**How can farmer managerial capacity contribute to improved farm performance? A study of dairy farms in Sweden**

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## Abstract

This paper investigates how managerial capacity aspects influence efficiency of dairy farms in Sweden. Based on non-parametric methods, Tobit and logistic regressions, several managerial capacity aspects are found to influence long and short run input efficiency scores, but to influence output efficiency less. Examples of important aspects are: internal locus of control, positive profitability attitude, profitability perception and participation in study circles. Based on this, a way of supporting dairy farms to become more profitable is to organize educational and discussion clubs where the farmers learn from each other and form professional dairy farm advisors.

**Keywords**

dairy farms, data envelopment analysis, decision-making, efficiency, logistic regression, managerial capacity, Tobit regression

Several studies on dairy and livestock farms show unambiguous results: the farms could be much more profitable than they are (Latruffe et al., 2005; Lawson et al., 2004; Oude Lansik et al., 2002; Heshmati and Kumbhakar, 1994; Tauer, 1993 and Bravo-Ureta and Rieger, 1991). An urgent question is why the farms are not as profitable as they can be. Differences in managerial capacity are emphasized in the literature as a reasonable explanation (Boehlje & Eidman, 1984; Wilson et al., 1998; Nuthal, 2001).

Because of its complexity, managerial capacity has often been treated as a black box, represented only by a few aspects such as age and education of the manager, when authors try to explain efficiency differences in agricultural production (see for example Sharma et al., 1999; Coelli et al., 2002a). The decision-making process, which is argued by Rougoor et al. (1998) to be an essential aspect of managerial capacity is normally omitted. In efficiency studies at dairy farms, the decision-making process has, to the best of our knowledge, never been considered. In studies of other agricultural production lines there are only a few examples. Wilson et al. (2001) included business objective and number of information sources as explanatory variables for technical inefficiency in wheat farms in England, along with farm area, farmer age and education. Trip et al. (2002) model technical inefficiency in greenhouses as dependent on the values of the manager and the quality of planning, data recording and evaluation. Although these studies are moves in the direction of a better understanding of how managerial capacity influences firm level efficiency and do include aspects of the decision-making process, much is still unknown.

This study aims to investigate empirically the impact of personal aspects and decision-making characteristics on farm level efficiency, in a sample of Swedish dairy farms. Further, the study aims to investigate the impacts of personal aspects on the decision-making characteristics that prove important for farm efficiency. We want to conclude not only on how aspects of managerial capacity influence farm level efficiency directly, but also understand why farmers have certain decision-making characteristics. Knowledge of this can contribute to a better understanding of how these farms can be supported to improve their efficiency and thus their profitability, leading to more sustainable farms.

The study differs from previous empirical literature explaining efficiency by considering the concept of managerial capacity at a deeper and more detailed level. None of the previous studies include a detailed analysis of the personal aspects of the farmer: yet personal aspects are assumed to influence the decision-making (Lee et al., 1999). Personal traits such as attitude and perception are likely to influence the decision-making and thereby the farm outcome. Furthermore, a farmer's locus of control can influence his or her ability (Öhlmér, 1998) which in turn should influence farm efficiency. Decision-making aspects e.g. what kind of information sources are used, how information is processed and how responsibility is born are not previously studied in light of farm level efficiency. Because these are vital aspects of the decision-making process, they are likely to add to the understanding of how managerial capacity contributes to efficiency. This study is the first to assess the impact of managerial capacity on efficiency on dairy farms, which differs considerably from the previous applications of wheat farms and greenhouses. Previous literature, which seriously considers the managerial aspect, focuses solely on technical efficiency. However, there is no obvious evidence why the same factors would explain all efficiency scores. Various aspects of managerial capacity may have different impact on the technical, economic and allocative long and short run efficiency scores, which is studied in this paper.

**Aspects on managerial capacity**

Rougoor et al. (1998) provided a framework for analyzing managerial capacity in light of farm efficiency. They considered managerial capacity as consisting of both personal aspects of the manager (in terms of drives and motivations, abilities and capabilities and biography) and of the decision-making process (in terms of planning, implementation and control). Rougoor et al. (1998) maintained that both the personal and decision-making aspects are necessary for understanding managerial capacity. In their model, personal aspects influence the decision-making, which in turn affects the efficiency. According to Gasson (1973) goals and values (i.e. drives and motivations) of farmers can be divided into four groups: instrumental, social, expressive and intrinsic. Perception, attitude and locus of control are further aspects of a manager's personality that have received attention in the literature. Perception can be defined as the way in which an individual sees the world (e.g. Hogarth, 2001). Attitude can be defined as a readiness or tendency to respond in a certain way (Fishbein and Azjen, 1975). The concept of attitude has been included in several studies aimed at explaining farmer behavior (Garforth et al., 2006; Bregevoet et al., 2004; Beedell and Rehman, 2000; Pennings and Leuthold, 2000). A person's locus of control indicates his or her perceived ability to influence what happens. It is often considered on a scale ranging from internal to external locus of control. Internal locus of control means that the individual believes that he or she can influence his or her situation, and external locus of control means that the individual believes other events, people, or faith are the key influences on his or her situation. Daft (2003) stressed internal locus of control as an important personality trait of entrepreneurs. Öhlmer (1998) and Öhlmer et al., (1997) found a connection between the ability of the farmer and his or her locus of control. Studies outside the agricultural setting have shown that locus of control influences behavior at least to some extent (e.g. Begley et al., 1987; Hansemark, 2003).

Decision-making processes are often described as linear processes of how decision should be made (For reviews see for example Rougoor et al., 1998; Öhlmér et al., 1998; Lunneryd, 2003). This attitude towards decision-making was challenged in a model of farmers' decision-making process described in Öhlmér et al. (1998). They suggested a model of how farmers actually do make decisions, rather than how they should make decision. This approach is appealing in this study. Based on 18 case studies Öhlmér et al. (1998) suggested that the decision-making process consists of four phases: problem detection, problem definition, analysis and choice, and implementation. Furthermore, each phase consists of four sub processes: searching for information and paying attention, planning, evaluating and choosing, and bearing responsibility. Each phase can be described as a spiral where the farmer can go back to previous phases and sub processes if needed. Five characteristics of the farmer decision-making process are stressed: continually up-dating, the use of a qualitative approach to evaluate outcomes, the preference of a " 'quick and simple' "(Öhlmér et al., 1998, p. 288) approach, incremental implementation, and finally checking clues to the future results during implementation. The qualitative approach was further discussed in Öhlmér and Lönnstedt, (2004) who maintain that intuitive decision-making cannot per se be said to be wrong. They concluded that the common view that decision-makers either use an intuitive or an analytical approach is not supported in their study. On the contrary, they suggest that the intuitive process may also be engaged in an analytical decision-maker's process.

Rougoor et al. (1998) maintain that the decision-making process can be difficult to measure in an explicit way, but suggests that the number of consultant visits at the farm, the time spent on processing farm results and the quality of the planning and control can be indicators of how the decision-making is done. We focus on the use and analysis of information in the decision-making process, and on how responsibility is born. Decision-making is much about handling information. For example, information is scanned and processed to detect and define problems. Information needs to be gathered and evaluated to choose action alternatives and to check results. Differences in information sources and in processing the information, which mirrors the degree of analytical thinking that the farmer uses, may affect the quality of the decision-making process, which in turn may affect farm performance. The quality of the intuitive process depends heavily on accurate feedback (Hogarth, 2001), i.e. on responding to relevant information on results. This view toward decision-making means that we focus on the sub processes in the model by Öhlmér et al. (1998).

Building on the model developed by Rougoor et al. (1998) and on the further aspects in the literature described above, we identify the aspects and relationships presented in figure 1 to be important determinants of the managerial capacity in farms.

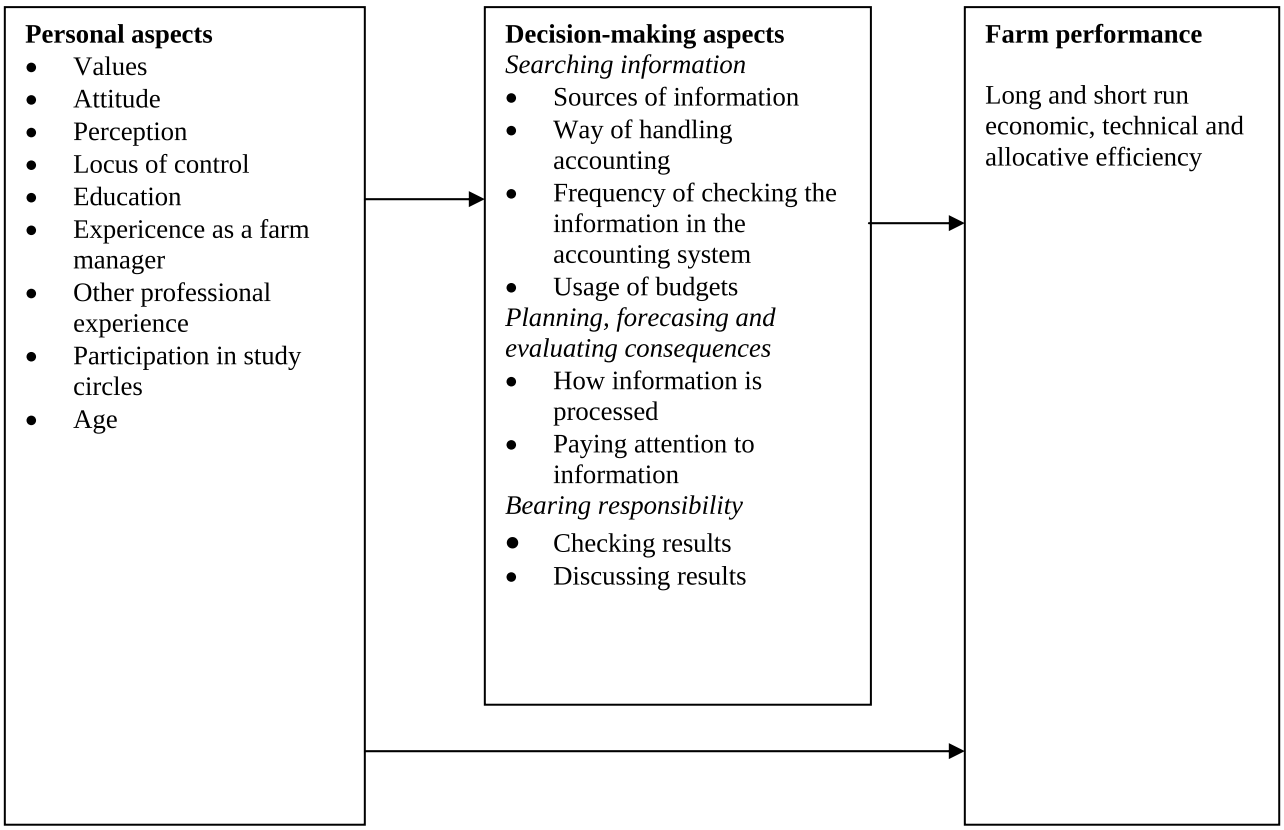


Figure 1: Managerial capacity and its connection with farm level performance.

Our model is conceptually similar to that of Rougoor et al. (1998) but it differs in the level of detail and in some other aspects. We consider the personal aspects of the farmer to influence farm level performance both channelled through the decision-making process, and directly. The direct connection between personal aspects and efficiency is justified because the personal aspects contributes to a person's general experiences and thus to a readiness to act in certain ways, without necessarily going through the deliberate decision-making system. This reasoning builds on the tacit and deliberate systems described by Hogarth (2001).

## Methodology

In this section the methodology used in the paper is described

### *Farm level efficiency*

Farm level efficiency scores are defined as economic, technical and allocative input (cost side) and output (revenue side) efficiency based on the framework by Farrell (1957). These measures are related in that economic efficiency is an overall efficiency measure, consisting of both technical and allocative efficiency. In their original forms, efficiency studies assume free disposability of the inputs (Coelli et al., 1998). In the short run this is questionable for some inputs. We will take this into consideration and estimate both long and short run efficiency levels. In the long run we consider all inputs as adjustable. In the short run, capital and farmer labor are considered as given. Only the input efficiency scores will be affected by assuming some inputs as given. In total nine different aspects of farm level performance will be studied. These, and their economic interpretation, are displayed in table 1:

Table 1: Definitions of farm level performance and their economic performance.

| **Definition of farm level performance** | **Economic interpretation** |
|---|---|
| Long run economic input efficiency | Produce a given set of outputs using the smallest and cheapest set of inputs, in the long run. |
| Long run technical input efficiency | Produce a given set of outputs using the smallest set of inputs, in the long run. |
| Long run allocative efficiency | Combine inputs in the cost-minimizing way, in the long run |
| | |
| Short run economic efficiency | Produce a given set of outputs using the smallest and cheapest set of inputs, in the short run. |
| Short run technical input efficiency | Produce a given set of outputs using the smallest set of inputs, in the short run. |
| Short run allocative efficiency | Combine inputs in the cost-minimizing way, in the short run |
| | |
| Economic output efficiency | Produce the maximal set of outputs, given the set of inputs, while maximizing revenue |
| Technical output efficiency | Produce the maximal set of outputs, given the set of inputs |
| Allocative output efficiency | Combine outputs in the revenue-maximizing way |

The Data Envelopment Analysis (DEA) (Charnes et al., 1978), is used to estimate the efficiency scores. An advantage of DEA, compared to the competing parametric method, is that it allows easily for multiple outputs. A methodology that allows easily for multiple outputs is appealing because dairy farms always produce at least the products milk and livestock. DEA does not require the selection of a specific functional form, which is desirable because erroneous selection of functional form may cause biased efficiency scores. A further advantage of DEA is that it allows straightforwardly for the decomposition of economic efficiency into its technical and allocative parts. However, DEA is a deterministic approach. All deviations from the efficient frontier will be considered as inefficiency, implying that the inefficiency will be overestimated. To conserve space and enhance focus, the equations used to solve for the DEA efficiency scores are in appendix 1.

*Determining the relationships between managerial capacity and farm level performance*

The relationship between managerial capacity and farm level efficiency is analyzed in two independent steps. In the first step, the impacts of both the personal and the decision-making characteristics on the efficiency scores are determined. Because we believe that personal aspects affect the efficiency scores in two ways (see Section 2) we conduct this step in two parts. In part one, we estimate the effect of personal aspects on the efficiency scores, and in part two, we estimate the effect of the decision-making aspects on the efficiency scores. In the second step of the analysis, the significant decision-making aspects in step one are modeled as dependent on the personal aspects. To summarize, the following equations are independently estimated:

$$efficiency = f(personal \quad aspects) \tag{1}$$

$$efficiency = f(decision \quad aspects) \tag{2}$$

$$decision \quad aspects = f(personal \quad aspects) \tag{3}$$

In the first step of the analysis, the dependent variables are the efficiency scores. These are censored at one, making the Tobit regression model a suitable choice to assess that impact of the personal and decision-making aspects. The combination of DEA and a second step regression is common in the efficiency literature, where examples include Tauer (1993), Sharma et al. (1999), Iráizoz et al. (2003), Helfand and Levine (2004) and Galanopoulos et al. (2006). The combination was also stated as logically and intuitively appealing for policy analysis and decision-making in Yu (1998). However, it was criticized in a paper by Simar and Wilson (2007), who suggested two bootstrap algorithms that could be used instead. In an empirical comparison Afonso and Aubyn (2006) found that the bootstrap algorithms and the DEA-Tobit combination yielded very similar results. Consequently, the DEA-tobit combination can be used because it is computationally easier than the bootstrap algorithms. Further, and more importantly, because some data are missing in the second stage regressions (see Section 5.2), following the bootstrap algorithms would mean that we cannot use large parts of our data because all data need to be involved in the entire bootstrap process. The DEA-tobit combination, however, allows us to use all observations to estimate the efficiency scores. Not until in the regressions, the observations with missing values on the explanatory variables need to be removed.

Some of our explanatory variables are ordinal scale variables. Although theoretically not quite correct, ordinal scale variables are often included as explanatory variables in regression analysis in the psychology literature (see for example Hertzman et al., 2001; Marchand et al., 2005 and Bousman et al., 2005) because converting them to dummy variables means a loss of information. This approach is also found in the agricultural economics literature (see for example Trip et al., 2002). When a variable is considered at an ordinal scale, it is of course not possible to say how much better one rating is to another. The coefficients of these variables will have to be interpreted with care, only as directions.

In the second step of the analysis, the dependent variables are the aspects of the decision-making that proved significant in the first step. Logistic regressions are used in this step, because they allow for the dependent variable to be a dummy variable or on ordinal scale.

## Data

We used farm level accounting data and a specification of the number of hours worked at the farm to construct the input and output variables used in the DEA equations. These data come from Statistics Sweden, and is an unbalanced panel starting in 1998 and ending in 2002. We let each farm be represented by its own average of the years it participated in the panel, as an attempt to correct for stochastic variations in the data, which are not handled in DEA. A farm is defined as dairy farm, and included in our study, if its income part from milk, compared to total income from milk, livestock, crop and forage, exceeds 50%. In total, after removing three potential outliers, our dataset consists of 507 farms. Price data are not explicitly included in the dataset from Statistics Sweden, but when they could not be calculated from it, they were taken from a database consisting of yearly gross margin budgets for different agricultural production lines and regions in Sweden (www.agriwise.org 2005). The managerial capacity aspects were collected through a mail questionnaire. The questionnaire was sent to the farmers in February 2005. The response rate was 65%, however there were some missing answers in the returned questionnaires.

*Inputs and outputs*

Six inputs were considered: fodder, labour, capital, energy, seed and fertilizer. Fodder, seed and fertilizer were all measured in kilograms, labour was measured in hours, capital in SEK and energy in units. The fodder variable represents all purchased fodder used at the farm, mainly concentrate and mineral fodder. Labour consists of all labour hours used at the farm, by both the farmer and possible employees. Capital is a measure of inventories, buildings and production rights.

Five outputs were considered: milk, livestock, crops, forage and "other". All outputs except "other" were measured in kilograms. The "other" variable is a measure in SEK and consists of all remaining income at the farm, mostly allowances. It was divided by an output price index (Swedish Board of Agriculture, 2004) and the output price index was considered as the price of the "other" output. This way of treating a monetary output is similar to that of Coelli et al. (2002b). Summary statistics of the inputs and outputs are contained in table 2:

Table 2: Summary statistics of the inputs and outputs

| **Variable** | **Mean** | **Std** |
|---|---|---|
| *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 capacity aspects*

The factors considered to describe the personal and decision-making aspects of managerial capacity were outlined in figure 1. A dummy variable for being located in the north of Sweden was included in all regressions of equations 1 and 2, to account for differences in the external environment. The north of Sweden can be argued to differ considerably from the south, because of differences in climate, soil and field size, as well as in allowances. Here follows a more detailed description of how the measures of the managerial capacity aspects were constructed.

*Values* were considered as being instrumental, expressive, social or intrinsic. In the questionnaire, the farmers were asked to rate a number of value statements corresponding to each of these values on a scale ranging from one to four. One meant that the value in the statement was not important at all, and four meant that it was very important. A farmer was assigned to a value type if he or she had rated at least one statement corresponding to that specific value type as very important. A farmer could thus belong to all value types if he or she had rated statements corresponding to all types as very important.

*Profitability attitude* was measured by considering *i)* the farmer's perceived profitability in his or her dairy farming today and *ii)* the expected profitability in the nearest future years. The perceived and expected profitability is considered to influence the farmer's attitude to farming. The farmer was asked to rate the perceived present profitability in his or her dairy production on a scale ranging from one to five. One meant that the farmer believed that he or she experienced very good profitability and five meant that the farmer believed that he or she experienced very bad profitability. Likewise, the farmer was asked to rate how the profitability of his or her dairy production would develop in three years, although the option "I will have quitted in three years" was added. Dummy variables were then constructed for a positive attitude. A farmer was considered to have a positive attitude towards dairy production today if he or she answered one or two in the first case, and a positive attitude towards dairy production in the future if he or she answered one or two in the second case.

A measure of *profitability perception* was constructed in two steps. First, the farmer was asked to compare the profitability of his or her farm to that of an average Swedish dairy farm on a scale one to five. One meant that the profitability was a lot better and five meant that it was much worse. Second, the real performance, as calculated by the accounting data, was compared to the farmer's rating. Farm level averages of all the efficiency scores were calculated and considered the real performance. The farms were ranked according to this score and then divided into five equally large groups. The groups were then assigned scores ranging from one to five, with one given to the best group. A measure of the farmer's perception was calculated by subtracting the first score from the second score. Perception was thus measured on a scale ranging from negative deviations from reality to positive deviations.

*Locus of control* was measured on a scale from one to four ranging from low to high internal locus of control. In the questionnaire, the respondents were asked to indicate which one of a number of factors influenced long run profitability of their farm the most. If the farmer indicated his or her own decisions as the most important factor, a locus of control rate of four was assigned. If the farmer indicated his or her family as the most important factor, a rate of three was assigned. An indication of politicians or the dairy plant processor as the most important factor gave a score of two, and if the weather, faith, or luck was mentioned as the most important factor a score of one was assigned.

The *education* of the decision-makers at the farm was considered as dummy variables and measured both in terms of having any university or collage education, and in terms of having an education in agriculture.

*Experience as a farm manager* was measured as the number of years the respondent had been a farm manager.

*Professional experience from other sectors than farming* was measured as the number of years the farmer had worked in other sectors than the agricultural sector. A distinction was made between being a worker and a manager in other sectors. If no other professional experience existed, the farmer was assigned a zero.

*Participation in study circles* was measured on a scale ranging from one to four, corresponding to never participating to participating every year.

*Age* was measured as the farmer's age at the end of the data panel, i.e. in 2002.

*The information used in the decision-making* was considered as being of the following four types: dairy farm advisors, family members, other farmers or colleagues, and media. In the questionnaire, the farmer was asked to rate a number of information sources, corresponding to the types defined above, on a scale ranging from one to four. One meant that the source was not important at all, and four meant that it was very important. A farmer was assigned to an information source type if he or she had rated at least one of the information sources corresponding to that source type as important or very important. A farmer can thus belong to all source types if he or she had rated sources corresponding to all types as important or very important.

The *way of handling accounting* considered whether a professional accountant did all the accounting or not. If that was the case, a one was assigned. If the farmer did all or at least part of the accounting him or herself, a zero was assigned.

*How often the book keeping is checked* was measured on a scale ranging from one to five, where one meant never and five meant at least every month.

*Budget preparation* was considered as the active preparation of new budgets for the coming year. If the respondent prepared a new budget for the coming year, a one was assigned. If no budgets were prepared, or if the income and expenses of the previous year were used as budgets, a zero was assigned.

*Analytical thinking* was considered as the presence of analytical thinking while processing information. It was included as a dummy variable in the regressions. It was assumed that everyone uses intuition when processing information, but that some also use analytical thinking.  In the questionnaire, the respondents were asked to indicate how they process information, and if they answered "using paper, pencil and calculator" or "using a computer" they are considered as having analytical thinking.

*Degree of attention paid to information* was measured on a scale ranging from one to four. The scale ranged from no attention at all, to studying the information in detail. In the questionnaire, alternatives according to this scale were given and the farmer was asked to indicate the alternatives that described him or herself. A measure of attention was then constructed by considering the alternative chosen by each farmer that gave the highest level of detailed studying.

*Checking the results*. In the questionnaire, the respondent was asked to indicate whether the results of a decision was normally checked or not. If the respondent checked the results, at least in broad, then he or she was considered to check the results, otherwise not. This was included in the regressions as a dummy variable.

*Discussing decisions.* If the respondent discussed his or her decisions with someone before implementing them this variable was assigned a one, otherwise a zero.

Table 3 contains summary statistics of the managerial capacity aspects considered in this study. It is interesting to note that all considered values except expressive values seem to be important to several farmers. Few farmers have a positive profitability attitude to farming today, and even fewer have a positive profitability attitude to farming in the future. The average level of profitability perception is -0.09, which means that, on average, the farmers perception of reality coincide with reality according to the accounting data. When it comes to the decision-making aspects, it is interesting to note that about 200 of the farmers who answered the questionnaire consider each information source as important. Much less than half of the farmers in our sample had an analytical approach of processing information even though a high degree of attention was paid to the information.

Table 3: Summary statistics of the managerial capacity aspects

| **Variable** | **Scale** | **Value (Std)** | **Missing values** |
|---|---|---|---|
| Geographic location | 1 if the respondent is situated in the north of Sweden | 146 | - |
| | 0 if not | 361 | |
| *Personal aspects* | | | |
| Values: | | | |
| Instrumental | 1 if the respondent has instrumental values | 212 | 200 |
| | 0 if not | 95 | |
| Expressive | 1 if the respondent has expressive values | 127 | 227 |
| | 0 if not | 81 | |
| Social | 1 if the respondent has social values | 177 | 219 |
| | 0 if not | 111 | |
| Intrinsic | 1 if the respondent has intrinsic values | 206 | 205 |
| | 0 if not | 96 | |
| Profitability attitude 1 | 1 if the respondent has a positive profitability attitude towards dairy farming today | 58 | 189 |
| | 0 if not | 260 | |
| Profitability attitude 2 | 1 if the respondent has a positive profitability attitude towards dairy farming in the future | 45 | 201 |
| | 0 if not | 216 | |
| Profitability perception | -4=The most negative deviation.............4=The most positive deviation | -0.090 mean (1.531) | 217 |
| Locus of control | 1=Low locus of control..........................4=High locus of control | 3.220 mean (0.987) | 194 |

**Table 3 continued**

| | | | |
|---|---|---|---|
| University education | 1 if the respondent has a university or college education | 31 | 179 |
| | 0 if not | 282 | |
| Education in agriculture | 1 if the respondent has an agricultural education | 156 | 179 |
| | 0 if not | 172 | |
| Experience as a farm manager | Number of years | 25.253 mean (9.729) | 183 |
| Other professional experience (worker) | Number of years | 3.478 mean (7.610) | 188 |
| Other professional experience (manager) | Number of years | 0.868 mean (4.045) | 188 |
| Participation in study circles | 1=Never...............................................4=once a year | 2.148 mean (1.197) | 177 |
| Age | Years | 51.234 mean (9.028) | - |
| *Decision making aspects* | | | |
| Important sources of information: | | | |
| Farm advisors | 1 if the respondent considers farm advisors as important | 226 | 203 |
| | 0 if not | 78 | |
| Family | 1 if the respondent considers family as important | 211 | 221 |
| | 0 if not | 75 | |

**Table 3 continued**

| | | | |
|---|---|---|---|
| Other farmers or colleagues | 1 if the respondent considers other farmers or colleagues as important<br>0 if not | 213<br>87 | 207 |
| Media | 1 if the respondent considers media as important<br>0 if not | 208<br>91 | 208 |
| Accounting | 1 if the accounting is conducted by only professional accountants<br>0 if not | 60<br>272 | 175 |
| Check accounting | 1=Never.............................................5=Every month | 3.232 mean (1.259) | 179 |
| Budgets | 1 if the respondent does a completely new budget<br>0 if not | 47<br>266 | 194 |
| Analytical way of processing information | 1 if the respondent processes information in an analytical way<br>0 if not | 124<br>203 | 180 |
| Degree of attention paid to information | 1=Low degree......................................4=High degree | 2.969 mean (0.722) | 184 |
| Checking results | 1 if the respondent check results<br>0 if not | 211<br>116 | 180 |
| Discussing decisions | 1 if the respondent discusses the decision with someone<br>0 if not | 294<br>33 | 180 |

## Results

In this section the results of the study are presented.

### *Efficiency levels*

Farm level efficiency scores were obtained by solving equations A1 through A12 in Appendix 1. The input and output prices were considered as given to facilitate the calculations. The farms are assumed to operate under variable returns to scale. Summary statistics of the efficiency scores are contained in table 4:

Table 4: Summary statistics of the efficiency results

| Efficiency type | Mean | Min | Max | Std |
|---|---|---|---|---|
| *Input orientation long run* | | | | |
| Economic efficiency | 0.645 | 0.119 | 1.000 | 0.165 |
| Technical efficiency | 0.865 | 0.410 | 1.000 | 0.148 |
| Allocative efficiency | 0.752 | 0.119 | 1.000 | 0.161 |
| *Input orientation short run* | | | | |
| Economic efficiency | 0.616 | 0.118 | 1.000 | 0.242 |
| Technical efficiency | 0.889 | 0.282 | 1.000 | 0.165 |
| Allocative efficiency | 0.692 | 0.118 | 1.000 | 0.226 |
| *Output orientation* | | | | |
| Economic efficiency | 0.745 | 0.240 | 1.000 | 0.180 |
| Technical efficiency | 0.854 | 0.276 | 1.000 | 0.164 |
| Allocative efficiency | 0.873 | 0.294 | 1.000 | 0.117 |

The results indicate that there are large variations in farm level efficiency, which means that there are large possibilities to improve efficiency. Economic efficiency consists by definition of technical and allocative efficiencies. In the long run input case, the allocative efficiency is lower than the technical efficiency, which implies that the main reason for long run economic input inefficiency is that of difficulties in cost-minimizing.

This feature is also true for the short run economic input efficiency, in fact the effect is even more striking here. The economic efficiency in the output case is higher than that in the input case. The average allocative output efficiency is higher than the average technical output efficiency, implying that the reasons for economic output inefficiency lie more in technical processes than in the combination of outputs.

*The impact of managerial capacity on farm level efficiency*

In a first step, the impact of the personal and of the decision-making aspects on the efficiency scores were independently assessed by Tobit regression. In a second step, the impact of the personal aspects on the decision aspects which proved significant was assessed. The logistic model was used, because the dependent variables were either dummy variables or ordinal scale variables. However, to avoid convergence problems, the Probit model was used when the dependent variable was the decision aspect *discussing results*. The logistic model builds on the logistic function whereas the Probit model builds on the cumulative normal function. These functions are very similar, making the choice of which one to use a matter of taste and convenience (Kennedy 2001).

As indicated in table 3, there were missing values in the dataset collected through the questionnaire. The missing values were due both to totally blank questionnaires and to questionnaires that were only partly completed. To explore the possibility of systematical differences between the farms that had missing values and those who had no missing values at all, the average levels of the different efficiency scores in the two groups were compared. We have reasons to believe that the farms which had no missing values in the decision-making variables (233 farms) have, on average, a higher level of long run economic input efficiency (p-value = 0.0967), compared to the farms that had missing values (274 farms). Further, the farms without missing values have, on average, higher economic and allocative output efficiency (p-value=0.0127 and 0.0015, respectively). We also have reasons to believe that the farms that had no missing values in the personal aspect variables (196 farms) are characterized by higher economic and allocative output efficiency (p-value = 0.0808 and 0.0126 respectively). Consequently, the farmers who were included in the regression analyses were characterized by higher efficiency, as far as some efficiency scores are concerned, which has to be kept in mind when analyzing the results. In the cases where the differences in the average efficiency levels were significant, the differences are between 0.0245 and 0.04.

*Regression results*

To enhance the readability of this paper, we present the regression results of equation 1, 2 and 3, focusing on those with economic efficiency scores as dependent variables because these are the overall efficiency scores. In presenting the results, we focus only on the significant relationships. Tables showing the complete equations are contained in appendix 2. The results are presented in accordance with figure 1. Similarities or differences in the models of technical and allocative efficiencies are commented on in the text. Figure 2 shows the managerial capacity aspects that significantly influence the long run economic input efficiency.

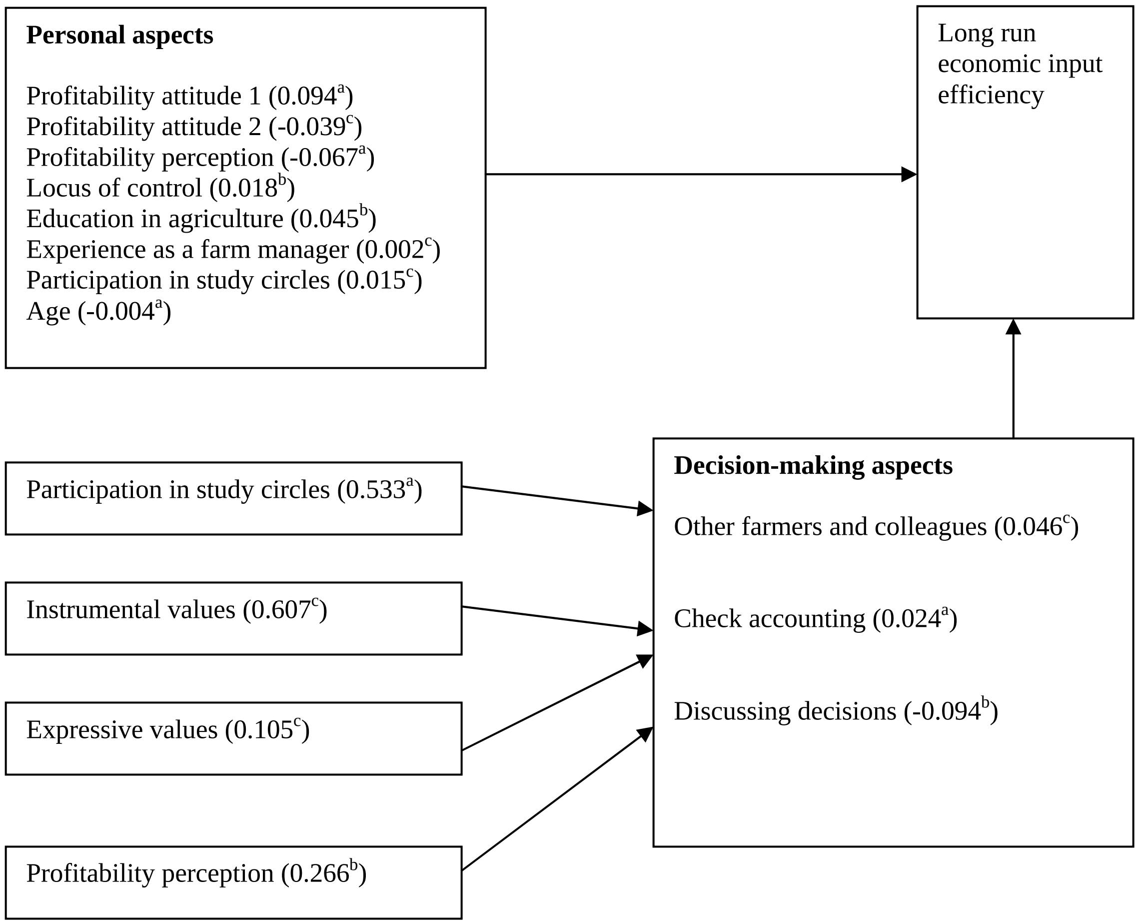


Figure 2: The significant relationships for long run economic input efficiency. [a] indicates statistical significance at the 1% level, [b] indicates statistical significance at the 5% level and [c] indicates statistical significance at the 10% level.

As indicated in figure 2, a positive profitability attitude towards dairy farming, both today and in the future, affect the long run economic efficiency. As expected, the influence is positive for a positive profitability attitude towards dairy farming today. This impact is also found on long run technical input efficiency. However, a positive profitability attitude towards dairy farming in the future has a negative impact on long run economic efficiency. Profitability perception influences the long run economic efficiency in a significantly negative way. This means that believing that one's farm is better than it really is leads to a decrease in efficiency. Likewise, a more pessimistic view of one's profitability reality compared to reality leads to higher efficiency. This result is also found for long run technical and allocative input efficiencies. Locus of control has a significant and positive impact on long run economic input efficiency. Consequently, a higher degree of internal locus of control leads to higher efficiency. Education in agriculture, experience as a farm manager and participation in study circles influence long run economic input efficiency in a significantly positive way, as expected. The effect of study circles holds also for technical efficiency. Education in agriculture and experience as a farm manager also significantly influence long run allocative input efficiency. The age of the farmer has a significantly negative impact and this was also found for the allocative efficiency. None of the considered farmer values were found to influence long run economic input efficiency significantly: however, expressive values influence technical efficiency in a significantly negative way.

As for the decision-making aspects, other farmers and colleagues as important information sources and checking accounting have significant and positive impacts on long run economic input efficiency. Discussing decisions was found to have a significantly negative impact on efficiency. This is the contrary to what is expected. Long run technical input efficiency is significantly influenced by only one decision-making aspect, attention, whereas allocative efficiency is influenced by the aspects of checking accounting and discussing results, in the same way as economic efficiency. Considering other farmers and colleagues as important information sources for decision-making is found to be influenced by participation in study circles. The decision-making aspect of checking accounting is influenced by instrumental and expressive values, while perception has a positive impact on discussing decisions, which in turn affected efficiency negatively. Figure 3 shows the significant relationships between managerial capacity and short run economic input efficiency.

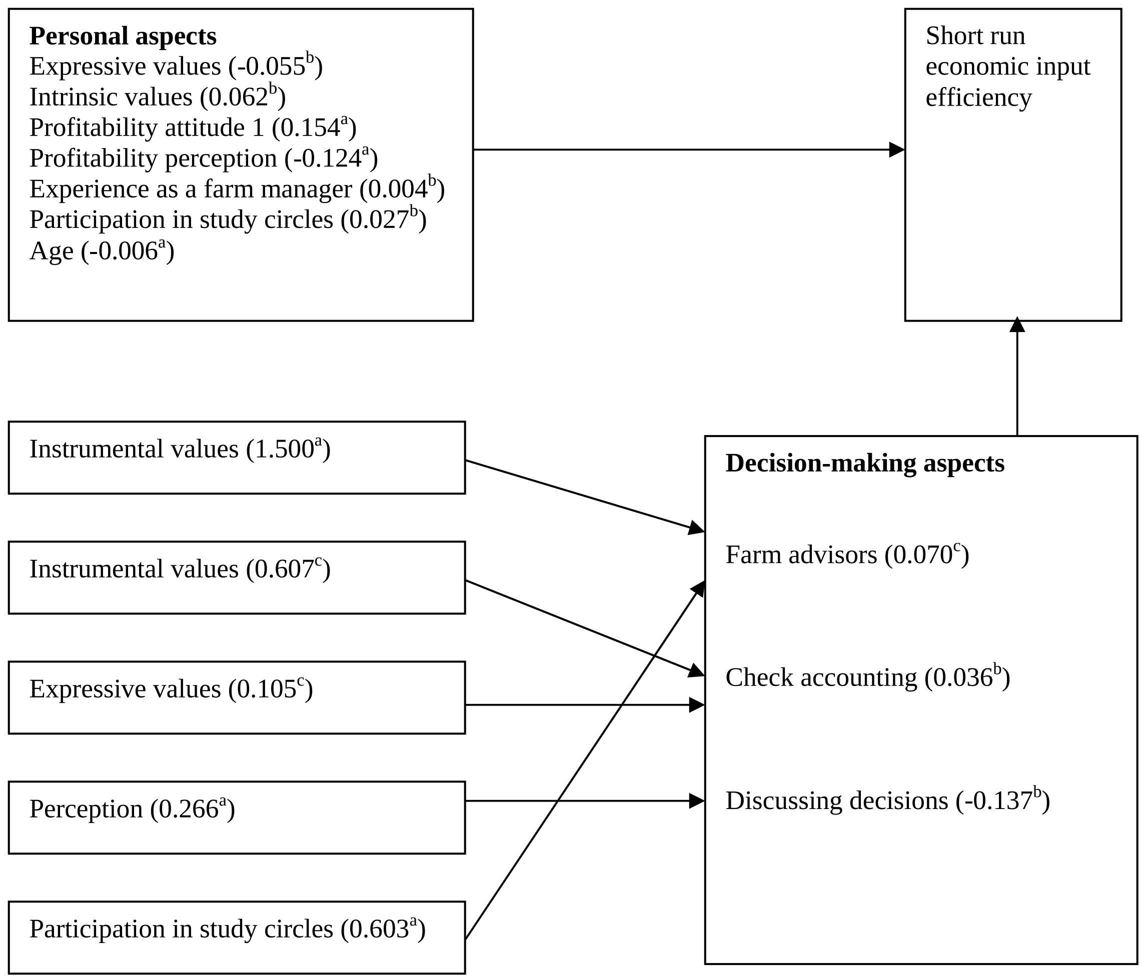


Figure 3: The significant relationships for short run economic input efficiency. [a] indicates statistical significance at the 1% level, [b] indicates statistical significance at the 5% level and [c] indicates statistical significance at the 10% level.

The short run economic input efficiency is found to be significantly negatively influenced by expressive values, but significantly positively by intrinsic values. Short run technical input efficiency is also significantly positively influenced by intrinsic values. Further, this efficiency score is negatively influenced by instrumental values. A positive profitability attitude towards dairy farming today influence the economic efficiency significantly and positively, whereas profitability perception, as in the long run case, influenced the economic efficiency negatively. These effects were also found for technical and allocative efficiency. A positive profitability attitude to future dairy farming also influenced technical efficiency in a significantly negative way. Experience as a dairy farmer and participation in study circles were found to influence short run economic input efficiency significantly positively. Likewise, the age of the farmer had a significantly negative impact. The effect of participation in study circles holds for short run technical input efficiency too, and the effect of experience as a farm manager and age hold for short run allocative efficiency input efficiency.

The decision-making aspects found to significantly influence the short run economic input efficiency are farm advisors as information source, checking accounting and discussing decisions. The impact of the first two are positive, while that of the latter is negative. The same results are found for short run allocative input efficiency, whereas family as an important information source influences technical efficiency significantly negatively, and attention positively. Checking accounting and discussing decisions are significant determinants also of long run economic input efficiency, and the influence of personal aspects on these were commented on above. Farm advisors as important an information source, however, is positively influenced by the personal aspects of instrumental values and participation in study circles.

In figure 4, the significant relationships for economic output efficiency are shown. An obvious feature of figure 4, compared to figure 2 and 3 is that a lot fewer significant relationships exist in the output case compared to the input cases.

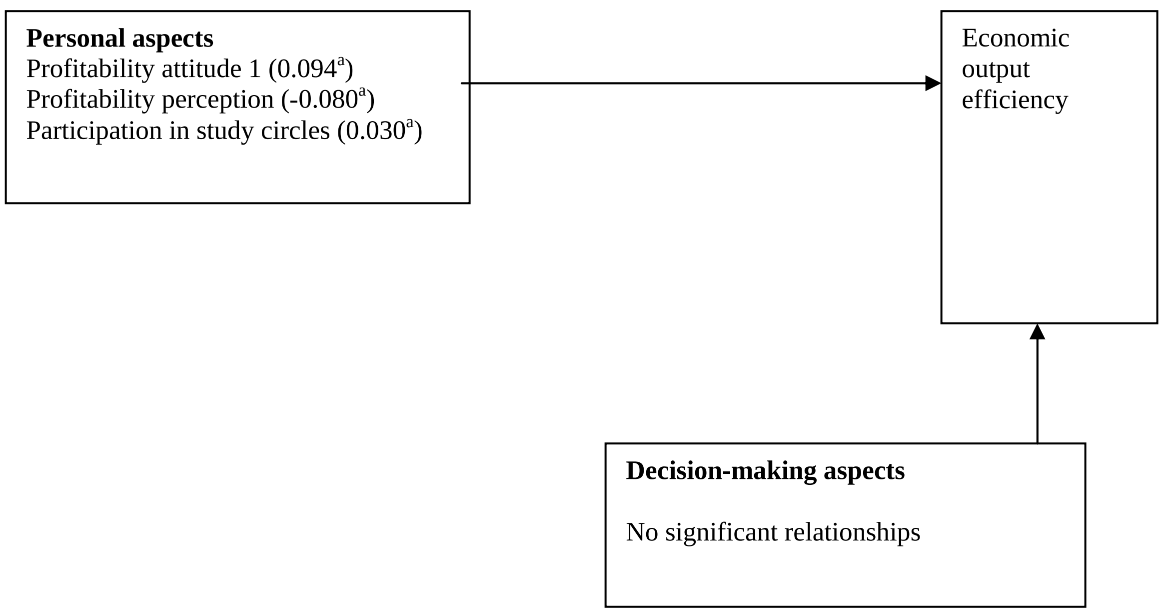


Figure 4: The significant relationships for economic output efficiency. [a] indicates statistical significance at the 1% level, [b] indicates statistical significance at the 5% level and [c] indicates statistical significance at the 10% level.

The personal aspects of a positive profitability attitude to dairy farming today, perception and participation in study circles influence economic output efficiency in the same way as the economic input efficiency scores. These effects are also significant for technical output efficiency, whereas only the first two are significant for allocative output efficiency. Further, an expressive value influences technical output efficiency negatively. None of the decision-making aspects influenced the economic output efficiency significantly. However, the decision-making aspect attention influenced the technical output efficiency significantly and positively, and other farmers and colleagues as an important information source influenced the allocative output efficiency in a significantly negative way.

**Discussion**

This study aimed to investigate the impact of managerial capacity aspects, i.e. personal features of the manager and decision-making characteristics, on farm level efficiency in a sample of Swedish dairy farms. Moreover, the paper aimed to investigate the impacts of personal aspects on the significant decision-making characteristics. The estimated efficiency scores showed that farm level performance can be greatly improved if all farms are as efficient as the best ones in our sample. This is in line with previous findings in the literature (e.g. Latruffe et al., 2005; Lawson et al., 2004; Oude Lansink et al., 2002; Heshmati and Kumbhakar 1994; Tauer 1993; Bravo-Ureta and Rieger 1991). It is, however, not meaningful to discuss how much better or worse Swedish dairy farms are compared to farms in other countries. Differences in methodologies may cause the efficiency scores to differ from each other (see for example Coelli et al., 1998). Moreover differences in variables and data may also cause differences in efficiency levels. More importantly, is that this study showed that several of the managerial capacity aspects influence farm level performance in a significant way. This holds in particular for the input efficiency scores.

An obvious feature of the regression results is that values affect short run efficiency to a larger extent than the long run efficiency scores. In both the long run input efficiency cases and in the output efficiency cases, only the effect of instrumental values is significant, and only for the technical efficiency scores. In the short run case, on the other hand, economic efficiency is influenced by expressive values, such as getting a challenge or realizing dreams, in a significantly negative way. An explanation for this finding may be that a creativity value, which we interpret expressive values to be, constrains productivity (Shalley 1995). Short run economic efficiency is positively affected by intrinsic values. The effect of intrinsic values is also found for short run technical efficiency. Further, instrumental values influence short run technical efficiency in a significantly negative way. Values are thus more important for farm performance in the short run. An explanation for this may be that in the short run, the intuitive, experience based thinking can be dominating, because most actions are known and have been handled before. Goals, which are formed by values, influence the intuitive thinking (Klein et al., 2005). In the long run, where the analytic thinking is arguably more important, because many actions are unknown, differences in values are less important.

A positive profitability attitude to dairy farming today was found to be an important personal aspect. It influenced all efficiency scores except long run allocative input efficiency in a significantly positive way. Of course this can be argued to be an effect of how the profitability attitude to dairy farming was measured: a farmer was considered to have a positive profitability attitude if he or she believed that the profitability of his or her dairy farming was good or very good. This objection is at least partly set off by the effect of the profitability perception variable, which showed that farmers who are better than they believe they are, are more efficient.

Locus of control influenced long run economic input efficiency in a significantly positive way. Thus, farmers who believe that they can influence their own actions are more efficient. The importance of a belief that one can influence one's situation was also found by Nordström Källström (2002) who studied factors important for not leaving farming in Sweden.

An education in agriculture seemed to be important only in the long run, because it influenced only the long run economic and allocative input efficiency scores significantly. University education and experience from other sectors than farming did not affect any of the efficiency scores. Experience of farming, on the other hand, proved important for the both long and short run economic and allocative efficiency. Similar results were found by Wilson et al. (2001) for wheat farmers in England. They found a positive relationship between technical output efficiency and experience, but no effect of university education. Wilson et al., (1998) also found support for the significance of experience. Furthermore, in our study, participation in study circles affected all economic and technical efficiency scores in a significantly positive way. Consequently, up-dating knowledge continuously and experience seem more important than formal education in agriculture in the short run. In addition, it is possible that study circles not only contribute by improving farmer skills, but also contribute by satisfying social needs. Isolation was mentioned as a reason for leaving farming in the study by Nordström Källström (2002). The age of the farmer negatively affected all economic and allocative input efficiency scores. A reason for this may be that younger farmers are more alert to technology changes which leads to more profitable input allocations. A further reason elaborated by Gasson et al. (1988) is that investments in family farms often follow the life cycle of the family, so that large investments are done prior to the retirement of the farmer. This implies that older farmers may have too much capital in their farms in relation to their production. Still further reason for the negative relationship between age and efficiency is as suggested by Lowe et al., (1997) that farmer retire gradually, down sizing the production.

For the decision-making aspects, it is interesting to note that they did not significantly effect the economic output efficiency. One reason may be that the information reaching the farms is focused on the input perspective, i.e. the cost side. A further reason may be that the production plans in dairy farms are very long term, leaving little room for adjustments, even if the information indicates that it would lead to higher profitability.

It is also interesting to note that neither an active approach to budgets nor having an analytical approach to analyzing information in the decision-making process influence any of the considered efficiency scores. Öhlmér and Lönnstedt (2004) concluded that the intuitive process may be involved even when farmers use an analytic approach to analyzing information. Consequently, our results implies that there are no efficiency differences between farmers who only use intuition and these who also use an analytical approach.

Discussing the results with someone influenced both long and short run economic input efficiency significantly and negatively. A closer look at the data reveals that the most common group to discuss decisions with is the family. This may suggest that unsuccessful farmers keep their problems within the family. Participation in study circles may indicate discussions with other farmers, and study circles influenced the efficiency scores positively. Reasons for this may be that farmers are more willing to discuss their production if they do not experience any important problem at their farm.

**Conclusion**

Our analysis of managerial capacity and its relationship with farm level performance contributed to new insights into how dairy farms are to become more efficient because it was conducted at a deeper and more detailed level compared to previous literature. It also included the information handling aspect not previously considered in light of farm level efficiency and particularly not in light of dairy farm efficiency. The inclusion of several efficiency measures gave a more complete view of efficiency and how it is affected by managerial capacity. A feature for all managerial capacity factors that contribute to improved efficiency is that they may have a larger influence on the input efficiency scores. Our results show that especially intrinsic values, a positive profitability attitude towards dairy farming today, internal locus of control, an education in agriculture, experience as a farm manager and participation in study circles are personal characteristics of the farmer that contribute to improving at least some of the farm level efficiency scores. Further, important decision-making aspects are especially farm advisors and other farmers and colleagues as important information sources, checking accounting and attention. Personal aspects of the farmer that are correlated with the decision-making aspects important for improved efficiency are values that are either instrumental or expressive, and participation in study circles. To support dairy farms to become more efficient and thus more profitable, combined educational and discussion clubs could be organized, where the farmers get to learn from both each other and professional dairy farm advisors, as well as inspire each other. Further, actions aiming at strengthening the farmers' internal locus of control and positive profitability attitude are important to help the farms becoming more efficient.

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## References

Agriwise: http://agriwise.org/ visited January 10-11 2005, October 2005.

Afonso, A. and St. Aubyn, M. (2006). Cross-country efficiency of secondary education provision: A semi-parametric analysis with non-discretionary inputs. Economic modelling. 23: 476-491.

Bedell, J and Rehman, T. (2000). Using social-psychology models to understand farmers' conservation behaviour. Journal of Rural Studies. 16: 117-127.

Begley, T. M. and Boyd, D. P. (1987). Psychological characteristics associated with performance in entrepreneurial firms and smaller businesses. Journal of Business Venturing. 2: 79-93.

Bergevoet, R. H. M., Ondersteijn, C. J. M., Saatkamp, H. W., von Woerkum, C. M. J. and Huirne, R. B. M. (2004). Entrepreneurial behaviour of Dutch dairy farmers under a milk quota system: value, objectives and attitudes. Agricultural Systems. 80: 1-21.

Boehlje, M. D. and Eidman, V. R. (1984). Farm management. John Wiley & Sons: Canada.

Bousman, C. A., Blumberg, E. J., Shillington, A. M., Hovell, M. F., Ji, M., Lehman,

S. and Clapp, J. (2005). Predictors of substance use among homeless youth in San Diego. Addictive Behaviors. 30: 1100-1110.

Bravo-Ureta, B. E. and Rieger, L. (1991). Dairy farm efficiency measurement using stochastic frontiers and neoclassical duality. American journal of agricultural economics. 73: 421-428.

Charnes, A., Cooper, W. W. and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. European Journal of Operational Research. 2: 429-444

Coelli, T., Rao, P. D. S. and Battese, G. E. (1998). An introduction to efficiency and productivity analysis. Kluwer academic publishers, UK: London.

Coelli, T., Rahman, S. and Thirtle, C. (2002a). Technical, Allocative, Cost and Scale Efficiencies in Bangladesh Rice Cultivation: a Non-parametric Approach. Journal of Agricultural Economics. 53: 607-626.

Coelli, T., Grifell-Tatjé, E. and Perleman, S. (2002b). Capacity utilization and profitability: A decomposition of short-run profit efficiency. International journal of production economics. 79:261-281.

Daft, R. L (2003). Management. Thomson Learning. USA.

Farrell, M. J. (1957). The measurement of productive efficiency. Journal of the royal statistical society. Ser. A 120: 253-281.

Fishbein, M. and Ajzen, I. (1975). Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research. Addison-Wesley Publishing Company: USA.

Galanopoulos, K., Aggelopoulos, S., Kamenidou, I. and Mattas, K. (2006). Assessing the effects of managerial and production practices on the efficiency of commercial pig farming. Agricultural Systems. 88: 125-141.

Garforth, C., McKemey, K., Rehman, T., Tranter, R., Cooke, R., Park, J., Dorward, P. and Yates, C. (2006). Farmers' attitudes towards techniques for improving oestrus detection in dairy herds in South West England. Livestock Science 103: 158-168.

Gasson, R. (1988). The farm as a family business: a review. Journal of Agricultural economics. 39(a): 1-41.

Gasson, R. (1973). Values and values of farmers. Journal of agricultural economics. 24: 521-542.

Hansemark, O. C. (2003). Need for achievement, locus of control and the prediction of business start-ups: A longitudinal study. Journal of Economic Psychology. 24: 301-319.

Helfand, S. M. and Levine, E. S. (2004). Farm size and the determinants of productive efficiency in the Brazilian Center-West. Agricultural Economics. 31: 241-249.

Hertzman, C., Power, C., Matthews, S. and Manor, O. (2001). Using an interactive framework of society and lifecourse to explain self-rated health in early adulthood. Social Science & Medicine. 53: 1575-1585.

Heshmati, A. and Kumbhakar, S. C. (1994). Farm heterogeneity and technical efficiency: Some results from Swedish dairy farms. The journal of productivity analysis. 5: 45-61.

Hogarth, R. M. (2001). Educating Intuition. The University of Chicago Press: USA.

Iráizoz, B., Rapún, M. and Zabaleta, I. (2003). Assessing the technical efficiency of horticultural production in Navarra, Spain. Agricultural Systems. 78: 287-403.

Kennedy, P. (2001). A guide to econometrics. Blackwell publishers inc. USA.

Klein, G., Pliske, R., Crandall, B. and Woods, D. D. (2005). Problem detection.

Cognitive Technology Journal. 7: 14-28.

Latruffe, L., Balcombe, K., Davidova, S. and Zawalinska, K. (2005). Technical and scale efficiency of crop and livestock farms in Poland: does specialization matter? Agricultural Economics. 32: 281-296.

Lawson, G. L., Agger, J. F., Lund, M. and Coelli, T. (2004). Lameness, metabolic and digestive disorders, and technical efficiency in Danish dairy herds: a stochastic frontier production approach. Livestock Production Sciences. 91: 157-172.

Lee, D., Newman, P. and Price, R. (1999). Decision making in organizations. Prentice Hall, Glasgow.

Lowe, P., Clark, J., Seymour, S. and Ward, N. (1997). Moralizing the environment - countryside change, farming and pollution. UCL Press. United Kingdom.

Lunneryd, D. (2003). Unique Decision Making with Focus on Information Use - The case of converting to organic milk production. Acta Universitatis Agriculturae Sueciae. Agraria 405.

Marchand, A., Demers, A. and Durand, P. (2005). Does work really cause distress? The contribution of occupational structure and work organizations to the experience of psychological distress. Social Science & Medicine. 61: 1-14.

Nordström-Källström, H. (2002). Att vara lantbrukare eller inte. En studie av förutsättningar för livskraftigt lantbruk i tre nedläggningsdrabbade områden i Sverige. ISSN: 1102-3007. Jordbruksverket rapport 2002:10. Sweden.

Nuthal, P. L. (2001). Managerial ability - a review of its basis and potential improvements using psychological concepts. Agricultural Economics. 24: 247-262.

Öhlmér, B., Brehmer, B. and Olson, K. (1997). Decision Making Processes of Swedish Farmers - Detection of Problems. In Antonides, G. W., van Raaij, F. and Maital, S (eds). Advances in Economic Psychology. John Wiley & Sons: Chichester.

Öhlmér, B. (1998). Models of Farmers' Decision Making. Problem Definition. Swedish Journal of Agricultural Research. 28: 17-27.

Öhlmér, B., Olson, K. and Brehmer, B. (1998). Understanding farmers' decision making proceses and improving managerial assistance. Agricultural Economics 18: 273-390.

Öhlmér, B. and Lönnstedt, L. (2004). Design of Economic Information. A Pilot Study of Accounting Information in Decision-making Processes. Acta Agric. Scand., Sect.

C, Food Economics. 1: 222-231.

Oude Lansink A., Pietola, K. and Bäckman, S. (2002). Efficiency and productivity of conventional and organic farms in Finland 1994-1997. European Review of Agricultural Economics. 29: 51-65.

Pennings, J. M. E. and Leuthold, R. M. (2000). The Role of Farmers' Behavioral Attitudes and Heterogeneity in Future Contracts Usage. American Journal of Agricultural Economics. 82: 908-919.

Rougoor, C. W., Trip, G., Huirne, R. B. M. and Renkema, J. A. (1998). How to define and study farmers' management capacity: theory and use in agricultural economics. Agricultural Economics. 18: 261-272.

Sharma, K. R., Leung, P., Zaleski, H. M. (1999). Technical, allocative and economic efficiencies in swine production in Hawaii: a comparison of parametric and nonparametric approaches. Agricultural Economics. 20: 23-35.

Shalley, C. E. (1995). Effects of coaction, expected evaluation, and goal setting on creativity and productivity. Academy of Management Journal. 38: 483-503.

Simar, L. and Wilson, P. W. (2007). Estimation and inverence in two-stage, semi-parametric models of production processes. Journal of econometrics. 136: 31-64.

Swedish Board of Agriculture (2004). Prisindex på jordbruks- och livsmedelsområdet. ISSN 140-5834. Serie JO - Jordbruk, skogsbruk och fiske. Sveriges officiella statistiska meddelanden.

Tauer, W. L. (1993). Short-run and long-run efficiencies of New York dairy farms. Agricultural and resource economics review. 22: 1-9.

Trip, G., Thijssen, G. J., Renkema, J. A. and Huirne, R. B. M. (2002). Measuring managerial efficiency: the case of commercial greenhouse owners. Agricultural Economics. 27: 175-181.

Wilson, P., Hadley, D and Asby, C. (2001). The influence of management characteristics on the technical efficiency of wheat farmers in eastern England. Agricultural Economics. 24: 329-338.

Wilson, P., Hadley, D., Ramsden, S and Kaltsas, I. (1998). Measuring and Explaining Technical Efficiency in UK Potato Production. Journal of Agricultural Economics. 49: 294-305.

Yu, C. (1998). The effects of exogenous variables in efficiency measurement - A monte carlo study. European Journal of Operational Research. 105: 569-580

## Appendix 1 DEA equations

Assume that we have *n* observations, which use the input matrix $X$, to produce the output matrix $Y$. The input and output matrices of each individual farm, *i*, are $x_i$ and $y_i$ respectively. Each farm faces a cost-minimizing input bundle, $x_i^*$, an input price vector $w_i$, a revenue-maximizing output bundle $y_i^*$ and a vector of output prices $p_i$. Furthermore, we assume that in the short run, the input matrix $X_v$ corresponds to the variable inputs that the *n* farms use to produce the output matrix $Y$ together with the input matrix $X_f$ of fixed inputs. The variable and fixed input vector of each individual farm is $x_{vi}$ and $x_{fi}$ respectively. The cost-minimizing input bundle of variable inputs for the *i*th firm is $x_{vi}^*$ with the corresponding input price vector $w_{vi}$.

For the *i*th farmer, the long run economic input efficiency $EI_i$ is calculated by first solving the following program:

$$
\begin{aligned}
&\min_{\lambda, x_i^*} \; w_i' x_i^* \\
\textit{subject to} \quad & -y_i + Y\lambda \geq 0, \\
& x_i^* - X\lambda \geq 0, \\
& N1'\lambda = 1, \\
& \lambda \geq 0
\end{aligned}
\tag{A1}
$$

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 A1 is compared with the actual cost:

$$EI_i = \frac{w_i' x_i^*}{w_i' x_i} \tag{A2}$$

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

$$\begin{aligned} &\min_{\lambda, x_{i^*}} \; w_{vi}' x_{vi}^* \\ \textit{subject to} \quad & -y_i + Y\lambda \geq 0, \\ & x_{vi}^* - X_v\lambda \geq 0, \\ & x_{fi} - X_f\lambda \geq 0, \\ & N1'\lambda = 1, \\ & \lambda \geq 0 \end{aligned} \tag{A3}$$

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

$$EI_{si} = \frac{w_{vi}' x_{vi}^*}{w_{vi}' x_{vi}} \tag{A4}$$

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

$$
\begin{aligned}
& \min_{\theta_i,\lambda} \theta_i \\
\textit{subject to} \quad & -y_i + Y\lambda \geq 0, \\
& \theta_i x_i - X\lambda \geq 0, \\
& N1'\lambda = 1, \\
& \lambda \geq 0, \\
& \theta_i \in (0,1]
\end{aligned}
\tag{A5}
$$

where $\theta_i$ 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:

$$
\begin{aligned}
& \min_{\theta_{si},\lambda} \theta_{si} \\
\textit{Subject to} \quad & -y_i + Y\lambda \geq 0, \\
& \theta_{si}\, x_{vi} - X_v\lambda \geq 0, \\
& x_{fi} - X_f\lambda \geq 0, \\
& N1'\lambda = 1, \\
& \lambda \geq 0, \\
& \theta_{si} \in (0,1]
\end{aligned}
\tag{A6}
$$

where $\theta_{si}$ is the short run technical input efficiency of the *i*th firm.

Both long and short run allocative input efficiencies are calculated residually:

$$AI_i = \frac{EI_i}{\theta_i} \quad \text{(A7)}$$

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

$$AI_{si} = \frac{EI_{si}}{\theta_{si}} \quad \text{(A8)}$$

where $AI_{si}$ is the short run allocative input efficiency of farm *i*.

Economic output efficiency is calculated by first solving the following linear program:

$$\begin{aligned}
&\max_{\lambda, y_i^*} \; p_i' y_i^* \\
\textit{Subject to} \quad & -y_i^* + Y\lambda \geq 0 \\
& x_i - X\lambda \geq 0 \\
& N1'\lambda = 1 \\
& \lambda \geq 0
\end{aligned} \quad \text{(A9)}$$

Equation A9 calculates the maximal revenue that the farm can receive if outputs were combined in their optimal way. Economic output efficiency, $EO_i$ for the *i*th farm, is then solved by the following equation:

$$EO_i = \frac{p_i' y_i}{p_i' y_i^*} \quad \text{(A10)}$$

where the actual level of revenue is compared to the maximal level.

Technical output efficiency is solved by the following program:

$$\begin{aligned} & \max_{\phi_i,\lambda} \phi_i \\ \textit{subject to} \quad & -\phi_i y_i + Y\lambda \geq 0, \\ & x_i - X\lambda \geq 0, \\ & N1'\lambda = 1 \\ & \lambda \geq 0 \\ & 1 \leq \phi_i < \infty \end{aligned} \tag{A11}$$

where the inverse of $\phi_i$, $\frac{1}{\phi_i}$ is the technical output efficiency of firm *i*. If the firm is operating under constant returns to scale, this will be the same as long run technical input efficiency.

Allocative output efficiency, $AO_i$, is calculated residually as in the input cases:

$$AO_i = \frac{EO_i}{\frac{1}{\phi_i}} \tag{A12}$$

If input and output prices are assumed to be given, the calculations of economic efficiency can be facilitated by reducing equations A1 and A2, A3 and A4, and A9 and A10 to the same principal form as the equations for the technical efficiency scores

## Appendix 2: Regression results

Table A1: Regressions of the personal aspects on the efficiency scores

| | Input efficiency | | | | | | Output efficiency | | |
|---|---|---|---|---|---|---|---|---|---|
| | Long run | | | Short run | | | | | |
| | ***Economic*** | ***Technical*** | ***Allocative*** | ***Economic*** | ***Technical*** | ***Allocative*** | ***Economic*** | ***Technical*** | ***Allocative*** |
| ***Regression 1 - Personal aspects*** | | | | | | | | | |
| Intercept | 0.682[a] | 0.919[a] | 0.794[a] | 0.647[a] | 1.143[a] | 0.732[a] | 0.760[a] | 0.834[a] | 0.899[a] |
| Geographic location | -0.027 | -0.017 | -0.012 | -0.076[b] | 0.011 | -0.084[b] | -0.033 | -0.030 | -0.003 |
| Instrumental | 0.009 | 0.022 | 0.006 | 0.000 | -0.092[c] | 0.042 | 0.023 | 0.031 | 0.001 |
| Expressive | -0.013 | -0.049[c] | 0.019 | -0.055[b] | -0.052 | -0.039 | -0.025 | -0.052[c] | 0.010 |
| Social | 0.020 | 0.021 | 0.013 | 0.019 | 0.052 | 0.011 | 0.006 | 0.021 | -0.007 |
| Intrinsic | 0.005 | 0.020 | -0.005 | 0.062[b] | 0.081[c] | 0.043 | -0.001 | 0.021 | -0.014 |
| Profitability attitude 1 | 0.094[a] | 0.099[a] | 0.042 | 0.154[a] | 0.104[b] | 0.133[a] | 0.094[a] | 0.106[a] | 0.034[c] |
| Profitability attitude 2 | -0.039[c] | -0.036 | -0.015 | -0.022 | -0.113[b] | 0.013 | -0.034 | -0.024 | -0.021 |
| Perception | -0.067[a] | -0.101[a] | -0.022[a] | -0.124[a] | -0.134[a] | -0.089[a] | -0.080[a] | -0.095[a] | -0.023[a] |
| Locus of control | 0.018[b] | 0.007 | 0.019 | 0.017 | -0.003 | 0.013 | -0.007 | -0.003 | -0.009 |
| University education | 0.014 | -0.019 | 0.028 | 0.064 | -0.033 | 0.082 | -0.029 | -0.039 | 0.004 |
| Education in agriculture | 0.045[b] | -0.033 | 0.068[a] | 0.039 | -0.056 | 0.057[c] | -0.009 | -0.018 | 0.009 |
| Experience as a farm manager | 0.002[c] | 0.001 | 0.003[c] | 0.004[b] | 0.001 | 0.005[b] | -0.001 | 0.007 | -0.001 |
| Other professional experience (worker) | -0.001 | -0.001 | -0.001 | 0.000 | -0.002 | 0.000 | 0.000 | -0.001 | 0.001 |
| Other professional experience (manager) | 0.001 | 0.004 | 0.000 | 0.002 | 0.001 | 0.001 | 0.001 | 0.000 | 0.001 |
| Participation in study circles | 0.015[c] | 0.041[a] | -0.004 | 0.027[b] | 0.064[a] | 0.002 | 0.030[a] | 0.052[a] | 0.001 |
| Age | -0.004[a] | -0.002 | -0.004[b] | -0.006[a] | -0.005 | -0.005[b] | 0.000 | -0.001 | 0.001 |
| Log likelihood | 127.581 | -0.731 | 74.861 | 36.727 | -48.168 | 3.634 | 55.346 | -13.292 | 121.47 |

[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.

Table A2: Regressions of the decision making aspects on the efficiency scores

| | Input efficiency | | | | | | Output efficiency | | |
|---|---|---|---|---|---|---|---|---|---|
| | Long run | | | Short run | | | | | |
| | ***Economic*** | ***Technical*** | ***Allocative*** | ***Economic*** | ***Technical*** | ***Allocative*** | ***Economic*** | ***Technical*** | ***Allocative*** |
| ***Regression 2 - Decision aspects*** | | | | | | | | | |
| Intercept | 0.616[a] | 0.874[a] | 0.749[a] | 0.596[a] | 1.003[a] | 0.718[a] | 0.766[a] | 0.817[a] | 0.972[a] |
| Geographic location | -0.089[a] | -0.052 | -0.061[a] | -0.158[a] | -0.033 | -0.155[a] | -0.061[b] | -0.078[b] | -0.008 |
| Farm advisors | 0.014 | 0.019 | 0.006 | 0.070[c] | 0.018 | 0.067[c] | -0.002 | 0.010 | -0.014 |
| Family | -0.014 | -0.051 | 0.005 | -0.039 | -0.145[b] | -0.006 | -0.015 | -0.059 | 0.003 |
| Other farmers or colleagues | 0.046[c] | 0.039 | 0.028 | 0.053 | 0.015 | 0.045 | -0.004 | 0.057 | -0.033[b] |
| Media | -0.011 | 0.000 | -0.008 | -0.034 | -0.007 | -0.030 | 0.020 | 0.001 | 0.009 |
| Accounting | 0.021 | 0.032 | 0.009 | 0.038 | 0.056 | 0.029 | 0.013 | 0.024 | -0.001 |
| Check accounting | 0.024 [a] | -0.011 | 0.031[a] | 0.036[b] | -0.007 | 0.041[a] | 0.001 | 0.004 | -0.004 |
| Budgets | -0.014 | 0.014 | -0.022 | -0.048 | -0.013 | -0.053 | 0.001 | 0.006 | -0.014 |
| Analytical | -0.009 | -0.040 | 0.002 | -0.007 | -0.010 | -0.005 | 0.005 | -0.029 | 0.014 |
| Attention | 0.022 | 0.062[b] | -0.008 | 0.021 | 0.078[b] | -0.008 | 0.031 | 0.068[b] | -0.005 |
| Checking results | -0.017 | -0.007 | -0.011 | 0.013 | 0.028 | -0.017 | -0.001 | -0.018 | 0.015 |
| Discussing decisions | -0.094[b] | -0.069 | -0.069[c] | -0.137[b] | -0.093 | -0.129[c] | -0.070 | -0.073 | -0.033 |
| Log likelihood | 79.782 | -61.373 | 80.489 | -51.163 | -113.421 | -39.198 | -7.061 | -75.329 | 129.585 |

[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

Table A:3: Regressions of the personal aspects on the significant decision aspects

| Dependent variable / Independent variables | Farm advisors (odds ratio) | Family (odds ratio) | Other farmers or colleagues (odds ratio) | Check accounting (odds ratio) | Attention | Discussing decisions |
|---|---|---|---|---|---|---|
| Intercept | -0.919 | 1.809 | 0.265 | | | 0.879 |
| Intercept 5 | | | | -1.885[c] | | |
| Intercept 4 | | | | -1.037 | -5.632[a] | |
| Intercept 3 | | | | -0.196 | -2.514[b] | |
| Intercept 2 | | | | 2.499 | 0.130 | |
| Instrumental | 1.500[a] (4.462) | 1.150[b] (3.158) | 0.315 (1.370) | 0.607[c] (1.835) | 0.778[b] (2.177) | 0.157 |
| Expressive | 0.107 (1.113) | -0.141 (0.868) | -0.304 (0.738) | 0.105[c] (1.110) | -0.336 (0.715) | -0.0681 |
| Social | -0.187 (0.829) | -0.083 (0.920) | -0.088 (0.916) | -0.511 (0.600) | -0.174 (0.841) | -0.045 |
| Intrinsic | 0.265 (1.113) | -0.288 (0.750) | -0.376 (0.686) | -0.036 (0.965) | -0.260 (0.771) | -0.470 |
| Attitude 1 | -0.150 (0.861) | 0.278 (1.321) | 0.528 (1.696) | 0.410 (1.507) | 0.479 (1.615) | 0.390 |
| Attitude 2 | 0.124 (1.132) | -0.412 (0.663) | -0.266 (0.767) | 0.484 (1.623) | 0.600 (1.822) | 6.712 |
| Perception | -0.049 (0.952) | 0.352[b] (1.422) | 0.097 (1.102) | 0.065 (1.067) | -0.012 (0.988) | 0.266[b] |
| Locus of control | -0.054 (0.947) | -0.439[c] (0.645) | 0.087 (1.091) | 0.190 (1.210) | 0.128 (1.136) | 0.032 |
| University education | -0.565 (0.568) | -1.336[b] (0.263) | -0.068 (0.935) | 0.353 (1.423) | 0.642 (1.900) | 6.058 |
| Education in agriculture | 0.223 (1.249) | -0.162 (0.851) | -0.104 (0.901) | -0.109 (0.897) | 0.152 (1.165) | 0.124 |
| Experience as a farm manager | -0.028 (0.972) | -0.037 (0.964) | -0.021 (0.980) | -0.010 (0.990) | -0.004 (0.996) | -0.048 |
| Other professional experience (worker) | 0.003 (1.003) | -0.022 (0.978) | 0.014 (1.014) | 0.021 (1.022) | 0.043[b] (1.044) | 0.172 |
| Other professional experience (manager) | -0.006 (0.994) | -0.034 (0.967) | -0.035 (0.966) | 0.019 (1.019) | 0.049 (1.050) | 2.068 |
| Participation in study circles | 0.603[a] (1.827) | 0.188 (1.206) | 0.533[a] (1.705) | 0.192 (1.211) | 0.562[a] (1.755) | 0.205 |
| Age | 0.011 (1.011) | 0.027 (1.027) | -0.002 (0.998) | -0.007 (0.993) | 0.035 (1.035) | 0.023 |

[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 l