is to partly level out production costs between regions. These are costs not included in the gross margin (building costs, labour requirement due to lower crop yields). Regional subsidy differences explains a large part of the variation in E1 (24.5% in 2000 and 21.3 % in 2001). These shares are reduced to 15.1 % in 2000 and 10.3 % in the following year when explaining variation in E2. This is as expected since a larger share of the relevant costs are taken into account. Regional subsidy is not a potential variable to use as a KPI, but it is an interesting variable to include to explain differences between regions.

Concentrate use is to a certain extent interchangeable with forage use, so a useful measure of the efficiency of both concentrate use and forage use is milk income less variable feed cost in milk production per litre milk (Milk minus feed). Milk minus feed is a significant variable in all equations. It is the clear number two with 22.9 and 12.1 % of the variation in E1. The marginal impact of this variable is mainly the direct impact. The importance is somewhat reduced regarding variation in E2, with an explanatory power of 9.1 percent and 6.0 percent in 2000 and 2001. The relative importance of milk minus feed increases when milk price is low. In addition, the direct impact of this variable reduces and the indirect impact is negative when interaction with gross roughage cost per litre milk is taken into account. Feed costs include variable roughage costs, concentrate costs and variable costs with other feedstuffs. Under Norwegian conditions, variable roughage costs per Feeding Units milk (FUm) are significant lower than concentrate costs. Normally substitution is therefore profitable. The degree of substitution depends on the roughage quality. Good quality roughage in sufficient amounts appears to be an important strategy to maintain efficient milk production. Farrar & Franks (1998) apply a similar aggregate variable as in the present study, margin over feed and forage. Margin over feed and forage is the value of milk output less the cost of concentrates, bulk feed and forage variable costs. Farrar & Franks (1998) report a significant impact of margin over feed and forage on gross margin per litre. The herds with the highest margin over feed and forage fed fewer concentrates and more roughage per litre milk produced, thus achieving a lower feeding cost. The findings in the present paper indicate that milk minus feed is of significant importance, and therefore strongly support the findings of Farrar & Franks (1998). The results of Pritchard & Smith (1987) also indicate that it is the difference between milk price and feed costs which is crucial, and not so much the milk price or feed costs separately.

In addition to milk minus feed, both concentrate cost per litre of milk and variable roughage costs per litre of milk contribute to efficiency. The negative effects of high concentrate and variable roughage costs support the findings of Rougoor et al (1999), Cunningham et al (1998), McGilliard et al (1989), Williams et al (1987) and Pritchard & Smith (1987).

Consumption articles, often thought of as being unessential, play a significant role in explaining efficiency in all four models. On approximately 25 % of the farms in 2001 consumption articles constituted more than 0.18 NOK per litre of milk. The interaction with other variables suggests that feed production method and more use of roughage for milk production may reduce the negative impact of high expenditure in this cost group. Farrar & Franks (1998) also report relatively large differences between herds in expenditure on dairy sundries per cow.

Milk yield per cow enters the final regression models both for E1 and E2 in 2001, but is suppressed by percentage quota filling in 2000. Flaten (2001) concluded that moderate milk yield per cow often turned out to be the most profitable under Norwegian conditions. In this perspective it is a bit surprising that milk yield explains as much as 7.5 % of the variation in E1 in 2001. In Hansen et al. (2004) it is shown that the 314 farms which increased their efficiency index most from 2000 to 2001, also increased their delivery of milk most. With cowshed capacity as a fixed resource in the short run, there are two main routes to increase milk delivery. One can either increase milk yield per cow, or rebuild stall for bulls to replace bulls with cows, or do both. As mentioned above, Flaten (2004) found it often profitable to buy milk quota and replace bulls with cows. Purchasing of quota did not take place in Norway in 2000, but in 2001 it was possible to buy quota. This might explain why milk yield per cow turned out to be an important variable in 2001. While Rougoor et al. (1999) report a negative effect of milk yield on gross margin per 100 kg milk, no such effect is reported here. When comparing the findings one must have in mind that the average milk yield in the Netherlands is significantly higher than in Norway, and this might explain the difference. A similar argument can be applied when comparing with McGilliard et al (1990), who report a negative effect on net cash income per cow above 8200 litres per cow.

Meat minus feed and kg meat produced per cow appear to be the two most significant variables with respect to meat production in both years. Meat minus feed is meat income less variable feeding costs, a parallel to milk minus feed in milk production. It is a good proxy for profit per kg meat produced. However, when interpreting the results one has to have in mind that a number of farms were left out in the analysis due to missing data with respect to meat production.

Veterinary costs and insemination costs both contribute linearly and negatively in explaining efficiency in all four models. Of all 12 different health variables tried, the aggregate variable veterinary/medicine cost turns out to be the most significant in predicting efficiency. The reported significance of low veterinary/medicine expenditures is in accordance with findings of Williams et al (1987) and Farrar & Franks (1998). In the present paper both insemination costs and fertility status were found to be important key performance indicators. Fertility status is an aggregate variable consisting of the following elements; number of services per conception, days from last insemination to calving, non return percentage after 60 days, involuntary culling due to fertility problems, and number of inseminated cows and heifers. The negative economic impact of reproduction problems reported in the present paper support the findings of Williams et al. (1987), McGilliard et al. (1990) and Rougoor et al. (1999).

In the NDFR insemination costs are included with extension service costs from TINE*. To interpret the results therefore is not straightforward, one variable presumably negating the other.

Age at first calving is found to have a negative impact on economic efficiency. This finding supports those of Mourits (2000), Williams et al. (1987), Pritchard & Smith (1987) and McGilliard et al. (1990).

Final comments

In an empirical study we are limited to investigating the importance of differences we find in the dataset. We have identified variables that may help explain the variation found in the dataset. Although we found the dataset to be representative for all Norwegian dairy farms, there will always be farms where the relative importance of the KPIs will differ from our ranking. That is, on farms with large acreage and cowshed capacity relative to quota, it might be profitable to put less weight on milk yield per cow than is evident in our study. One might also find farms with severe animal health problems, so the starting point for benchmarking is therefore far more easily perceptible than what our study suggests.

A natural follow up from this study would be to investigate KPIs which describe the managerial processes behind the KPIs identified in the present paper. This would operationalize the KPIs and enable an in depth development of an “improvement action plan”. Therein lies the key to the full utility of benchmarking activities and expanding the use of this technique into practice.

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