What is the effect of operational managerial practices on dairy farm efficiency? Some results from Sweden

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Selected Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007

Abstract

The article aims to investigate how operational managerial practices can contribute to improved farm level efficiency at dairy farms. Operational managerial practices are defined as animal health, breeding, and feeding practices. The main contribution of the article is that it investigates aspects that can be adjusted every day to improve farm efficiency. Aspects describing each of the considered managerial practices are regressed on farm level data envelopment efficiency scores based on farm level data from Sweden. The results show that changes in breeding and feeding practices can lead to improved efficiency. Breeding exactly the number of heifers that is needed for replacement of the dairy cows negatively affects long-run technical efficiency. On the other hand, analyzing forage positively affects long-run allocative efficiency and analyzing fodder grain positively affects short-run economic efficiency. Feeding the cows hay instead of only silage, reduces long-run economic efficiency. No significant effects of animal health practices were found. These results suggest that the farms in the sample are homogeneous in terms of animal health practices and that inefficient farms cannot become more efficient by adapting to the animal health practices of more efficient farms.

Keywords: allocative efficiency, dairy farms, data envelopment analysis, economic efficiency, operational managerial practices, technical efficiency, tobit regression, Sweden

Efficient dairy farm production is a desirable goal if the farms are to become and stay profitable and sustainable. This is naturally important not only to the individual farm owner, but also to the society as such, because farms contribute to work opportunities in the countryside and to biodiversity. When comparing the farms in a sample to the best practice farming in the sample at hand, previous empirical literature shows that inefficiency is present in dairy farming. The average efficiency and consequently profits can increase significantly if production is conducted with more intense use of inputs or with combinations of inputs and outputs closer to optimum (e.g. Lawson et al. 2004; Heshmati and Kumbhakar 1994; Bravo-Ureta and Rieger 1991). In this literature, potential increases in efficiency were as much as 30% in terms of the overall economic input efficiency, which requires both using inputs as intensely as possible and combining inputs optimally. The potential increase in efficiency from only using inputs more intensely was between 5% and 19%.

A question that arises is how the inefficient farms differ from the best practice farms. Profitable and efficient farming can, in many ways, be said to depend on the so-called managerial factor, canalized through decision making (Rougoor et al. 1998). Both in the long-run, when strategic factors are decided on and in the short-run when factors adjustable in the day-to-day management are considered, the decisions made will influence the prerequisites of the farm and thus its efficiency. Strategic factors lay a basis of the future performance of the farm and they are especially important when new farms are started or when old farms consider major changes like buying a neighboring farm. Hansson (in press) investigated the effect of strategic factors on farm level efficiency in

dairy farms in Sweden and concluded that factors such as size of fields, distance to fields, barn type and equipment for forage production significantly influenced farm level efficiency.

Even though long-run strategic factors lay a basis for the farm and therefore influence farm efficiency, differences in the short run operational, day-to-day work and managerial practices of the farmer are particularly interesting because these actions are possible to change on a short run basis. Consequently, identifying how differences in the operational work contribute to increased farm level efficiency is interesting because it helps us understand if the inefficient farms can rapidly improve their production, and if so, how they can do so. The relationships between economic consequences and managerial practices have attracted attention in some previous literature on dairy and other livestock farms. For example, Lawson et al. (2004) concluded that Danish dairy farmers reporting higher frequencies of lameness, ketosis and digestive disorders were more efficient contrary to what they had expected. On the other hand, farmers reporting higher frequencies of milk fever, were less efficient. Sorensen and Ostergaard (2003) found correlations between dairy farm profits and when the first insemination after calving occurred. Galanopoulos et al. (2006) found that several managerial practices such as insemination method, origin of genotype and how the feed was prepared influenced the technical efficiency of Greek pig farms.

The aim of the present article is to investigate if operational managerial practices can contribute to improved dairy farm efficiency, and if it does, how it influences efficiency. The study is conducted in a sample of Swedish dairy farms. Operational managerial

practices are defined as aspects describing animal health, breeding and feeding practices. The study differs from the previous dairy farm literature in particularly three major respects. First, the focus is on operational managerial practices that the manager can improve on a short-run basis. Previous literature has not explicitly concentrated on factors that the farmer can easily change in the short-run. Second, the effects of the operational managerial practices are assessed on technical as well as on allocative and economic efficiencies. Previous literature focusing on managerial practices and efficiency, e.g. Lawson et al. (2004) and Galanopoulos et al. (2006), have not considered allocative and economic efficiencies. Allocative efficiency considers the ability of the farmer to consider cost aspects when combining inputs. Economic efficiency is a wider measure because it measures overall efficiency, including both technical and allocative efficiencies. Inclusion of allocative and economic efficiencies consequently gives a more balanced view of efficiency and how it is affected by the operational managerial practices. Third, the study is conducted at the whole-farm level, in that it considers all major inputs and outputs at the farm when estimating the farm level efficiencies. Previous literature that studies dairy farm managerial practices and efficiency (Lawson et al. 2004) conducts a partial analysis, focusing only on the milk production. However, the efficiency results at the whole-farm level should be more interesting to the individual farmer. If the study is not focused on the whole-farm level, it may suggest actions that do improve the milk production but that deteriorate the whole-farm efficiency.

Operational managerial practices at a dairy farm

Three groups of factors which all are central aspects of the daily farm work, were hypothesized to be part of the operational managerial practices at a dairy farm: animal health, breeding, and feeding practices. All these groups consist of factors that can, if not be totally changed, at least be changed and improved in the daily work. The following factors in each group were considered.

- Animal health
  - *Age of the cow at the first calving*. The age of the cow at her first calving can be hypothesized to influence efficiency in two ways. First, a heifer that is older at her first birth will be unproductive for a longer period of time. Second, if the heifer is too young, health problems related to a first birth that is too early, may decrease farm efficiency.
  - *Time between births*. A longer period of time between births may lead to longer lactations. Longer lactations were found by Bertilsson et al. (1997) to increase milk yield. Further, longer periods of time between births may reduce udder problems arising from drying off cows when they are still high yielding (Bertilsson et al. 1997), leading to improved animal health. A longer time between births also leads to fewer pregnancies per cow, which should lead to improved animal health. On the other hand, longer time between births leads to fewer calves that can be sold. Further, the milk may not be of high quality towards the end of the lactations.

- *Time in dry between lactations*. A longer time in dry between lactations leads to a longer period of time of unproductive cows. However, a longer period in dry may also lead to better animal health, which may improve efficiency, given that the cows are not dried off when they are still high yielding.

- Breeding practices
  - *Breed percentage* of the total replacement. If the breed percentage exceeds the replacement percentage, the farmer has the possibility to evaluate the heifer before deciding whether or not she should become a dairy cow. If the breed percentage equals the replacement percentage, no such possibility exists and the farmer may have to replace culled dairy cows with heifers that are not good enough.
  - *Breeds.* In Sweden two types of breeds dominate: the Swedish Red and White Breed and the Holstein type. These two differ with respect to fat and protein content in the milk as well as milk yield. This in turn may cause differences in farm level efficiency.
- Feeding practices
  - *Analyses of forage and fodder grain*. Analysis of forage and fodder grain leads to potentially more optimal feeding with respect to the nourishment.
  - *Feed ration*. If the farmer has an explicit feed ration for each individual cow he or she is hypothesized be able to reduce farm costs by optimizing the feed input.
  - *Mix of forage*. The general view is that hay has a higher value of protein compared with silage (Shingfield et al. 2002) which should increase milk quality.

However, hay production is more labor intensive, leading to a more expensive forage compared to silage. The choice of forage mix is thus hypothesized to influence farm level efficiency.

Methodology

We consider efficiency in light of the well-known paper by Farrell (1957), where efficiency is described from the input and output perspective. The input perspective corresponds to the cost side of the farm, whereas the output perspective corresponds to the revenue side. Because we believe that the short-run managerial practices are important especially for cost-minimization, we focus on the input efficiency perspective in this paper. Considering farm performance within the efficiency concept is in no way self-evident. Profitability key indicators such as returns on equity or total assets could have been used instead. However, a major advantage of the efficiency approach, compared to key indicators, is that the efficiency approach takes a comprehensive view of the farm in that all major inputs and outputs are considered at the same time (Coelli, 1995).

The methodology used in this study is a two-stage process commonly used in the efficiency literature. The efficiency scores are estimated in a first step, and then the scores are used as dependent variables in a second-stage regression. Examples of studies using this approach include Tauer (1993), Sharma et al. (1999), Iráizoz et al. (2003), Helfand and Levine (2004) and Galanpoulos et al. (2006). In the first stage, the data envelopment analysis (Charnes et al. 1978), or DEA is used to estimate the farm level

economic technical and allocative input efficiency scores. Efficiency is consequently defined with an empirical approach according to the best practice in the sample at hand. DEA allows easily for models with more than one output, as in our case. Furthermore, with DEA it is straightforward to decompose economic efficiency into its technical and allocative parts. DEA is a nonparametric method, implying that it is sensitive to measurement errors. This means that the real efficiency scores may be underestimated. In this article, efficiency is calculated both on a long-run and short-run basis. In the long-run efficiency scores, it is assumed that all inputs can be reduced to their optimal levels, whereas in the short-run it is assumed that some inputs (farmer labor and capital) are difficult to adjust to optimal levels. We determine the effect of the operational managerial practices in a second stage Tobit regression. Tobit regression is preferable in the second stage because the DEA efficiency scores are censored at one.

Even though commonly used in the literature and also stressed as logically and intuitively appealing for decision making by Yu (1998), the two-stage process described above has received criticism by Simar and Wilson (2007) because if the explanatory variables in the second stage regression are correlated with the variables used in the first stage the Tobit regression results are likely to be biased. Coelli et al (2005) maintain that the estimation results may be biased if there are highly correlated with the inputs and outputs and the explanatory variables. Simar and Wilson (2007) suggest two bootstrapping techniques to overcome this problem. However in our case this is not thought to be a problem because the second stage explanatory variables are not highly correlated with the outputs and inputs. Further, using the approach suggested by Simar

and Wilson (2007) requires that all variables are included in the whole two-stage process. Apart from implying unnecessary extra computational burdens, the bootstrap approach has serious drawbacks in our case. Because we have pooled data from different sources, we get missing values for some variables. With the traditional two-stage approach we can estimate the first-stage efficiency scores using a dataset without missing values. In the second-stage regressions, this dataset is pooled with two other datasets without information for all farms in the first dataset. Following the bootstrap suggestion by Simar and Wilson (2007) would thus mean that some available information cannot be used, which will in turn influence the estimated efficiency scores. Further, an empirical comparison between the bootstrap approaches and the DEA-tobit approach, by Afonso and St. Aubyn (2006) showed that the results were very similar across methods.

DEA equations

Assume *n* farms that use the input matrix X to produce the output matrix Y. Each farm uses its individual input matrix x_i to produce its output matrix y_i. All farms also face their individual cost-minimizing input bundle, x_i^*, and an input price matrix w_i. Furthermore, assume that in the short-run only some inputs cannot be reduced to their optimal levels: denote this input matrix X_v. The corresponding matrix of fixed inputs is X_f. Each individual farm also faces its own matrices of variable and fixed inputs, x_{vi} and x_{fi} respectively. In this setting, the long-run economic input efficiency, EI_i, of the *i*th farmer, is calculated by first solving the following linear program:

$$
\begin{aligned}
\textit{subject to} \quad & \min_{\lambda, x_{i^*}} \; w_i' x_i^* \\
& -y_i + Y\lambda \geq 0, \\
& x_i^* - X\lambda \geq 0, \\
& N1'\lambda = 1, \\
& \lambda \geq 0
\end{aligned} \tag{1}
$$

which is the cost that would occur if the farm was operating at its cost-minimizing level. $Y\lambda$ and $X\lambda$ are the efficient projections on the frontier. $N1'\lambda = 1$ is a constraint ensuring variable returns to scale. In the next step the minimized cost calculated by equation 1 is compared with the actual cost:

$$
EI_i = \frac{w_i' x_i^*}{w_i' x_i} \tag{2}
$$

The short-run economic input efficiency EI_{si}, for the *i*th farm is obtained by first solving the following program:

$$
\begin{aligned}
\textit{subject to} \quad & \min_{\lambda, x_{i^*}} \; w_{vi}' x_{vi}^* \\
& -y_i + Y\lambda \geq 0, \\
& x_{vi}^* - X_v\lambda \geq 0, \\
& x_{fi} - X_f\lambda \geq 0, \\
& N1'\lambda = 1, \\
& \lambda \geq 0
\end{aligned} \tag{3}
$$

Short-run economic efficiency is then found by the same rationale as in the long run:

$$EI_{si} = \frac{w_{vi}' x_{vi}^{*}}{w_{vi}' x_{vi}} \tag{4}$$

The long-run technical input efficiency of each individual farm is calculated by solving the following linear program:

$$\begin{aligned} & \min_{\theta_i, \lambda} \theta_i \\ \textit{subject to} \quad & -y_i + Y\lambda \geq 0, \\ & \theta_i x_i - X\lambda \geq 0, \\ & N1'\lambda = 1, \\ & \lambda \geq 0, \\ & \theta_i \in (0,1] \end{aligned} \tag{5}$$

where θ_i is farmer i's level of long-run technical efficiency.

The short-run technical efficiency of each individual farm is solved by the following program:

$$
\begin{aligned}
& \min_{\theta_i,\lambda} \theta_{si} \\
\textit{Subject to} \quad & -y_i + Y\lambda \geq 0, \\
& \theta_{si}\, x_{vi} - X_v \lambda \geq 0, \\
& x_{fi} - X_f \lambda \geq 0, \\
& N1'\lambda = 1, \\
& \lambda \geq 0, \\
& \theta_i \in (0,1]
\end{aligned} \tag{6}
$$

where θ_{si} is the short-run technical input efficiency of the *i*th firm.

Long- and short-run allocative input efficiencies are calculated residually:

$$AI_i = \frac{EI_i}{\theta_i} \tag{7}$$

where AI_i is the long-run allocative input efficiency for the *i*th farm, and

$$AI_{si} = \frac{EI_{si}}{\theta_{si}} \tag{8}$$

where AI_{si} is the short-run allocative input efficiency of farm

Data

Data for this article were pooled from different sources. Farm level accounting data obtained from Statistics Sweden and price data obtained from a database consisting of

gross margin budgets for different agricultural production lines and regions in Sweden (www.Agriwise.org, 2005) were used to construct the variables needed to estimate the first stage efficiency scores. The data from Statistics Sweden were stratified according to geographic location and size. A farm was included in our study if it *i)* was part of the data collected from Statistics Sweden and *ii)* reported more than 50% of its income from milk compared to its total income from milk, livestock, crops and forage. Data on the operational managerial practices were obtained by combining a mail questionnaire and data from a dairy cow recording scheme conducted by the Swedish Dairy Association. The dairy cow recording scheme is a service offered to the dairy farms, where they, for instance, get their milk analyzed on a monthly basis. A report is sent to the farmers stating the analyze results, pregnancy and disease status of the herd. The questionnaire was sent to a sample of dairy farmers in February 2005. With the questionnaire, data for a larger study, of which this article is one part, were collected. In total 360 farmers answered the questionnaire, which gives a total response rate was 67%. The response rate corresponding to the subsample of dairy farms analyzed in this paper was 65%, with 330 answers, although some questionnaires were only partly filled out. All data except the questionnaire were collected during several years: thus we have access to a panel starting in 1998 and ending in 2002. In the study, each farm is represented by its own yearly average of the years 1998 through 2002. The first-stage efficiency analysis is based on information about 507 individual farms. In the second-stage regressions we have missing values both because not all farms participated in the dairy cow recording scheme and because not all farms answered the questionnaire. An alternative approach would have

been to base also the first-stage analysis on only those farms for which we have information about managerial practices. However, because the methodology used in this article to assess the farm level efficiency is based on the best practice in the sample at hand, leaving out those for which we had no information about the managerial practices might have lead to biased efficiency scores.

Five outputs and six inputs that were thought to be the major outputs and inputs of milk producing farms were considered. The outputs were milk, livestock, crops, forage and "other". Other is a monetary variable representing the remaining outputs at the farm, mostly allowances. It was divided by an output price index to avoid biases due to inflation. All other outputs were measured in kilograms. DEA is not sensitive to the choice of measurement units and the same efficiency results would have been obtained if, for instance, the outputs were measured in tons instead. The inputs were fodder, labor, capital, energy, fertilizer and seed. Fodder, fertilizer and seed were all measured in kilograms. Labor was measured in hours, capital in SEK and energy in units. Fodder consists of all purchased fodder at the farm, mostly concentrate and mineral fodder. Labor consists of the total labor use at the farm, both by family labor and employee labor. Capital measures the total value of production rights, inventories, and buildings. Energy, fertilizer, and seed each measure the amount used of each. When analyzing the short-run efficiency, the labor supply by the farmer and the capital variable were held constant.

Summary statistics of the outputs and inputs are contained in table 1. Correlations between the managerial practice variables are contained in table 2.

Table 1: Mean and standard deviations of the outputs and inputs used to construct the efficiency scores and of the variables describing aspects of the short-run managerial practices. The total number of observations is 507 farms.

Variable	**Mean**	**Standard deviation**	**Missing answers**
Outputs			
Milk (kilograms)	273 361	281 354	
Livestock (kilograms)	5 677	6 331	
Crops (kilograms)	39 742	126 707	
Forage (kilograms)	2 273	13 751	
"Other" (SEK)	107 398	213 201	
Inputs			
Fodder (kilograms)	157 353	183 950	
Labor (hours, total need)	4 461	2 186	
Labor (hours, by farmer)	2 615	765	
Labor (hours, by family and employees)	1 846	1 986	
Capital (SEK)	821 258	1 092 024	
Energy (units)	111 328	107 044	
Seed (kilograms)	6 920	13 137	
Fertilizer (kilograms)	4 809	6 236	
Managerial practice variables			
Animal health practices			
Age at first calving (months)	29.667	2.926	106
Time between births (weeks)	57.243	3.646	100
Time in dry (weeks)	9.230	2.236	189
Breeding practices			
Breeding percentage (1 if the breeding percentage equals the replacement percentage, 0 if not)	0.409	0.492	189
Breeds (% Swedish Red and White Breed)	63.226	32.135	167
Feeding practices			
Analysis of forage (1 if forage is analyzed, 0 if not)	0.802	0.399	173
Analysis of fodder grain (1 if fodder grain is analyzed, 0 if not)	0.418	0.494	213
Feed ration (1 if the farmer use a feed ration, 0 if not)	0.795	0.404	180
Mix of forage (1 if the cows are feed hay or a mix of hay and silage, 0 if	0.590	0.493	173

the cows are only fed silage)

Table 2: Correlations between the factors describing the short-run managerial practices.

	Age at first calving	**Time between births**	**Time in dry**	**Breed percentage**	**Breeds**	**Analysis of forage**	**Analysis of fodder grain**	**Feed ration**	**Hay**
Age at first calving	1.000								
Time between births	0.278[a]	1.000							
Time in dry	0.085	0.231[a]	1.000						
Breed percentage	-0.083	0.099[c]	0.085	1.000					
Breeds	-0.037	-0.163[a]	-0.027	-0.001	1.000				
Analysis of forage	0.114[c]	-0.160[a]	0.004	-0.077	0.026	1.000			
Analysis of fodder grain	-0.090	-0.086	0.025	-0.067	0.072	0.353[a]	1.000		
Feed ration	0.126[c]	-0.073	0.126[c]	-0.106[c]	0.089	0.663[a]	0.360[a]	1.000	
Mix of forage	-0.010	-0.037	-0.010	0.012	0.117[c]	-0.161[a]	-0.053	-0.175[a]	1.000

[a] indicates statistical significance at the 1% level or less, [b] denotes statistical significance at the 5% level or less, [c] indicates statistical significance at the 10% level or less.

Results

Equations 1 through 8 were used to solve for the farm level efficiency scores. To facilitate the computations, prices were considered as given. This meant that equations 1

and 2, and 3 and 4 could be reduced to the same principal form as equations 5 and 6. The results are contained in table 3.

Table 3: Mean, minimum (max), maximum (min), standard deviation and skewness of the efficiency results.

Efficiency type	Mean	Min	Max	Standard deviation	Skewness
Long-run					
Economic efficiency	0.645	0.119	1.000	0.165	0.366
Technical efficiency	0.865	0.410	1.000	0.148	-0.756
Allocative efficiency	0.752	0.119	1.000	0.161	-0.528
Short-run					
Economic efficiency	0.616	0.118	1.000	0.242	0.212
Technical efficiency	0.889	0.282	1.000	0.165	-1.213
Allocative efficiency	0.692	0.118	1.000	0.226	-0.218

The results show that efficiency can be improved if all farms were as efficient as the best practice farms. The average efficiency scores ranges from 0.616 for short-run economic efficiency, to 0.889 for short-run technical efficiency. Consequently, the results imply that if all farms were as good as the best ones, short-run cost could decrease by 38.4%. The skewness of the results shows that all the technical and allocative efficiency scores are skewed towards full efficiency, whereas both the long- and short-run economic efficiency scores are skewed towards the lower efficiency levels. The technical efficiency scores are more skewed towards full efficiency compared to the allocative efficiency scores. This implies that it is more common to be fully technically efficient than to be fully allocative efficient.

The managerial practice variables were regressed on the farm level efficiency scores. Six equations were estimated: long- and short-run economic, technical and allocative efficiencies were the dependent variables in turn. When pooling out three datasets, we got missing values in the variables describing the operational managerial practices for several observations. To investigate possible structural differences between the 169 farms that had no missing values in the operational managerial practices and the 338 farms that did, the average levels of efficiency were compared between the two groups. No statistically significant evidence supporting that there would be any differences in the average efficiency levels between the two groups were found. The regression results are contained in table 4.

Table 4: Regressions of the managerial practice variables on the long- and short-run efficiency scores.

	Long run efficiency			*Short run efficiency*		
	Economic efficiency	Technical efficiency	Allocative efficiency	Economic efficiency	Technical efficiency	Allocative efficiency
Intercept	0.945[a]	1.149[a]	0.903[a]	1.095[b]	1.580[c]	0.960[b]
Animal health						
Age at first calving	-0.002	0.007	-0.004	0.003	0.014	0.000
Time between births	-0.005	-0.006	-0.002	-0.008	-0.015	-0.003
Time in dry	0.000	0.003	0.000	-0.014	0.000	-0.014
Breed practices						
Breed percentage	-0.035	-0.065[c]	0.009	-0.004	-0.053	0.022
Breeds	0.000	0.001	0.000	0.0001	0.000	0.001
Feeding practices						
Analysis of forage	0.029	-0.087	0.079[c]	-0.089	-0.026	-0.074
Analysis of fodder grain	0.057	0.032	0.036	0.088[b]	0.024	0.065
Feed ration	-0.031	0.025	-0.012	0.035	-0.063	0.063
Forage mix	-0.045[c]	-0.036	-0.024	-0.051	-0.049	-0.054
Log Likelihood	64.10	-38.48	57.76	-41.75	-82.66	-32.84

[a] indicates statistical significance at the 1% level or less, [b] indicates statistical significance at the 5% level or less, [c] indicates statistical significance at the 10% level or less.

The regression results show that none of the animal health variables, i.e. the cow age at her first calving, the time between births and the time in dry between the lactations, affect either long- nor short-run efficiency in any significant way. Regarding the breed percentage, i.e. if the breed percentage equals the replacement rate, this has a significantly negative effect on the long-run technical efficiency. However, the breed percentage does not affect the long-run economic and allocative efficiencies, nor the short-run efficiencies. Feeding practices seem to affect the economic and allocative

efficiency scores more. Analysis of forage affects significantly and positively the long-run allocative efficiency, and analysis of fodder grain influences the short-run economic efficiency in a significantly positive way. Feeding the dairy cows hay, as opposed to only silage, affects long-run economic efficiency significantly negatively.

Discussion and conclusions

The aim of the present article was to investigate if operational managerial practices, defined as animal health, breeding and feeding practices, could contribute to improved dairy farm efficiency, and if it does, how it influences efficiency. The average efficiency scores reported in table 3 show that efficiency can be improved if all farms are as efficient as the best ones. Therefore, the efficiency results reported also show the importance of the problem, i.e. that it is urgent to explain whether operational managerial practices are correlated with efficiency and if so, how? The reported average long-run technical efficiency score is slightly higher compared with the findings by Heshmati and Kumbhakar (1994) who reported technical output efficiency in a sample of Swedish farms of between 81% and 83%. Input and output efficiencies are different conceptually, but when it comes to technical efficiency they coincide if constant returns to scale is assumed or actually the case. Consequently, differences in perspective may explain the differences in efficiency levels between our study and that of Heshmati and Kumbhakar (1994). The reported average technical input efficiency score is also slightly higher than that of Bravo-Ureta and Rieger (1991), who found an average technical efficiency score of 83% in a sample of New England dairy farms. Compared with the technical output

efficiency results reported for a sample of Danish dairy farms (Lawson et al, 2004) the technical input efficiency reported in this study is lower. The average long-run economic and allocative efficiency scores are slightly lower compared to those of Bravo-Ureta and Rieger (1991). None of the referred studies estimated the short-run efficiency scores. Because efficiency scores can be sensitive to the methodology used to estimate them, to the number of observations and to the variable specification used, it is difficult to argue on a firm basis that Swedish dairy farms are better or worse than other farms. It can be argued that a high average efficiency score signals a homogeneous sample in terms of efficiency, because efficiency studies compare the farms in the sample to the best practice farms in the given sample. Thus, what the comparisons between our results and those of other authors do show is that our sample is more heterogeneous, especially in terms of economic and allocative efficiency results because these scores are lower compared with other studies. In terms of technical efficiency, our sample seems to be less heterogeneous than that of Heshmati and Kumbhakar (1994) and to that of Bravo-Ureta and Rieger (1991). However, the sample by Lawson et al. (2004) seems less heterogeneous.

The analysis of the differences in animal health practices such as the age of the cow at first calving, the time between births and the time in dry between the end of the milk period and the following calving do not significantly affect any of the long- and short-run economic technical and allocative efficiency scores. Sorensen and Ostergaard (2003) found that postponed first inseminations after calving lead to decreases in farm profits. Postponed first inseminations after calving leads to longer time between births, the

measure included in this study. Profits in the model by Sorensen and Ostergaard (2003) were defined according to enterprise gross revenue, a short run measure. Reasons for why our result differed from that of Sorensen and Ostergaard can be that we base our analysis on the whole-farm level efficiency results. Further, the differences may depend on the fact that we based our analysis on an empirical setting. We investigated whether there are significant empirical differences between the most efficient farms, defined as the best practice farms, and the farms that are not fully efficient. Sorensen and Ostergaard (2003) based their analysis on a simulation model. Bertilsson et al. (1997) studied the effect of longer time period between births and found that cows with 18-month calving intervals yielded more milk per lactation compared with cows with 12-month calving intervals. The reason was that longer time periods between births lead to longer lactations. Possible reasons for why these positive effects of longer time between births do not carry over to the farm level efficiency scores may be that the effect of larger milk production is evened out by increases in fodder need and labor.

In terms of differences in breeding practices we studied the effect of letting the breeding of heifers equal the replacement rate of the dairy cows and the effect of breed choice in the herd. Letting the breeding of heifers equal the replacement rate, compared to breeding all heifers, had a significantly negative effect on long-run technical efficiency. A reason for this result is that farms that breed more heifers than needed can evaluate them before letting them become dairy cows. By doing this, the farmers can choose to keep only the most promising heifers. If the breeding equals the replacement need, this evaluation is not possible. The farmer then have to keep all heifers, including

the less promising ones and let them become dairy cows. This means that the herd is not optimized, according to animal quality, which leads to inefficiency.

Differences in feeding practices were studied in terms of analyzing forage and fodder grain, having a feed ration for the dairy cows and in terms of whether hay was included in the forage mix. Analyzing the forage significantly affected the long-run allocative efficiency, whereas analyzing the fodder grain significantly affected the short-run economic efficiency. An explanation for these results is that analyzes of the feeding facilitate more optimal feeding use. Interestingly, the effect of having an individual feed ration for the dairy cows did not significantly affect any of the efficiency scores. The reported results on how differences in feeding practices affect farm level efficiency implies that what is important is analyzing the feeding, not necessarily having an explicit feed ration. Thus, only analyzing the feeding leads to higher efficiency. Reasons for the results may be that even farmers who do not follow an explicit, predetermined feed ration, but who have analyzed their feedstuff can use their knowledge about the fodder quality when feeding their dairy cows and still optimize the feed input at least in broad. Feeding the cows a forage mix consisting at least to some extent of hay, significantly and negatively affected long-run economic efficiency. Thus, the argued positive effect of higher protein value in hay did not affect the efficiency. Reasons are that hay is a more labor-intensive production compared to silage. The positive nutrition effects of hay are thus offset by the increased resource need to harvest it.

Taken together, the results reported in this article show that some of the aspects in the operational managerial practices, especially the breeding and feeding management, can

lead to improved efficiency. Arguably, the considered operational managerial practices affect the ability to combine the inputs in more optimal ways (i.e. allocative efficiency) to a greater extent compared with the ability to use the inputs more intensely (i.e. technical efficiency). Furthermore, the effects of differences in operational managerial practices are likely to be larger on the long-run efficiency scores, with more significant results. Thus, although the operational managerial practices are possible to improve on a day-to-day basis, as opposed to strategic aspects, they are more likely to have effects in the long-run, when also the farmer labor and capital can be adjusted to optimal levels.

The results also implies that the farms in our sample apply similar animal health practices, regardless of level of efficiency. Similarity in animal health practices is also indicated by the small standard deviations in the summary statistics. An empirical approach was applied in this article, with the purpose of investigating whether less efficient farms could benefit from adapting to the management practices of the most efficient farms. A consequence of the results is thus that less efficient farms cannot learn how to become more efficient by adapting to the animal health practices used by the more efficient farms because the differences are too small. The similarity in the animal health practices is likely to be an effect of the fact that all farms considered in the regression analyzes participate in the dairy cow recording scheme, and consequently get similar management advise from the Swedish Dairy Association. Before changes in the operational managerial practices, regarding animal health, can be considered in order to improve farm level efficiency, more knowledge is needed about how improvements of these practices beyond the practice of the empirically most efficient farms affect farm

level efficiency, i.e. how to improve the practices of also the best farms. Experimental research or farmer participatory research is likely to be suitable for this. However, because the whole-farm economic consequences are what should be important to the individual farmer, these consequences need to be evaluated simultaneously.

Acknowledgement

Financial support from the Swedish Farmers' Foundation for Agricultural Research (SLF) is gratefully acknowledged.

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