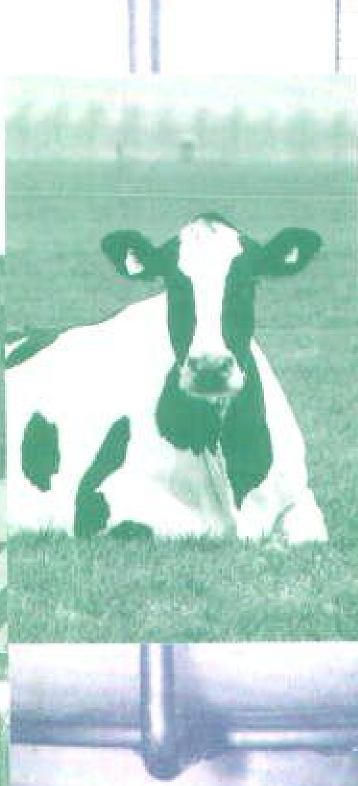
Management, milk production level and economic performance

an explorative study on dairy farms

C.W. Rougoor



Stellingen

1. Het realiseren van een hoog saldo per 100 kg melk door middel van een hoge melkproductie per koe vergt van de veehouder grote affiniteit met diermanagement en diergezondheid.
   Dit proefschrift

2. Verhogen van de melkproductie per koe moet economisch gezien geen eerste prioriteit zijn voor veehouders die zich met name interesseren in graslandmanagement.
   Dit proefschrift

3. Eén goede kennis van het gerealiseerde celgetal en de tussenkalftijd en hoe deze zich verhouden tot andere bedrijven is een algemeen kenmerk voor goed management.
   Dit proefschrift

4. Om een goede kwaliteit van kuilgras te realiseren, wordt op veel hoogproductieve bedrijven gras in een te jong stadium gemaaid. Dit gaat ten koste van de hoeveelheid en dientengevolge van het saldo.
   Dit proefschrift

5. Voor een goed inzicht in de economische situatie van melkveebedrijven, verdient het aanbeveling boekhoudgegevens van ten minste 3 jaar te gebruiken.
   Dit proefschrift

6. Partial Least Squares is een goede statistische methodiek voor epidemiologisch en economisch onderzoek als het aantal waarnemingen klein is en de te onderzoeken relaties complex.
   Dit proefschrift

7. Naast het fenotype van de koe speelt het fenotype van de veehouder een belangrijke rol bij het uiteindelijk productieniveau van een bedrijf.
   Dit proefschrift

8. Uit de NRS-lijsten met daarin een top-10 van bedrijven naar productie, mag niet worden afgeleid dat dit een graadmeter is voor de economische kwaliteit van het bedrijf en het management.

9. Doordat besluitvorming een 'vaag' proces is waarvan begin- en eindpunt moeilijk zijn vast te stellen, zal elke definitie ervan in praktijk moeilijk interpreteerbaar en toepasbaar zijn, ondanks een theoretisch correcte achtergrond.

10. Het feit dat er verschillen zitten tussen het zeggen en doen van veehouders toont aan dat ook zij gewoon mensen zijn.

11. Theoretisch zou eenzelfde onderzoek zowel wetenschappelijk als praktijkgericht kunnen zijn. In de praktijk wordt dit echter vaak belemmerd door de vraag naar 'snelle' resultaten, waardoor ingeleverd moet worden op het wetenschappelijk gehalte.

12. Het optimaal benutten van de mogelijkheden die de wet biedt op het gebied van zaken als hypotheek, beleggen van spaartegoeden, pensioenaanvulling en belastingaangifte zou de bestedingsruimte van de gemiddelde Nederlander sterk doen toenemen. Gezien de aard van deze werkzaamheden, zou de levensvreugde echter juist wel eens af kunnen nemen.

13. Een eerste succesvolle stap in de internationale wetenschappelijke wereld is als het versjouwen van een berg zand: een goede kruiwagen is effectiever dan alleen hard werken.

14. De uitdrukking 'zinloos geweld' is een pleonasme: geweld is altijd zinloos.

C.W. Rougoor
Management, milk production level and economic performance: an explorative study on dairy farms
Wageningen, 20 januari 1999

Management, milk production level and economic performance: an explorative study on dairy farms

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Management, milk production level and economic performance: an explorative study on dairy farms

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Abstract

Management, milk production level and economic performance: an explorative study on dairy farms
Management, melkproductieniveau en economisch resultaat: een verkennende studie op melkveebedrijven
Rougoor, C.W., 1999.

The research described in this thesis focuses on the relation between dairy herd management, milk production per cow, and gross margin per 100 kg of milk. The study was carried out as an explorative and empirical study. The thesis is composed of five parts. First, relations between technical data, including milk production, economic performance and nutrient losses were determined for a group of 478 farms. This part serves as the empirical basis for the study. Second, literature was reviewed as to the definition of management and management research. Third, based on this knowledge a field study was set up with 38 dairy farms. Technical and economic data were gathered during one year. Repeatability of economic data and milk production data was determined to get insight into the usefulness of one year of data. As could be expected, ranking over years of farms was not completely random. However, the ranking changed over time as well. This indicated that one year of data could be used to determine the influence of fixed effects on technical and economic performance, but year-effects cannot be separated. Fourth, two methodologies that were available to analyse this kind of data were described: Principal Components Regression (PCR) and Partial Least Squares (PLS). An overview of these two methodologies showed the advantage of using PLS for the current study, with a relatively large number of variables and complex relations that have to be determined. Fifth, the results of the analyses of the data set were described. Data were available on management, technical and economic performance. Management data were acquired by questionnaires, observations, and a workshop. PLS-models were constructed to determine the relationships between pasture and feeding management and gross margin, milk production level and nitrogen loss. The models were used to define hypotheses for the relationship between pasture and feeding management and gross margin and milk production. Also two models were set up to determine the relationships between mastitis and fertility management and gross margin and milk production. In the concluding chapter, a schematic overview is given of management characteristics that are clearly related to gross margin per 100 kg of milk and milk production per cow. Characteristics of the farmer are a central element of 'the key to success'. A high production per cow is not the best economic option for each farmer. High production per cow should only be advised when the farmer is able to give the herd the detailed attention and interest that are needed.

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Voorwoord

Een proefschrift schrijf je niet alleen........... De afgelopen 4 jaar heb ik hulp en advies van allerlei mensen gehad. Met Aalt Dijkhuizen, Ruud Huirne, Frits Mandersloot, Wim Hanekamp en Theun Vellinga heb ik heel wat uren over m'n onderzoek gepraat. Jullie kwamen altijd met enthousiaste ideeën en keken kritisch naar wat ik op papier zette. Bedankt! Naast deze 'dagelijkse' begeleiding, was er een hele club mensen die m'n onderzoek wat meer op afstand volgde. Johan van Arendonk, Hans Wilmink, Ynte Schukken, Mirjam Nielen, en Abele Kuipers: bedankt voor jullie kritische blik. Doordat jullie wat verder van het onderzoek afstonden, was jullie inbreng vaak verfrissend en vroeg ik me soms af waarom ik zelf niet op een bepaald idee gekomen was........

Het onderzoek is gebaseerd op praktijkmateriaal. Dit klinkt eenvoudig, maar het verzamelen hiervan is een boel werk, dat ik zeker niet in m'n eentje afgekund had. Alle veehouders die meegewerkt hebben wil ik hiervoor bedanken. Het heeft jullie heel veel koffie, tijd, en soms wat denkwerk gekost! Sandra Visser heeft het eerste half jaar van de praktijkproef enthousiast alle veehouders bezocht. Hiernaast hebben Sjouke Sinia, Erik Wierbos en Machiel Kamerbeek hun stageperiode gebruikt om gegevens voor m'n onderzoek te verzamelen. Voor de veehouders was het daarom vaak een verassing wie er nu weer op de stoep zou staan. Het enige dat hetzelfde bleef was het groene autootje. Aalt-Leno Beuker en Carlo Walschots hebben als afstudeeropdracht extra gegevens op een bepaald deelgebied verzameld en verwerkt.

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De lijst met mensen die ik zou willen bedanken is nog lang niet compleet. Allerlei mensen hebben enquêtes die ik had opgesteld kritisch bekeken, Diny Dijkhuizen heeft een groot gedeelte van m'n proefschrift op Engels gecontroleerd, Hetty Wolbers heeft ideeën aangedragen voor de voorkant, de AIO-discussiegroep in Wageningen heeft me een paar keer doorgezaagd over m'n onderzoek, m'n familie volgde kritisch waar ik mee bezig was, en zo kan ik nog wel even doorgaan. Dat doe ik niet. Ik wil het als volgt samenvatten: Iedereen die een bijdrage geleverd heeft: BEDANKT!

Dat lijkt een mooi slot voor een voorwoord, maar toch wil ik nog een paar zinnen toevoegen. Herke Jan; zonder jou waren de afgelopen jaren niet half zo leuk geweest. Bedankt voor je steun en vertrouwen.

Carin Rougoor
Lelystad, november 1998

Contents

Chapter 1

GENERAL INTRODUCTION

1.1 INTRODUCTION

Economic performance can differ considerably among dairy farms (Williams et al., 1987; Zweigbaum et al., 1989). These differences can partly be contributed to differences in farm structure, such as farm size and number of cows per worker (Williams et al., 1987). These factors have a major impact on the fixed costs of the farm. Fixed costs per cow are relatively low on large farms compared with small farms. The way the dairy herd is managed, and the way pasture is taken care of are examples of factors that influence variable costs. Feed costs and veterinary costs, for instance, are highly dependent upon the daily management at the farm. Increasing milk production per cow is often mentioned as an important management tool to increase economic performance (Schmidt and Pritchard, 1987; McGilliard et al., 1990). A higher milk production per cow does not only increase returns, but can also have advantages as to fixed costs and variable costs:

- In the long run, fixed costs will be lower per 100 kg of milk, because fewer cows, and therefore a smaller cowshed, are necessary to produce the same amount of milk;
- Under a milk quota system a higher milk production level will, in principle, result in better economic returns, because less feed per kg of milk is needed for maintenance;
- Under a milk quota system mineral losses per kg of milk, and due to that per hectare will, in principle, decrease (Mandersloot et al., 1993).

However, an increase in milk production per cow can also have disadvantages:

- Under a milk quota system herd size has to decrease and returns from cull cows and calves are lower in a smaller herd;
- In a high-producing herd the dry matter intake of the herd is often above the theoretical standard for that production level (Meijer et al., 1998);
- The animal health status can get worse. There is controversy in the literature whether or not a higher milk production in recent decades has caused the concomitant increase in diseases of the dairy cow (Gröhn et al., 1995). Sargeant et al. (1998), for instance, found small positive associations between the estimated breeding value for protein production and cystic ovaries, but no relation was found between previous production and all kinds of other diseases. However, Markusfeld (1990) found significant effects of previous production on clinical milk fever, ketosis, retained placenta, primary metritis, and inactive ovaries.

- Fertility results might be influenced negatively by the milk production level. Nebel and McGilliard (1993) stated that a higher milk production is associated phenotypically and genetically with reduced reproductive performance in lactating cows.

It is not easy to indicate the net balance of these advantages and disadvantages for an individual farm and its manager. Differences between comparable farms are usually attributed to differences in management of the farmer (Boehlje and Eidman, 1984; Williams et al., 1987). The examples mentioned above show that, among other things, feeding management, animal health management and fertility management seem to have an effect on technical and economic results of a high-producing herd.

Management is a very difficult concept and has (therefore) rarely been defined precisely. A general description of management says that it is the decision-making process in which limited resources are allocated to a number of production alternatives. This allocation of resources should be organized and operated in such a way that the firm's goals and objectives are achieved. It is a cyclical process, including planning, implementation and control. Depending on the planning horizon, strategic (long-term), tactical (medium-term) and operational (short-term) planning can be considered (Huirne, 1990; Kay and Edwards, 1994). This very general definition makes it difficult to measure management and management performance (Huirne et al., 1997). As a result, knowledge about the influence of management and decision making on farm results is limited.

1.2 GOAL OF THE STUDY

As mentioned in the previous section, increase in milk production level of the herd is often seen as an important management tool to increase economic performance and to decrease nutrient losses. The overall objective of the current research project was to determine what management, including personal characteristics, is needed by a dairy farmer to arrive at this situation. How can the farmer optimize his or her decision-making process in such a way that a certain milk production level will result in good economic returns? The research was focused on operational decisions that have to be made on a day-by-day basis. This objective can be split into the following research questions:

- What are the relations between technical and economic results on dairy farms?
- What are the relations between management and technical results in general?
- What are the relations between management and a 305-day milk production?
- What are the relations between management and gross margin per 100 kg of milk?

The major goal of the current study was to explore this field and to define hypotheses. Relations between farms were studied in an explorative study. So, results have to be interpreted in that way as well. The set-up of the study is a cross-sectional study. As a result, the study cannot prove whether changes in management within a farm will have the same results as found between farms. It can only indicate plausibility.

To study the relations between management, milk production, and economic returns, commercial dairy farms were followed intensively. Availability of budget and time and the wish to gather data very intensively at individual farm level were major reasons to restrict the data-gathering period to one year and 38 dairy farms.

1.3 OUTLINE OF THE THESIS

The research has been set up in different stages. First economic results and nitrogen losses of farms were explained by differences in technical results. Therefore, a data set with technical and economic data was analysed. Chapter 2 describes these analyses. Then, as explained before, dairy farm management had to be defined more precisely so that it could be used in this research. This question of how management can be defined and determined is addressed in Chapter 3, which basically reviews and interprets literature on the definition of management and management research.

The knowledge about technical relationships (Chapter 2) and the different aspects of management capacity (Chapter 3) was used to set up the field study. To get insight into the value of one year of data, repeatability of milk production and gross margin over time were measured. This is described in Chapter 4. In May 1997 the data collection had finished and the analyses of the data set could start. Chapter 5 describes the different methodologies to analyse the data set and the choice of the statistical methodology is founded.

In Chapters 6 and 7 the results of the analyses of the data set are described. Choices had to be made regarding the management aspects that could be measured successfully. The farmer has to take decisions on a daily basis on all kind of aspects. First, a distinction is made between pasture, feeding, animal health, fertility, and breeding management. Breeding management is dealt with in Chapter 5. In Chapter 6 the results concerning pasture management and feeding management are presented and discussed. Chapter 7 focuses on animal health and fertility management. Considering animal health we have chosen to focus on mastitis, which causes major losses in dairy cattle (Schepers and Dijkhuizen, 1991; Houben et al., 1993). In Chapter 8 all variables are integrated into one overall model and an evaluation of the entire project is given. Major focus of the evaluation is to discuss the research questions and outcome and to give recommendations for further research.

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Chapter 2

Relationships between technical, economic and environmental results on dairy farms: an explanatory study

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ABSTRACT

Path analysis was used to model multivariate relationships between milk yield, reproductive parameters, replacement, milk contents, farm characteristics, net returns and N-surplus. Data from an economic information system and DHIA-data were available from 478 farms. Two models were constructed: one to analyze the gross margin per 100 kg of milk, and one to analyze N-surplus per ha.

The first model showed that on the level of individual farms milk yield per cow in 305 days influenced reproductive parameters, the replacement rate and gross margin per 100 kg of milk. Besides milk yield, gross margin is highly dependent of quota per ha, concentrates per cow per year, percentage of protein in the milk and amount of silage bought per ha. Number of inseminations per pregnancy, births per cow per year, young stock per ha and the replacement rate had a small, but significant influence on the gross margin.

In the second model N-surplus per ha was found to be highly dependent upon milk quota per ha and the amount of concentrates per cow per year. Weaker, but still significant relationships were found with replacement rate, young stock per ha and milk yield per cow.

2.1 INTRODUCTION

Several authors have focused on the relationship between milk yield per cow and farm income. McGilliard et al. (1990) found that net cash income per cow per additional kg of milk was $0.22 at 5000 kg/cow per year, decreasing to $0 at 8162 kg per cow per year. Other studies have shown that marginal returns will remain greater than the marginal costs of an increased milk yield, up to a yield of 11.818 kg per cow per year (Schmidt and Pritchard, 1987). Stallings et al. (1992) found that high producing herds have a greater net cash income per cow than average producing herds. In all these studies the gross margin was measured on a per-cow basis. However, in a milk quota system the total amount of milk produced is the limiting factor. In that case it is better to optimize the gross margin per 100 kg of milk rather than per cow. Therefore, the gross margin per 100 kg of milk has been chosen as goal variable in this research. Gross margin is defined as the gross returns minus costs from purchased feed.

However, in the current study attention is not only paid to gross margin but also to interrelationships between different variables that all are expected to influence the gross margin. Results of Schmidt and Pritchard (1987) show a positive relationship between milk yield and replacement. Olds et al. (1979) and Ouweltjes et al. (1996) found that a higher milk yield resulted in more inseminations per pregnancy on the level of individual farms. In contrary to Laben et al. (1992), who did not find a relation between milk yield and number of inseminations. Ouweltjes et al. (1996) found at the farm level a positive relation between the interval between calving and first insemination and the non return rate, and a negative relationship between non return rate and number of inseminations per parity. Oldenbroek (1984) found a negative correlated response between selection for milk yield and fertility, however Shanks et al. (1978), in turn, did not show selection for milk yield to have a negative effect on fertility traits.

There is quite some literature available on the relationships between reproductive parameters and culling rate. Beaudeau et al. (1994), for instance, found there to be a positive relationship between poor reproductive performance and late culling. Reproductive failure was defined as the cows still not being fertilised at 110 days post partum. Erb et al. (1985) found a positive relationship between days to first service and culling. The current study will focus on relationships between parameters measured at the farm level, whereas most of the quoted research has been conducted on data of individual cows. Literature on relationships at the farm level, however, is rather scarce.

No attention was paid to the negative environmental effects of milk production in the literature. However, at present environmental effects are becoming more important, due to legal restrictions on environmental pollution. In the future, restrictions are to be placed on the maximum N-surplus per ha in the Netherlands. Hence, the second goal variable in this study is nitrogen surplus per ha. N-surplus per hectare is defined as the N-content in fertilizer and concentrates, minus the N-contents in milk and culled animals.

The objective of this paper is to get more insight into interrelationships between technical variables who are expected to influence the gross margin and the N-surplus and to define hypotheses on relationships (split into 3 component parts: common cause, direct cause, indirect cause) between milk yield and economic results and environmental effects (measured as N-surplus per hectare) on the level of individual farms.

2.2 MATERIALS AND METHODS

2.2.1 Data

Data from 680 farms were available from an economic information system for dairy farms (DELAR) and from the Royal Dutch Cattle Syndicate (NRS) over the period May 1993 till September 1994. The main aim of the DELAR-system is to give farmers information on milk yield, pasture and crops, use of concentrates, silage and milk products and insight into other costs such as fertilizer and contract work. NRS-data was available on milk yield, reproduction and breeding values. A selection of 478 farms was made: only farms with Dutch-Friesian and/or Holstein-Friesian cattle were included in the study. Table 2.1 gives some descriptive statistics on these farms. The milk yield per cow was standardized on a 305-day basis, using the formula proposed by Poutous and Mocquot (1975). On average there were 57 cows per farm, producing 7658 kg of milk in 305 days, resulting in a gross margin per 100 kg of milk of Dfl. 76.0 and an N-surplus of 424 kg per hectare.

Table 2.1 Descriptive statistics on selected farms in the dataset (N = 478).

Variables	Avg.	SD	Min	Max
No. of hectares	30.9	13.3	7.5	104.9
No. of cows	56.8	22.4	13.7	189.7
Milk yield (kg in 305 days)	7658	687	4892	10320
Milk quota per ha (kg)	14036	3459	6660	32068
Gross margin / 100 kg of milk (Dfl.)[1)]	76.0	5.7	57.8	102.6
Breeding value kg of milk	376	149	-274	830
Breeding value kg of fat	16.5	5.29	-13	31
Breeding value kg protein	15.2	4.2	-6	26
Correct oestrus (%)[2)]	56.4	6.6	26	76
Inseminations / pregnancy	1.96	0.34	1.07	3.64
Int. Calving-1st insemination (days)	79.1	11.4	51	193
Non Return (%)	61.9	10.4	30	96
Calving interval (days)	390.1	13.2	357	438
Replacement rate (%)	34.4	12.8	2	139
Concentrates / cow / yr (kg)	2512	590	972	5954
Fertilizer-N / ha	309	83	79	642
Mowing percentage	214	57	28	488
N-surplus per ha (kg)	424	99	76	876

1) Gross margin = gross returns – feed costs from purchased feed.
2) Percentage of oestri detected correctly

2.2.2 Path analysis

Path analysis was used to analyze the data using PROC GLM and PROC STEPWISE by SAS (SAS/STAT, 1988). Use of path analysis has several advantages. It forces the user to specify hypothesized interrelationships among variables, including direct and indirect causal associations. This allows the model builder to make use of available a-priori information regarding known or plausible asymmetric relationships. This is an important characteristic which is not included in conventional regression analysis (Goldsmith, 1977). Furthermore a variable can act as the dependent variable in one relationship, while it concommitantly acts as the independent (causal) variable in another relationship.

In path analysis, variables are connected by arrows that represent 'association' or hypothesized 'direct causation'. The path analysis model is read from left to right. Causation only flows (by assumption) along the unidirectional arrows. Exogenous variables are 'given' and no attempt is made to explain relationships between these variables. Therefore, these variables are placed on a vertical line at the far left of the path diagram. The statistical relationships between the exogenous variables are represented by curved, double-headed (bidirectional) arrows. These double-headed arrows imply a 'correlation' rather than a 'causal association'. The other variables are the 'endogenous variables'. It is the hypothesized relationships involving the endogenous variables that path analysis attempts to formalize. A linear regression takes place for every endogenous variable in the diagram. Standardized path-coefficients are calculated on the basis of these regressions. Coefficients are utilized in a standard unit form, for which the formula below is applied (Land, 1969):

$$p_{ij} = ß_{ij} * \sigma_j/\sigma_i$$

where p_{ij} = standardized path-coefficient between independent variable j and dependent variable i, $ß_{ij}$ is ß-coefficient of the linear regression from independent variable j (and other independent variables) on dependent variable i, σ_j = standard deviation of independent variable j, σ_i standard deviation of dependent variable i.

Given the preceding definition of the path-coefficient, it follows that the squared standardized path-coefficient measures the performance of the variance of the dependent variable for which the determining variable is directly responsible (Land, 1969). The model also includes error terms (E_i) for each endogenous variable. These represent the effects of extraneous variables not specified in the model and are the unexplained portion of the variance or statistical 'residuals' in variation of the endogenous variables. The weights of the E_i are calculated as $(1-R^2)^{.5}$. Where R^2 is the square of the multiple correlation coefficient and represents the explained portion of the variance in the dependent variable.

Bivariate correlations are estimated from the model by tracing out all possible paths between the variables, multiplying all standardized path-coefficients of a single path, and then adding these compound path-coefficients. Bivariate associations can be split into direct causal, indirect causal, and spurious associations (Erb et al., 1981). Causal relationships flow forward from one variable to another. When there is a direct arrow between the 2 variables, the association is direct. When several arrows are passed, the association is indirect. Spurious associations are traced by following an arrow backwards from the dependent variable in the model to another variable and then changing direction once to go forward to the other variable (only one change of direction is allowed in each path). The summation of the causal (direct and indirect) and the spurious associations gives the estimated total relationship between the two variables. This value can be compared with the observed correlation from a matrix of bivariate correlations.

2.2.3 Null path models

Two path diagrams were set up with linear relationships that were expected to be related to the gross margin per 100 kg of milk (Figure 2.1) and surplus of nitrogen (N) per ha (Figure 2.2). Not all possible associations were drawn; only paths which could be biologically justified or for which literature was available (discussed in the introduction), were used. To reduce the complexity of Figures 2.1 and 2.2 and for the sake of clearness, the error terms are not shown.

Farm intensity (expressed as the variables quota per ha, cows per ha and young stock per ha) was expected to influence the amount of silage bought per ha. This will in turn have an influence on the gross margin per 100 kg of milk.

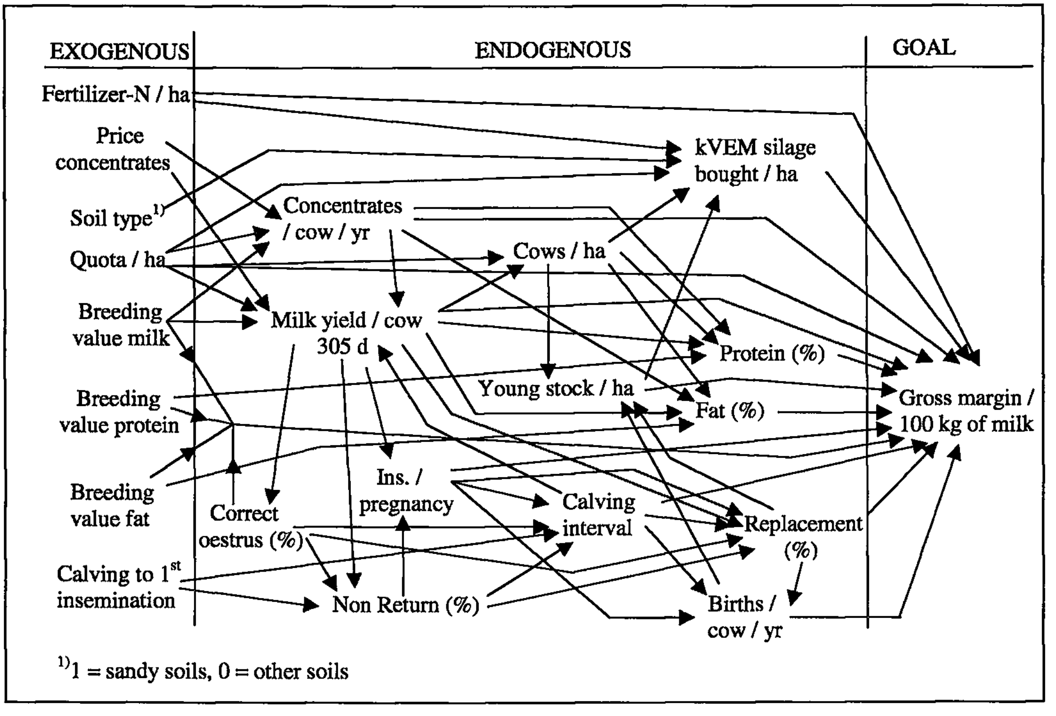

Figure 2.1 Null path analysis model for gross margin per 100 kg of milk.

Average breeding value for kg of milk was expected to influence the milk yield per cow, the amount of concentrates fed and the gross margin per 100 kg of milk (Figure 2.1). No arrow was drawn between breeding values for protein and fat and the milk yield per cow, since no direct causal relationship was expected. However, a positive association between the breeding value per kg of fat and protein and milk yield is expected because of the high correlation between the breeding value per kg of fat and protein and breeding value for kg of milk.

Besides this, milk yield in 305 days was expected to increase due to an increase in the amount and price of concentrates per cow per year, and an increasing calving interval. Quota per ha, cows per ha and milk yield are logically dependent upon each other.

Milk yield was expected to influence the fat and protein percentage in the milk, the replacement rate, and some reproductive parameters. Gross margin per 100 kg of milk can be seen as the result of gross returns of milk and cow inventory and the costs of feed. More specifically, the gross margin was expected to be dependent upon milk yield, the milk contents (i.e. percentages of fat and protein), the amount of feed bought, the replacement rate, the number of births per cow per year, and some reproductive parameters (Figure 2.1).

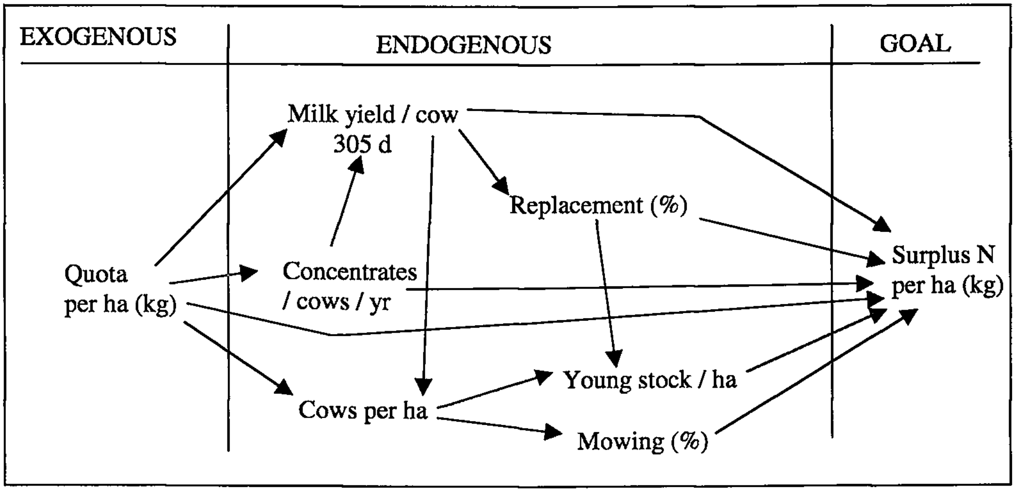

Figure 2.2 Null path analysis model for N-surplus per ha.

There is a fair amount of literature on the type of relationships mentioned above. However, up until now little knowledge was available on the effect of farm characteristics on N-surplus per ha. N is introduced on the farm by buying feed (concentrates and roughage) and fertilizer. Because their relationship with N-surplus per ha is arithmetical, these variables are not included in the model. The amount of feed and fertilizer probably depends on intensity of farming. Farms with a high milk quota per ha were expected to buy more feed because the amount of grass available on the farm per kg of milk will be smaller. Farms with a high mowing percentage of the grass might need to buy less feed, but may use more fertilizer, both also effecting the N-surplus. Therefore, these relationships have been included in the null path model. Output of N is realized by the sale of milk, silage, animals and manure. As a result of removal of these products and animals, surplus of N per ha will be expected to decrease. Hence, milk yield per cow and replacement rate are expected to influence N-surplus per ha.

Linear relationships were checked statistically on the basis of these two null path models, and non-significant relationships ($P > .10$) were removed from the models. The results of the 2 models will be discussed in the next section.

2.3 RESULTS

2.3.1 Gross margin per 100 kg of milk

In total, 21 of the arrows of the original model on gross margin per 100 kg of milk were excluded due to a lack of significance, resulting in the model shown in Figure 2.3. This Figure includes the standardized path-coefficients. The amount of nitrogen in fertilizer per ha was removed from the model since it did not influence the gross margin or the amount of silage bought.

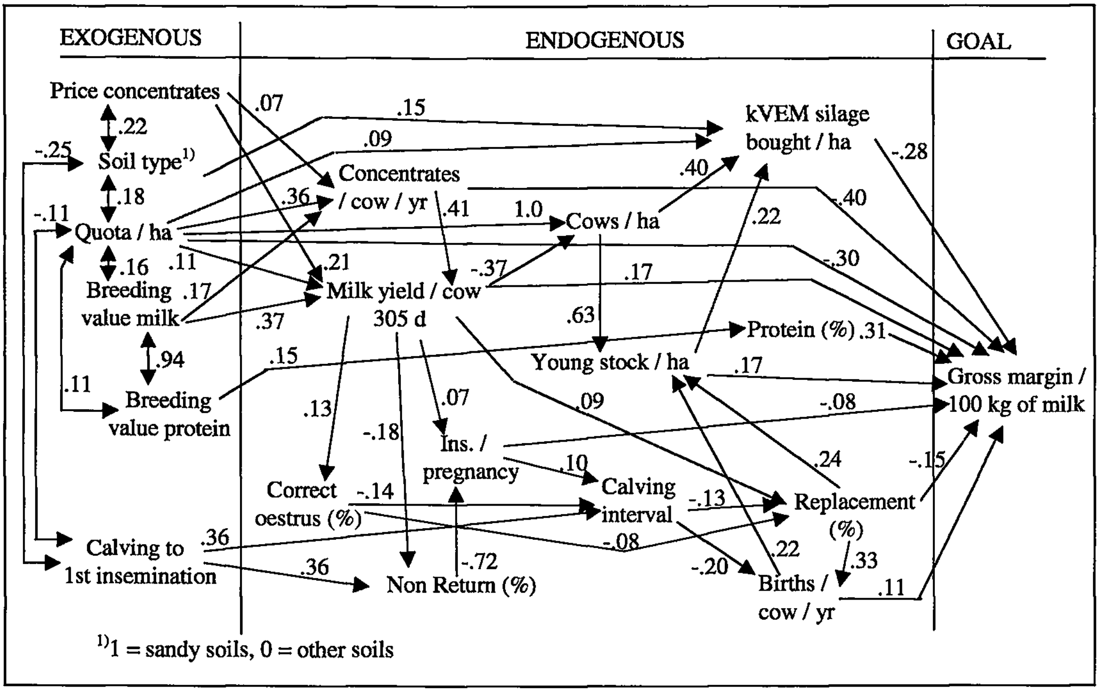

Figure 2.3 Final path analysis model for gross margin per 100 kg of milk. Arrow weight = standardized regression coefficients.

Farm intensity is an important factor in explaining differences in technical and economic farm results. Milk quota per ha directly influences the amount of concentrates used, the amount of silage bought, the number of cows per ha and the gross margin per 100 kg of milk.

The model shows that the milk quota per ha, the amount of concentrates used per cow per year, the price of the concentrates and the breeding value for kg of milk of the cow positively effect milk yield per cow in 305 days. Milk yield, in turn, has a direct negative effect on the number of cows per ha and the non-return rate. Milk yield directly positively influences the gross margin per 100 kg of milk. The standardized path-coefficient equals .17. Other aspects that are directly positively related to milk yield are replacement rate, percentage of oestrus detected correctly and number of inseminations per pregnancy. There are many potential relationships between reproductive parameters and replacement rate (see Figure 2.1). However, only calving interval and the percentage of oestrus detected correctly are directly significantly negatively related to the replacement rate. Number of inseminations per pregnancy and the non-return rate are not directly related to replacement rate. The expected relationship between non-return rate and calving interval is not significant. The interval between calving and first insemination has a significant direct effect on the calving interval and the non-return rate. Besides the interval from calving to first insemination, variability in calving interval could be explained by number of inseminations per pregnancy, and percentage of oestrus detected.

An important component of differences in gross margin is the amount of silage and concentrates that are bought. The direct path from concentrates per cow per year to gross margin per 100 kg of milk has a standardized path-coefficient of -.40. The direct path from the amount of silage bought per ha has a standardized path-coefficient of -.28, respectively (see Figure 2.3 and Table 2.2). Milk quota per ha is important in this respect. More quota per ha implies a higher feed requirement per ha, so more concentrates and silage will be bought.

The variables mentioned above are of major influence on the gross margin. Besides these, there are other variables with only a small, but significant effect on the gross margin. These include reproductive parameters (births per cow per year, and number of inseminations per pregnancy), the number of young stock per ha and the replacement rate (Figure 2.3).

Table 2.2 shows the division of associations into direct, indirect and spurious components with milk yield and gross margin per 100 kg of milk being the dependent variables. The direct causal associations are the standardized path-coefficients mentioned in Figure 2.3. The indirect causal and the spurious associations are calculated by tracing out all possible paths between the 2 variables in Figure 2.3. The total relationship between the independent and the dependent variable estimated by the model, is given in the column 'total estimated'. The column 'measured' shows the simple bivariate correlation between variables in the dataset.

The total association between milk yield per cow and gross margin per 100 kg of milk is, according the model, -.09 (Table 2.2). The correlation matrix however, shows a larger negative significant correlation of -.19, hence our final path model is not the most complete model. The measured correlation between independent variables and milk yield tends to be almost equal to the total estimated association (Table 2.2).

Table 2.2 Division of estimated bivariate associations into direct, indirect and common cause (spurious) components for gross margin per 100 kg of milk.

Variables		Association				
Independent	Dependent	Causal		Spurious	Total	
		Direct	Indirect		Estimated	Measured
Conc. / cow / yr	Milk yield	.41		.12	.53	.57[1),***]
Breeding milk	Milk yield	.37	.07	.04	.48	.51***
Breeding prot.	Milk yield			.42	.42	.45***
Quota / ha	Milk yield	.11	.15	.07	.33	.35***
Quota / ha	Gross margin	-.30	-.18		-.48	-.53***
Cows / ha	Gross margin		-.04	-.38	-.42	-.50***
Conc. / cow /yr	Gross margin	-.40	.07	.01	-.33	-.45***
Silage	Gross margin	-.28		-.07	-.35	-.38***
Protein (%)	Gross margin	.31			.31	.31***
Young stock/ ha	Gross margin	.17	-.06	-.33	-.21	-.25***
Milk yield	Gross margin	.17	-.01	-.25	-.09	-.19***
Ins. / pregnancy	Gross margin	-.08		.03	-.05	-.12**
Births / cow / yr	Gross margin	.11	.04	-.04	.11	.10*
Non Return	Gross margin		.06	-.03	.03	.08[3)]
Breeding prot.	Gross margin		.05	-.07	-.03	.07NS
Oestrus	Gross margin		.01	.02	.03	.04 NS
Replacement	Gross margin	-.15	.07	.02	-.06	.03 NS
Calving int.	Gross margin		-.02		-.02	-.02 NS
Breeding milk	Gross margin		-.06	-.01	-.06	-.01 NS

[1)] From original correlation matrix
[2)] Percentage of oestri detected correctly
[3)] P ≤ .10
* P ≤ .05
** P ≤ .01
*** P ≤ .001

Table 2.3 shows the error terms for all the variables. Most of the error terms of the endogenous variables are almost 1, implicating that a large portion of the variances remains unexplained. Sixty-nine percent of the variation in the goal variable (gross margin/100 kg of milk) cannot be explained by the path model (Table 2.3). The error term of cows per ha equals zero, implicating that its variance is completely explained by the independent variables. This is due to the fact that the variable cows per ha can be calculated out of the 2 independent variables in this model: cows per ha equals quota per ha divided by milk yield per cow.

Table 2.3 Error terms for the variables in the path model on gross margin.

Variable	Error term
Milk yield per cow (305 days)	.80
Protein (%)	.99
Gross margin / 100 kg (Dfl.)	.69
Cows / ha	.00
Young stock / ha	.70
Correct oestrus (%)	.99
Inseminations / pregnancy	.69
Non Return (%)	.93
Calving interval (days)	.92
Replacement rate (%)	.98
Price cow sold (Dfl.)	.96
Concentrates / cow / yr (kg)	.91
kVEM silage bought / ha	.87

2.3.2 N-surplus per ha

The mowing percentage is excluded from the original model on surplus of N per ha, because this aspect did not influence the surplus of N per ha significant. All the other relationships stayed in the model. The final model is given in Figure 2.4. Table 2.4 shows the division of associations.

As could be expected, the same associations between milk yield and replacement rate, cows per ha and concentrates per cow per year are found as in Figure 2.3. Milk quota per ha appears to be an important variable in explaining differences in surplus of N per ha, direct as well as indirect. The total estimated relationships for all of the farm intensity parameters, including cows per ha and young stock per ha as well, and N-surplus per ha are positive.
N-surplus per ha as the goal variable of the path diagram, turns out to be highly dependent on the amount of concentrates per cow per year, as a source of N. However, a higher amount of concentrates given per cow per year also results in a higher milk yield per cow. This, in turn, has a negative effect on the N-surplus. The total causal relationship equals -.16 (see Table 2.4). So, more concentrates per cow per year directly increases the N-surplus per ha, but decreases it indirectly. However, the negative relations between milk yield per cow and N-surplus, in turn, are completely outweighed by some spurious relationships. On the basis of this model it may be hypothesed that a higher milk yield per cow results in a lower N-surplus per ha, when this increase in milk yield is not completely the result of an increase in the amount of concentrates fed.

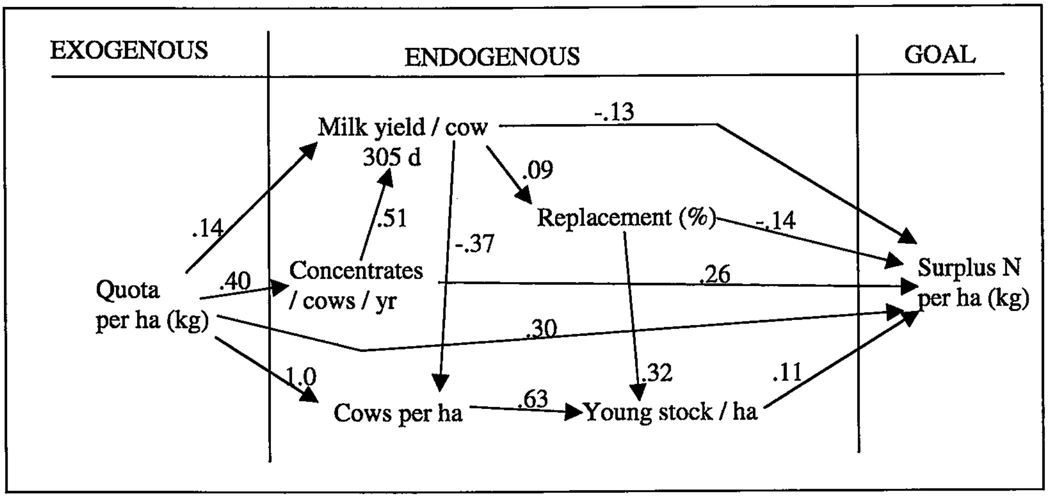

Figure 2.4 Final path analysis model for N-surplus per ha. Arrow weights = standardized partial regression coefficients.

Table 2.4 Division of estimated bivariate associations into direct, indirect and common cause (spurious) components for N-surplus per ha.

Variables		Association				
Independent	Dependent	Causal		Spurious	Total	
		Direct	Indirect		Estimated	Measured
Conc. / cow / yr	N-surplus	.26	-.08	.18	.36	.32***
Quota / ha	N-surplus	.30	.12		.42	.43***
Milk / cow	N-surplus	-.13	-.03	.17	.01	-.10**
Cows / ha	N-surplus		.07	.35	.42	.43***
Young stock	N-surplus	.11		.26	.37	.30***
Replacement	N-surplus	-.14	.03	.00	-.10	-.10*

* $P \leq .05$
** $P \leq .01$
*** $P \leq .001$

A less important but significant explanation for the N-surplus per ha, is the direct negative effect of replacement rate on N-surplus (p = -.14). The model on gross margin has already demonstrated that differences in replacement rate can partly be explained by differences in milk yield per cow.

Table 2.5 shows the error terms of the path diagram on N-surplus per ha. It can be concluded that 89 % of the variance in N-surplus per ha cannot be explained by the current model.

Table 2.5 Error terms for the variables in the path model of N-surplus per ha.

Variable	Error term
Milk yield (kg in 305 days)	.85
Cows / ha	.00
Young stock / ha	.71
Concentrates / cow / yr (kg)	.78
Replacement rate (%)	1.00
kVEM silage bought / ha	.88
Surplus of N / ha (kg)	.89

2.4 DISCUSSION AND CONCLUSIONS

Milk yield per cow is a central factor in the model to explain variation in gross margin per 100 kg of milk. A positive relationship between milk yield and gross margin might be expected: farms with higher milk yield per cow are expected to have lower feed costs per 100 kg of milk, due to fewer maintenance requirements per 100 kg of milk. The causal associations are indeed positive (Table 2.2). However, due to spurious effects, the overall effect is negative. The most important spurious relationship resulting in this negative correlation, is the fact that farms with a high milk yield use more concentrates per cow per year. Besides, there is a positive relationship between milk quota per ha and milk yield per cow. It is obvious that more intensive farms face higher costs when purchasing feed. These extra costs and the higher use of concentrates most probably outweigh the decrease in maintenance costs as a result of the higher milk yield per cow.

A negative causal relationship between the variables milk yield per cow and N-surplus per ha was found, but due to spurious effects, the overall relationship estimated from the model, is slightly positive (.01; see Table 2.4). The same line of reasoning can be used as has been done for the relationship between milk yield and gross margin per 100 kg of milk. Farms with higher milk yield per cow tend to be farms with a higher milk quota per ha and the use of concentrates per cow per year is higher. These two aspects are positively related to the N-surplus per ha (see Table 2.2) and they outweigh the decrease in N-surplus due to the higher milk yield per cow.

A limitation of the current approach is that only linear relationships are included in the model. However, it can be expected that, in practice, both goal variables (gross margin per 100 kg of milk and N-surplus per ha) have a range of values that can be reached. In the literature different views on the relationship between milk yield and gross margin have been discussed (mentioned in the introduction). Current data is not sufficiently detailed to estimate these relationships satisfactorily. Further research is needed to gain more insight into these kinds of relationships.

Jansen (1985) stated that higher production is largely obtained by better management, causing an overall positive relationship between fertility and production. This can explain the positive relationship found between milk yield and percentage of oestrus observed correctly. However, besides this positive relationship, milk yield was found to have a direct negative effect on the non-return rate and a positive effect on number of inseminations per pregnancy (both pointing to a decrease in fertility) in the current study. So, the results of this study are not in agreement with the statement of Jansen (1985).

Data used in the analysis are farm averages. Therefore, this data can only be used for between-farm comparison. Effects within herds cannot be determinds. So, it cannot be used to demonstrate whether, for instance, relationships between milk yield and reproductive parameters are the result of differences in reproductive management between high and low yielding farms or the result of real biological differences between high and low yielding cows. The current data set does not include all the necessary data to completely explain why farms differ. More research is needed on management aspects of the farmer: how does a farmer make decisions, how are the daily activities carried out, etc.. To collect this data, farms need to be visited regularly, since no data sets are available at present. By doing so, differences in endogenous variables will be explained and the relationship between milk yield, N-surplus and gross margin can be clarified more precisely. Results is under way to collect (and analyse) these data.

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Chapter 3

How to define and study farmers' management capacity: theory and use in agricultural economics

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ABSTRACT

Textbooks and articles on farm management stress the importance of the management capacity of the farmer with respect to his farm results. However, explicit definitions together with an elaboration of this concept are hard to find. In this article, aspects of management capacity are grouped into (1) personal aspects, consisting of farmer's drives and motivations, farmer's abilities and capabilities and his biographical facts such as age and education, and (2) aspects of the decision-making process, consisting of practices and procedures with respect to planning, implementation and control of decisions at the farm. Empirical studies on the role of management capacity in relation to farm results are reviewed. Frontier production functions are widely used in recent literature to estimate technical and economic efficiency of farms. However, in explaining differences in efficiency most studies do not go further than adding a biographical variable (e.g. level of education). This study concludes that a next step would be to include aspects of the decision-making process. Longitudinal on-farm observations, which give possibilities for studying the dynamic aspects of the decision making, are suggested to further analyze the concept of management capacity.

3.1 INTRODUCTION

It is a well-established fact that economic performance can differ considerably between farms, even if they are operating under more or less similar production conditions. Differences in economic results are usually attributed to differences in the management of the farmer (e.g. Boehlje and Eidman, 1984). Management capacity can be seen as a separate, fourth factor of production, in addition to the traditional factors land, labour and capital (e.g. Case and Johnston, 1953). Then, what constitutes this special production factor? Despite many books and articles in the field of farm management and decision theory, the management process itself largely remains a black box, and management capacity is rarely explicitly defined and measured. The aim of this article is (1) to give an overview of main aspects of management capacity, (2) to discuss the problems and opportunities with respect to measuring and collecting data of management capacity, (3) to review the empirical studies that relate management capacity to farm results and (4) to detect weak spots and give suggestions for improvements.

The outline of this article follows these four points. All sectors of agriculture are included, so farms and farmers also refer to greenhouses and growers. For the sake of readability, we write "he" instead of "he or she" when referring to a farmer or a manager in general.

3.2 ASPECTS OF MANAGEMENT CAPACITY

Concise definitions such as "farm management is concerned with the decisions that affect the profitability of the farm business" (Castle et al., 1987: p. 3) or "using what you have to get what you want most" (Kadlec, 1985: p. 3) make clear that farm management is concerned with resources, decisions and results. Kay and Edwards (1994: p. 7) list some phrases often used in definitions of management and show three common elements: (1) the need to establish goals, (2) the existence of resources to use in order to meet the goals and (3) the possibility to use resources in alternative ways, varying in degree of effectiveness and efficiency, to produce several agricultural products. This description is rather broad and resembles common definitions of economics as a science that studies the ways in which finite amounts of resources are allocated to an infinite number of wishes.

A major part of any textbook on farm management is devoted to economic concepts and quantitative techniques for calculating optimal levels of inputs (resources) and outputs (products) under well-defined restrictions, i.e. managing resources in order to get the best results. A factor which may be overlooked when farm management is treated in a formal, more or less mathematical way is the role of the farm manager in the decision making. His management capacity is the decisive factor when it comes to applying sound theoretic principles in practice. Johnson et al. (1961) describe a large study where this problem is paid attention to: the Interstate Managerial Study. Objectives of this study were, for instance, to describe the role of information and decision making. A survey was conducted among 1075 farm managers. This study was not the first on this subject, but due to its comprehensiveness it can be seen a breakthrough in research on management in agriculture. Harling and Quail (1990) developed a simplified general management model, containing five elements: strategy, environment, resources, managerial preferences and organization, which must be brought in balance.

Management capacity is defined here as having the appropriate personal characteristics and skills to deal with the right problems and opportunities in the right moment and in the right way. Starting point is the manager who has certain qualities. By means of his decision making he will try to optimize (or at least influence) the technical and biological processes at the farm (see Figure 3.1). These processes, controllable to only a certain extent, determine the technical and economic results of the farm. Stochastic elements, such as the weather, the incidence of pests and diseases and fluctuations in the market (prices) also play their part. Farm managers perform their task in an environment which changes over time in a hardly predictable way and therefore causes risk and uncertainty in the decision making. Boehlje and Eidman (1984: p. 670) distinguish four major dimensions: (1) the institutional environment (e.g. regulations on water, land and air pollution), (2) the social environment (e.g. the family of the farmer), (3) the physical environment (including the weather and the state of the technology) and (4) the economic environment (which determines prices of inputs and products).

Personal characteristics and skills, which are an important aspect of managerial capacity can be divided into (1) drives and motivations, e.g. farmers' goals and risk attitude, (2) abilities and capabilities, e.g. cognitive and intellectual skills and (3) biography, e.g. background and experience (e.g. Muggen, 1969). Such personal characteristics and skills of the farmer are often assumed to be important in explaining differences with respect to the success of the farm.

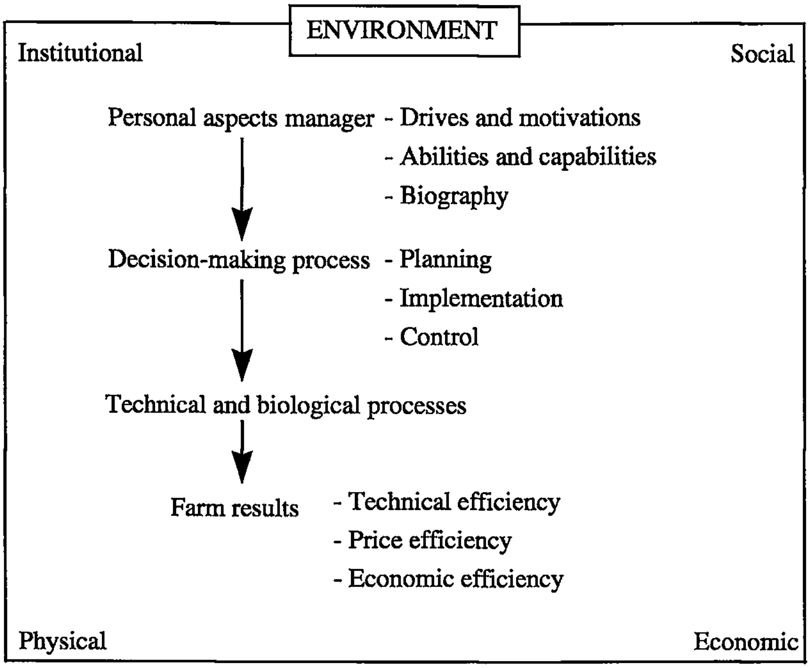

Figure 3.1 Management capacities in relation to environment, biological processes and farm results.

A farmer who is confronted with favourable external conditions and who also has high personal skills - one might say favourable internal conditions - is likely to have good results. But still, it can go wrong when the decision-making process is poor. Following the steps of a well-defined process helps a decision maker to make a decision in a logical and organized manner and will on average lead to better results. Simon (1977) distinguishes four phases: intelligence, design, choice and review. Another well-known division of the decision-making process is: planning, implementation and control. Further subdividing the process lead Kay and Edwards (1994: p. 13) to the following steps, assuming that goals (step 0) have already been established: 1. identify and define the problem, 2. collect data and information, 3. identify and analyze alternative solutions, 4. make the decision - select the best alternative, 5. implement the decision, 6. monitor and evaluate the results and 7. accept the responsibility for the decision. Following such a process can help to (easily) explain and justify a decision, a criterion used for its quality by Slovic et al. (1977).

An important notion, in connection with the foregoing, is that in assessing the quality of a decision, one can use not only outcome-oriented criteria (the final results), but also process-oriented criteria. In other words, one can judge whether a decision is right before the outcome is apparent by looking at the process that led to the decision. Simon (1977; 1982: p. 426) uses the term procedural rationality. One hundred percent rationality is usually not realized or even wanted. Human decision making can be characterized by impulsive responses, satisfying rather than optimizing behaviour and by bounded rationality rather than complete rationality. Summarizing this so called model of bounded rationality (Simon, 1982): a decision maker is not likely to change, and make new decisions, unless a certain level of dissatisfaction about the current situation is reached. Then, in making a decision he is bounded by his limited cognitive skills, e.g. with respect to the amount of information that he can process. However, given these boundaries, he will try to act rational. He will use his skills and try to make reasonable - in stead of optimal - decisions.

At every step of the decision-making process part of the rationality can be lost. In order to be effective it is a basic condition that priorities are set and time is divided accordingly. Otherwise the decision maker might get entangled in smaller details of relatively unimportant decisions and forget to deal with the real important problems and opportunities (e.g. Covey, 1989). A manager can make an overview of the areas he should deal with and then choose which factors are most critical for being successful (Rockart, 1979). This can be called the meta-decision: deciding which decisions are most valuable to put an (intellectual) effort into, i.e. where and how to spend the time as a manager. Setting priorities and dividing time is an important aspect of the decision-making process. The choice of a number of critical processes, out of the complete picture of tasks, helps a farmer to concentrate on the right problems and to allocate his limited time in the right way. A complete picture of the farm could be made using fields of management (e.g. finance, production, personnel and marketing), functions of management (e.g. planning, implementation and control) and/or level of management (e.g. strategic, tactical and operational) as entries; see e.g. Boehlje and Eidman (1984: p. 15) who give a list of major activities for each function of management. An example of an overview of the organization of the farm is the 'Dutch information model', that describes all functions, processes, information flows and data of the farm (De Hoop, 1988; Poppe, 1991).

3.3 MEASURING MANAGEMENT CAPACITY

3.3.1 Personal aspects and decision-making processes

Some of the personal aspects (age, education, experience on the farm) of the farmer can be measured relatively well. Other personal aspects which lie in the area of drives and motivations, or abilities and capabilities are much harder to detect and quantify. They can be diverse, unclear and hidden. Hedges (1963: p. 30) lists 19 of the more important traits and characteristics associated with capable management, such as willingness to learn, decisiveness and self-confidence. But, he remarks that "we are not able to measure such a complex successfully, nor to evaluate its precise significance". Yet some progress has been made. A direct way to ask for drives and motivations is performed by Huirne et al. (1997). They asked farmers to point out the goals they had for their farms. They used several worksheets, consisting of open questions and closed questions and they also used small tasks.

Decision-making processes, as part of the management concept, are difficult to study in practice. Literature from the Business School shows how complex management can be. For instance, Mintzberg (1973: pp.10-11) cites two studies (Carlson, 1951 and Davis, 1957) on managerial work in order to make clear that a manager is not working according to the classical functions of management, such as planning and controlling. A manager does not neatly divide his time in planning, implementing and controlling. This means that these concepts need to be translated into explicit, formalized actions and procedures that can be distinguished and measured. Such actions may be the frequency of consultants visiting the farm, the time spent on reading and processing farm results, or the time spent on meetings with personnel. Rather than measuring time and frequency of these actions, one could observe the (physical) results, showing evidence of a high quality with respect to planning and control. For instance, does the farmer have written plans - and if so, to what degree of detail and how far reaching in time - and how much does he know about facts and figures on his farm in relation to other farms? By distinguishing phases of the decision-making process and by defining explicit actions related to these phases, an opening is created to measure and quantify part of the management capacity.

3.3.2 Data collection

Several data sources can be used to study management capacity. Mintzberg (1973: pp. 221-229) gives a review of methods used to gather data on managers. To study the management capacity of a farmer, being the executive of a small company, one can use either existing data or create new data. Several options are listed in Figure 3.2. These options are grouped into four main categories: (1) analyzing existing farm data, (2) single on-farm investigations, (3) longitudinal on-farm observations and (4) off-farm experiments.

Each data source has its advantages and disadvantages. The first group (1) of data sources makes use of already existing material, either produced by the farmer himself, as a primary source, or by others as a secondary source. Also data can be used from existing study groups where farmers compare their results. A substantial advantage of these data sources are the low costs connected to them. A disadvantage is that they usually do not cover the research question completely. The data methods in group (2), interviews and questionnaires can be made up so that they entirely cover the research question and they can be performed at relatively low cost. However, one may question the reliability and accuracy of interviews and questionnaires: the respondent may have forgotten relevant details or deliberately give 'socially desired' answers or answers that avoid cognitive dissonance. Also, answers may be biased by the manager's perception of his own job (Mintzberg, 1973: p. 222).

Data sources (3) and (4) give more possibility for checking and for in-depth research, but are relatively expensive. Longitudinal on-farm observations (group 3) are based on repetitive data collection throughout a period of time. These observations are more expensive, but are more likely to generate more reliable and accurate data. Another advantage is that these methods are better compatible with decision-making processes, which are also continuous and dynamic by nature. The researcher will be visiting the farm on a regular basis to make observations and to ask questions (e.g. about his plans) and, in addition, the farmer may be requested to keep certain records during the intervals between the visits. A problem with this kind of studies is articulated by Dillon and Hardaker (1993: p. 43) who write: "the mere presence of the observer can lead the person being studied to modify her or his behaviour".

GROUP 1 ANALYZING EXISTING FARM DATA
1. Primary source: written plans, calculations, calenders, records kept, etc.
2. Secondary source: tax data, accounting data, etc.

GROUP 2 SINGLE ON-FARM INVESTIGATIONS
3. Interviews
4. Questionnaires

GROUP 3 LONGITUDINAL ON-FARM OBSERVATIONS
5. Unstructured observations (participation)
6. Structured observations
7. Records kept by farmer on request (panel data)

GROUP 4 OFF-FARM EXPERIMENTS
8. Tests
9. Role-playing, gaming, simulation
10. (Computer) experiments

Figure 3.2 Forms of data collection to study management capacity of farmers.

Finally, group (4), one can take the farmer away from his farm, take him to a 'laboratory', which can be a room equipped with computers, and study his management capacity through (personality) tests or (computer) experiments under controlled conditions. An example of this kind of research can be found in Cross et al. (1994) who describe workshops held with groups of farmers in order to investigate, among other things, the strengths and weaknesses of their information system.

In the next section empirical studies are reviewed with respect to the parts of management capacity they consider and the technique(s) they use for data collection and analysis.

3.4 REVIEW OF EMPIRICAL STUDIES

3.4.1 Methodology

This section focuses on empirical studies that explicitly deal with management capacity of farmers in relation to technical and/or financial results at the farm level. Empirical studies have been selected on the basis of the following criteria: (1) one or more aspects of management capacity of the farmer has been measured, (2) technical and/or financial results have been measured, (3) a relationship between management capacity and results has been analyzed, and (4) the research has been published in scientific agricultural economics and related English-language journals in 1980 or later. Table 3.1 gives an overview of studies that meet these criteria.

The variables analyzed are investigated and compared with the aspects in Figure 3.1 (see previous section). Besides these variables measuring management capacity, Table 3.1 contains farm results. Studies are divided into those using the production frontier approach and those using other approaches. Battese (1992) reviews the methods that can be used to estimate the production frontier: deterministic frontiers, stochastic frontiers and panel data models. The current study is focusing on types of efficiency that can be measured. The production frontier approach distinguishes technical efficiency (TE), price efficiency (PE) (also called allocative efficiency), and economic efficiency (EE). Technical efficiency is the ability to avoid waste by producing as much output as input usage allows, or by using as little input as output production allows. Price efficiency is the ability to combine inputs and outputs in optimal proportions in light of prevailing prices (Fried et al., 1993). Economic efficiency is a measure of overall performance and is equal to technical efficiency times price efficiency (i.e., EE = TE * PE) (Bravo-Ureta and Pinheiro, 1993). The studies which do not use the production frontier approach use straightforward technical results (T) or financial results (F). In total twenty three studies will be discussed here, of which the majority is dealing with dairy farming, but also crop, greenhouse, swine and mixed farming are dealt with. First, the methods and techniques used to measure farm results will be discussed. After that the methods to study management capacity will be worked out.

Management capacity in these empirical studies has been related to the farm results. What variables are used as indicator(s) for farm results? In Table 3.1 it can be found that nine studies compare management capacity with financial farm results (indicated by F, PE or EE in Table 3.1). Especially in the latest years, the production frontier approach has been used more and more to determine farm results. Stefanou and Saxena (1988) calculate the price, or allocative, efficiency. Ali and Finn (1989), Parikh et al. (1995), Bravo-Ureta and Rieger (1991), Adesino and Djato (1996) and Wang et al. (1996a and 1996b) calculate the economic efficiency. In other studies plain financial parameters are used as an indicator for farm results. Achten et al. (1983) use the money value of the real yield in horticulture. Jofre-Giraudo et al. (1990) evaluate the influence of management capacity on economic benefit, however, in a subjective way. The manager is asked whether or not the benefits of their management changes had compensated the costs. Jose and Crumly (1993) use several debt and income indicators. Other studies focus on technical aspects only, for instance milk production (Sharma and Patel, 1988; Tarabla and Dodd, 1990), or respiratory disease in swine (Hurnik et al., 1994a,b).

Some studies relate the management capacity to more than one technical parameter (Goodger et al., 1984, 1984/1985 and 1988; Bigras-Poulin et al., 1984/1985b; Cowen et al., 1989, Rosenberg and Cowen, 1990), ranging from the number of repeat breeders to somatic cell count (as an indicator for quality of milk), disease rates and culling rate. Overall it can be concluded that all kinds of different methods are used as an indicator for farm results. The studies which use the economic efficiency criteria, are the only ones that (can) combine technical and economic results.

Table 3.1 Variables describing management capacity included in empirical studies.

	Management Capacity[1)]		Results[2)]	no. of farms included
	personal aspects	decision making		
PRODUCTION FRONTIER APPROACH				
Moock (1981)	B	P	TE	152
Jamison and Moock (1984)	B,A	P	TE	683
Kalirajan and Shand (1985)	B,A	P,C	TE	91
Stefanou and Saxena (1988)	B	-	PE	131
Ali and Flinn (1989)	B	-	EE	120
Bravo-Ureta and Rieger (1991)	B	P	EE	511
Kumbhakar and Heshmati (1995)	B	-	TE	250/430
Parikh et al. (1995)	B	-	EE	436
Adesina and Djato (1996)	B	P	EE	410
Battese et al. (1996)	B	-	TE	499
Wang et al. (1996a,b)	B	-	EE	786/1889
OTHER APPROACHES				
Achten et al. (1983)	B,D	P,C	F	71
Goodger et al. (1984,'84/'85,'88)	B,D,A	P,C	T	20/50
Bigras-Poulin et al. (1984/'85a,b)	B,D,A	C	T	110
Sharma and Patel (1988)	B	-	T	176
Cowen et al. (1989)	-	P,C	T	218
Jofre-Giraudo et al. (1990)	-	P,C	F	50
Rosenberg and Cowen (1990)	-	P,C	T	87
Tarabla and Dodd (1990)	B,D	C	T	123
Jose and Crumley (1993)	A	-	F	120
Hurnik et al. (1994a,b)	B,D	-	T	69
Kiernan and Heinrichs (1994)	-	C	T	329
Dewey et al. (1995)	D	C	T	76

1) B= biography, D = drives and motivations, A = abilities and capabilities, P = planning, I = implementation, and C = control

2) TE = technical efficiency
PE = price efficiency (= allocative efficiency)
EE = economic efficiency
F = financial parameter
T = technical parameter

Although many different methods to measure management capacity are available (see Figure 3.2) it turns out that in practice single on-farm observations are most frequently used. Kumbhakar and Heshmati (1995), Ali and Flinn (1989), Battese et al. (1996) and Wang et al. (1996a,b) use panel data. However, these data lack information on the decision-making process: only the farm results over time are measured. Longitudinal on-farm observations are likely to generate more reliable and accurate data. However, they are more expensive and time-consuming.

Almost all studies use questionnaires or interviews except for Goodger et al. (1984 and 1988) and Goodger and Kushman (1984/1985). They make observations and perform measurements on the farm. This method of research is much more time consuming, as reflected in the number of farms included in the research: Goodger and Kushman (1984/1985) used 20 farms. The only off-farm experiment in which the relation between management capacity and farm results is measured is found in Jose and Crumley (1993), who use a psychological test.

3.4.2 Personal aspects

Quite some work has been done on the relationship between education and farm efficiency. From different studies it can be concluded that education has a positive influence on farm results, especially in developing countries. Lockheed et al. (1980), Bravo-Ureta and Pinheiro (1993), and Phillips (1994) review papers that measure the effect of a farmer's educational level and exposure to extension services on his productivity. They focus on studies performed in low-income regions. Overall, they find confirmation for the hypothesis that education, as a part of the farmers' biography, will have a positive effect on farmers' efficiency. Other studies (see Table 3.1) also indicate that education is positively correlated with farm results (Moock, 1981; Achten et al., 1983; Jamison and Moock, 1984; Bigras-Poulin et al., 1984/1985b; Stefanou and Saxena, 1988; Ali and Finn, 1989; Parikh et al., 1995; Battese et al., 1996; Wang et al., 1996). However, no significant effect of education on farm results is found by Kalirajan and Shand (1985), Tarabla and Dodd (1990), Boris and Rieger (1991) and Adesina and Djato (1996).

Another personal aspect quite often looked at, is the experience and/or the age of the farmer. The influence on farm results is not straightforward. Some studies find a positive effect of experience (Kalirajan and Shand, 1985; Stefanou and Saxena, 1988), others do not find an effect at all (Sharma and Patel, 1988; Hurnik et al, 1994a,b). A negative influence of age on farm results is found by Parikh et al. (1995), but no effect by Jamison and Moock (1984) and Tarabla and Dodd (1990). Battese et al. (1996) do find effects of age on technical efficiency. However, the direction of the effect differs between districts of Pakistan. Bravo-Ureta and Rieger (1991) find opposite effects of age (also called experience) on TE, PE and EE. To summarize, biographical aspects can affect farm results, technical as well as financial, but the results are diffuse: sometimes an effect is found, sometimes there is not.

Drives and motivations that are investigated vary from goals of the farmer, attitude towards paperwork, openness to new ideas, level of ambition, satisfaction with farming, to most preferred job at the farm. Milk yield and fat yield are positively correlated with level of ambition (Bigras-Poulin et al., 1984/1985b). Satisfaction with farming is usually found not to be of any influence on farm results (Tarabla and Dodd, 1990; Hurnik et al, 1994), only Bigras-Poulin et al. (1984/1985b) find an influence of satisfaction with farming on farm results, in terms of rate of culling and fat and milk yield. Dewey et al. (1995) find litter size being influenced by the most preferred job of the farmer. Almost all these studies show that farm results are dependent upon some aspects of drives and motivations of the farmer, but these aspects and the resulting effects are measured in a lot of different ways, which complicates making comparisons.

Table 3.1 indicates that ability and capability variables (as part of the personal aspects of the farmer) are rarely analyzed. Besides that, these variables are diverse, making it difficult to draw an overall conclusion on their effect on farm results. Variables mentioned in the studies vary from knowledge of cow behaviour, knowledge of technical recommendations and prices, understanding of technology, to assertiveness and temperament. No influence of level of assertiveness on farm results is found (Bigras-Poulin et al., 1984/1985b). Goodger et al. (1984) and Goodger and Kushman (1984/1985) calculate an overall management index. They put the same weight on all kind of aspects, to calculate an overall score. Knowledge of cow behaviour is one aspect of this index. They find a positive relation between the overall management index and farm results, but the separate effect of knowledge has not been determined. Understanding of technology, measured by asking the farmer to describe the different recommendations of new technologies, is found to have a significant (positive) effect on the yield of rice (Kalirajan and Shand, 1985). Jamison and Moock (1984) measure numeracy, literacy and an agricultural knowledge test score. These aspects are taken as variables in different production function regressions. Sometimes a positive effect is found on production, sometimes no effect could be determined. Jose and Crumly (1993) compare the temperament factors with financial measurements. They find that 'thinking people' have higher total assets than 'feeling people', and 'extravert people' have higher debts than 'introvert people'. From this small overview on relations between abilities and capabilities of the farmer and farm results, it can be concluded that the knowledge in this area is still rather limited in agricultural literature. It can be concluded that the influence of education is often studied, while other personal aspects are under-exposed.

3.4.3 Decision-making processes

With respect to decision making, a distinction is made between planning (P), implementation (I) and control (C). Studies on planning can be divided into two groups. The first group measures aspects of the decision-making process itself (e.g. the length of the planning horizon and the degree of detail), the other group focuses on aids that are used for the decision making (e.g. use of computer records, extension services, and other information processing devices). Studies looking at the decision-making process itself usually find a positive effect of planning on farm results. The variables used, however, are very diffuse. Achten et al. (1983) investigate to what degree of detail plans are made, concerning production, labour requirement, etcetera. Planning of short-term decisions and activities prove to be an important factor which influences the yield level of greenhouse vegetable producers. Decision-making procedures in staff matters are investigated by Goodger et al. (1984) and Goodger and Kushman (1984/1985) as an indicator of management effectiveness. A judgment on the quality of the decision-making process of the farmer is made during an open interview on how the farmer makes his decisions. They find a positive relationship between an overall management score (the decision-making process being a part of it) and milk yield, days in milk, and days open. Cowen et al. (1989) investigate the effect of data processing devices: whether the farmer made use of computer records, or lists of things to do (e.g. cows to breed). They find that use of computer records or lists of things to do results in observation of problems in an earlier stage. Rosenberg and Cowen (1990) determine the level of rationality in the decision-making process of the farmer, by asking the farmer to describe the process (e.g. how milkers were chosen). They do not find a relation with farm results.

Studies focusing on aids that are used for decision making, are mostly focusing on the use of external advisors. Jofre-Giraudo et al. (1990) are the only ones who measure other aspects as well. They investigate what sources of information for planning purposes are used (e.g. records from the dairy herd improvement association (DHIA), own herd records, etcetera). However, the collected data are not sufficient to relate this to the results of the farm. The findings with respect to the influence of external advisors are mixed for the different kinds of efficiency. Adesina and Djato (1996) do not find a significant influence of extension on economic efficiency. Moock (1981), and Kalirajan and Shand (1985), find a positive effect of the number of extension visits, as a source of information, on technical efficiency. Bravo-Ureta and Rieger (1991) find an effect of extension on efficiency. However, the effect on technical efficiency is positive, but the effect on price efficiency and economic efficiency is negative. This shows that focusing on technical efficiency alone may have a negative influence on the overall economic efficiency. The risk of producing beyond the optimal economic level of production is present.

None of the studies report findings on the quality of the implementation of decisions. However, implementation is closely related to time allocation: how is a farmer using his time? Time allocation, is included in five studies and, again, the elaboration of it is rather heterogeneous. Time allocation variables vary from the time available for cleaning, time spent at keeping health records, time spent on heat detection, time spent on management and hours of continuing education, to regularity of communication with milkers about job performance. Time spent at keeping health records turns out to decrease the incidence of reproductive disorders (Bigras-Poulin et al., 1984/1985b). Regularity of communication with milkers about their job performance has a positive influence on milk yield (Rosenberg and Cowen, 1990). Dewey et al. (1995) have found a positive effect of the time spent on heat detection and breeding on the average litter size. They also asked farmers whether or not they spent enough time on insemination of sows and heat detection. Here, no relationship is found with the farm results. Jofre-Giraudo et al. (1990) asked farmers to estimate the time they spent on management. Farmers with an information system spent more time on management than farmers without. However, no clear relation is found with the financial results of the farm. Although different studies focus on time allocation of the farmer, none of the studies measure the complete distribution of time of the farmer over all kinds of different activities. This would be interesting and clarifying, yet difficult to carry out.

Studies focusing on the control part of the decision-making process are divided into two groups: studies focusing on aspects of the decision making itself (e.g. criteria used for evaluation of farm results), and studies that investigate side-line aspects. The use of information - as a side-line aspect -seems to have a positive effect on the results. Cowen et al. (1989) and Kiernan and Heinrichs (1994) investigate whether or not external data are used as a source of information. Both find a positive influence of using this external data on farm results. Jofre-Giraudo et al. (1990) also investigate the use of external data but do not relate this to farm results. Tarabla and Dodd (1990) find that the number of times the milking machine is tested per year is positively correlated with the quality of milk. Rosenberg and Cowen (1990) find that use of written records in the herd decision making, has a positive influence on the quality of milk, the average days open and leads to a smaller number of services per conception. They also have a look at the decision-making process itself: the criteria used in the evaluation of farm results are studied. The hypothesis was that the objective criteria combined with regular communication with milkers about their job performance would lead to higher results. But they do not find support for this hypothesis. Both aspects do not seem to influence the farm results. So, no study is found where an effect of the quality of the control itself - as part of the decision-making process - on the farm result could be determined.

To summarize the above, two observations can be made. First, studies which use the production frontier approach usually look at age/experience and education of the farmer and to the use of extension services (as part of the planning), yet ignore other personal aspects of the farmer and his decision-making process. Other studies take into account more aspects, but none includes all aspects of management capacity (B, D, A, P, I and C; see Table 3.1). Second, when an aspect is taken into account, the elaboration of it differs greatly between studies, leading to a wide range of variables measured.

3.5 DISCUSSION AND CONCLUSIONS

This article reviewed empirical studies that relate farm results to management variables. First, the concept of management capacity was elaborated. Management capacity was defined as having the appropriate personal characteristics and skills (including drives and motivations, abilities and capabilities and biography), to deal with the right problems and opportunities in the right moment and in the right way. The way problems and opportunities are dealt with by the farmer/manager is reflected in the decision-making processes (split into planning, implementation and control), meant to influence the technical and biological processes on the farm, which in turn determine the farm results. Each of these steps can be controlled only partly, stochastic elements from the environment also play their part.

Empirical studies show an influence of management capacity on farm results. For instance, Jose and Crumly (1993) who find a relation between personal characteristics and economic results. Overall, the proportion of variance in the dependent (result) variables that is explained by the independent (management) variables differs from 7% to 40% between the studies reviewed. However, these values are hard to compare, due to differences in the way management capacity is defined in these studies, differences in independent variables that are included, and differences in definition of farm results.

Recent studies frequently use the production frontier approach to estimate technical and/or economic efficiency at farms. Elements of management capacity can be added to the list independent variables in this approach. Most often education and experience are taken into account. The method has met critique on the applicability of the rules of neoclassical economics to traditional agriculture (e.g. Torkamani and Hardaker, 1996). Furthermore, for the purpose of relating farm results to management capacity, the production frontier approach must be compared to other methods. The path model approach, for instance, gives the opportunity to set up a stepwise analysis, as shown in Figure 3.1 (where personal aspects influence the decision-making process, which, in turn, influences the farm results). So, whether to use the production frontier approach or an alternative approach, needs attention on forehand, taking into account the pros and cons of the different alternative methodologies.
Most empirical studies on management capacity of farmers, in relation to farm results, use questionnaires and interviews for data collection. These are usually executed without repetition, leading to single measurements. To effectively analyze the role of all aspects of management capacity, other methods can be useful. On-farm investigations, with regular repetition, are more appropriate to study management capacity of farmers. Such longitudinal observations are more in line with the dynamic nature of decision-making processes. Also, they give opportunities for verification and are therefore likely to give a more realistic picture. Off-farm experiments with farmers, e.g. in a computer laboratory, can be used to simulate decision-making processes, to assess certain abilities and capabilities of the farmers and to find out about their drives and motivations and their attitude toward risk. However, there is considerable evidence to suggest that the external validity of decision-making research that relies on laboratory simulations of real-world decision problems is low (Ungson and Braunstein, 1982: p. 39). To provide evidence on validity of different methods, the need for multimethod approaches is generally acknowledged.

The last objective of this study was to detect weak spots and to give suggestions for improvements for studying management capacity in relation to farm results. It can be concluded that the decision-making process is under-exposed. This is especially the case for the studies using the production frontier approach. The decision-making process can only be measured by longitudinal data, for instance structured farm observations/visits in time, to follow the planning, implementation and control on the farm. This kind of studies can lead to a better understanding of differences in success between farmers and can serve as a basis for support and improvement of their farm results.

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Chapter 4

Repeatability in ranking of dairy farms on technical and economic performance over years

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ABSTRACT

Repeatability of farm average 305-day milk production and gross margin per 100 kg of milk was evaluated for 39 farms. Ranking of gross margin, its underlying factors (i.e. milk price, returns from cull cows and calves, costs of concentrates, and costs of roughage purchases per 100 kg of milk), and 305-day milk production was not completely random over the 4 years of the study. The coefficient of concordance ranged between .55 and .82. The costs of roughage purchased had the lowest concordance over time, 305-day milk production had the highest concordance. For each year and each farm, the difference between average gross margin and farm-specific gross margin was calculated. The standard deviation (SD) of these values was calculated for each farm, and showed differences between farms in variability in gross margin over years (the farm-year-specific SD varied between farms from .56 to 5.73). All the underlying factors showed a deviation over years. So, variability of gross margin can be due to changes in all underlying factors. The impact on gross margin of purchased roughage was not of major importance, because its absolute impact on the gross margin is small. It is concluded that milk production data over 1 year is a reliable indicator for the typical farm milk production. As gross margin fluctuates considerably over time, however, it is preferred to base economic research on data over more than 1 year.

4.1 INTRODUCTION

Management and efficiency studies use different time periods to investigate technical and economic results. Bigras-Poulin et al. (1984/85), Dohoo et al. (1984/85), and Carley and Fletcher (1986), for instance, all investigated the influence of management practices on average milk production. Bigras-Poulin et al. (1984/85), and Carley and Fletcher (1986) used one year of data to calculate herd average milk production, whereas Dohoo et al. (1984/85) used herd averages based on 2.5 years of data. The pros and cons of these different time periods have rarely been discussed. Repeatability over time is actually assumed to be present for economic as well as for technical results when data over only 1 year is used. When results of a farm are measured at one point in time, the assumption is made implicit that a ranking of farms based on economic and technical results should be quite stable over years. When there is high repeatability, the factors that influence these technical and economic results can be determined with only one-year's technical and economic data. However, when the ranking in technical and economic results is not stable across time, more years of data will be necessary.

The literature addressing repeatability of economic and technical results within farms is limited. Most studies use data with time-series observations for the farms involved, the so-called panel data (Battese, 1992). In some cases they keep the same farms in the panel but they do not report the differences over years *within a farm* (Thijssen, 1992; Kumbhakar and Heshmati, 1995; Dawson and Lingard, 1989). These studies provide insight into whether a factor always has a positive influence on farm results and whether this differs between years. However, the question whether farm results vary considerably over years within a farm typically is only raised incidentally. Fyfe (1967) calculated correlations between .42 and .61 in net farm income of 95 cattle-fattening farms between pairs of years. Zachariasse (1972) used net farm income per ha to calculate a concordance over years within crop farms. He concluded that over 8 years, the ranking of the farms on net farm income per ha was not random. The coefficients of concordance ranged between .43 and .59 and were significant. Using data over 4 years from 126 farms, McGilliard et al. (1990) calculated the repeatability (a measure of within-herd variability across time, defined as variance of herds across time divided by total variance across time) for financial variables and for production variables. Repeatability for financial variables ranged between .32 and .87, and for production variables (including milk production and days open) between .53 and .84. Jansen et al. (1987), who used the same definition of repeatability as McGilliard et al. (1990), found yearly repeatability of herd milk production averages from .85 to .90. The correlations they found between successive years for herd fertility variables were lower (ranging from .36 to .73). From figures given by Mao (1976), a repeatability of .67 for herd milk production could be calculated. Jalvingh (1993) found correlation coefficients between years for technical results of sows ranging from .45 to .82.

The purpose of the current study was to determine whether the gross margin per 100 kg of milk and the farm average milk production per cow are stable over years. The influence of the different underlying factors (i.e., milk price, returns from cull cows and calves, feeding costs) on this variability were determined. Research questions were:

- Is the ranking of farms with respect to gross margin per 100 kg of milk and the underlying factors random over time?
- Is the 305-day milk production ranking of farms random over time?

The outcome was used to discuss whether management and efficiency studies should include data over 1 year or > 1 year. A second purpose was to examine the differences between farms in variability over years. Variability in farm results might be dependent upon farm-specific parameters and the management capacity of the farmer. The last two issues were discussed.

4.2 MATERIALS AND METHODS

4.2.1 Data

Data on milk production (farm average 305-day milk production per cow per year) were obtained from the Royal Dutch Cattle Syndicate (NRS). Their data set includes about 80 % of all Dutch dairy cows. The GIBO group, an accountancy agency, provided the economic data for the farms. The GIBO group is one of the biggest accountancy agencies in the Netherlands. They serve a small percentage of Dutch dairies. However, general characteristics as farm size, farm intensity and soil type show that these dairies can be seen as representatives for Dutch dairies. The data used in this study were collected for a related study, which examined the influence of management on milk production and gross margin per 100 kg of milk. As the budget for obtaining farm-specific data was limited, it was necessary to conduct a stratified sample. Rougoor et al. (1997) showed that there is a significant influence of milk quota per ha on gross margin per 100 kg of milk. Therefore, only farms with a milk quota in between 10500 to 14500 kg of milk per ha were selected. Gross margin per 100 kg of milk is defined as the gross returns minus costs from purchased feed per 100 kg of milk for this study. The gross margin was used to stratify the farms, based on the period May 1993 to May 1994 (for farms using a non-calendar year accounting period) or January 1994 till January 1995 (for farms with a calendar year accounting period). Milk production data were also used for stratification. Average 305-day milk production per farm was calculated for the period August 1993 till August 1994. To maximize differences between farms in gross margin and milk production, farms with average values for these variables were excluded. Farms had to meet the following 2 criteria:

1. A gross margin above Dfl. 78.40 or below Dfl. 77.40 per 100 kg of milk;
2. A 305-day milk production above 7450 kg or below 7270 kg.

This way, a data set was created which could be used to investigate the relation between variation in management and milk production and gross margin. Farms were selected out of the 'tails' of the normal distribution. Due to that, a maximum difference between farms for milk production and gross margin was ensured. However, due to this selection, the relation between milk production and gross margin in the data set is artificial. Therefore, the data set cannot be used to determine the relationship between these 2 variables. A total of 77 farms met these criteria and all were invited to participate in this study. Of these 77 farms, 39 were willing to make their data available (a 51% response rate). This self-selection may have biased the experimental group. However, it is very unlikely that due to this selection the repeatability of ranking will be influenced. The number of farms in the 4 research groups is shown in Table 4.1.

Table 4.1. Number of farms in the different research groups in the Netherlands, 1993 to 1997.

Gross Margin	305-d milk production		Total
	High (>7450 kg)	Low (<7270 kg)	
High (> Dfl. 78.40)	12	10	22
Low (< Dfl. 77.40)	9	8	17
Total	21	18	39

Gross margins and milk production data were available for 4 years (1993/1994 through 1996/1997). The data on milk production were complete for these 4 years. The gross margin data was less complete; only 30 farms had data available for all 4 years. From these 30 farms, one farm was excluded from the analysis because it was considered to have questionable figures. Its gross margin showed an extreme outlier for 1 year. Data of the remaining 29 farms were used to test the hypotheses as described in the introduction.

4.2.2 Analytical procedure

The analyses were done in three steps:

1. The correlation between different years for each farm was calculated for milk production and gross margin. This gave insight into relationships within each individual farm over the successive years. Due to the classification in high and low groups (Table 4.1), the variables are not normally distributed. This is taken into consideration by calculating the correlation for the different groups separately.

2. To verify the hypotheses regarding the ranking of farms over years, Friedman's blocked, non-parametric 2-way ANOVA (Owen, 1962) was used. Friedman gives an overall index to compare data over more than 2 years. In this way, the relative concordance of the milk production and the gross margin over the years and the relative concordance of the underlying factors (milk price per 100 kg of milk, costs of concentrates per 100 kg of milk, etc.) could be calculated. The null hypothesis was:

- Each ranking of farms within a year (based on milk production, gross margin or any of the underlying factors) is expected to have the same probability of occurrence.

The alternative hypothesis is:

- At least one of the farms has a higher total ranking based on milk production, gross margin or any of the underlying factors than one of the other farms.

The null hypothesis is expected to be withdrawn, indicating the ranking of the farms over years was not completely random but dependent upon the ranking in other years. The coefficient of concordance (W) can be used to check the hypothesis:

$$W = \frac{Q}{b(t-1)}$$

where:

Q = the Friedman test statistic (Owen, 1962);
t = number of farms included in the ranking;
b = number of years included in the ranking (4 in this case).

The coefficient of concordance can vary between 0 and 1. A value of 1 implicates complete concordance. A value of zero implicates a completely random distribution of farm rankings over years. In this study, farms were grouped on gross margin and milk production, thus, the farms were not randomly selected out of the performance distribution. However, within a subgroup the farms were representatives for that group. This implies that calculating the ranking separately for high and low gross margin and for high and low production will give correct estimates. So, the ranking was done for the same groups as used in Tables 4.2 and 4.3. Some of the underlying factors had missing values for some of the years. There were no missing values for the milk production data. Therefore, the number of farms per ranking ranged from 8 to 21.

3. The correlation and the coefficient of concordance estimate the overall variability, but they do not indicate whether or not there are differences in variability between farms. Therefore, other methodologies will be used. The coefficients of concordance of gross margin and the underlying factors provide information on the repeatability of the ranking of these factors. However, the influence of the underlying factor on the variability of the gross margin is dependent not only on the concordance, but also on the absolute variability of the factor. For example, a 10-% change in milk price will have a much bigger influence on the gross margin than a 10-% change in the costs of concentrates, due to a difference in relative contribution to the gross margin. Therefore, the standard deviation (SD) of the difference between the average value of a factor and its farm-specific value was calculated over 4 years for all factors. This indicates the absolute variability within each factor. Another limitation of the coefficient of concordance is that it does not show whether all farms have the same variability within a factor or whether one farm has more variability than another does. This can also be shown by the within-farm SD across 4 years. The coefficient of variation (CV) standardises this SD by dividing it by the average value of the variable across 4 years. The CV shows the relative degree of variation each factor displays.

4.3 RESULTS

4.3.1 Correlation over years

The correlations between the farm-specific gross margins for 4 successive years are shown in Table 4.2. The group with the high gross margin per 100 kg of milk had relatively low correlations between the year 1993/94 and the other years. These low correlations are not due to just one of the underlying factors; similar correlation matrices for the underlying factors for this group (not shown here) had correlations between 1993/94 and other years which ranged from .15 to .87. One of the reasons for the low correlation between gross margins from 1993/94 and from 1994/95 was a change in milk production per ha within a farm. The correlation between change in gross margin and change in milk production per ha was -.50, suggesting that farms that had an increase in milk production per ha had a bigger decrease in gross margin per 100 kg of milk than farms that did not have an increase in milk production per ha. This can be explained by an increasing need to buy roughage from outside the farm when milk production per ha is increasing. This is consistent with Rougoor et al. (1997) (milk production per ha is one of the major factors that influences gross margin negatively).

The correlation for 305-day milk production was high for the farms in the high-producing group, but considerably lower in the low-producing group (Table 4.3). This indicated that farms with a high farm average milk production had a higher repeatability of milk production than low-producing farms. Comparison of Tables 4.2 and 4.3 indicates that the correlation between years was considerably higher for 305-day milk production than for gross margin.

Table 4.2 Average, SD, and correlation between gross margins per 100 kg of milk (in Dfl.) for 4 successive years for Dutch dairy farms between 1993 and 1997. P-values: * <.05; ** < .01; *** <.001

				Correlation matrix			
Year[1)]	No.	Mean	SD	93/94	94/95	95/96	96/97
High gross margin / 100 kg of milk							
93/94	19	81.8	2.2	1.00			
94/95	21	79.1	3.8	.31	1.00		
95/96	21	73.4	4.1	.59***	.42*	1.00	
96/97	21	66.7	5.0	.18	.59**	.71***	1.00
Low gross margin / 100 kg of milk							
93/94	12	73.5	4.6	1.00			
94/95	16	71.2	4.2	.39	1.00		
95/96	15	67.3	3.7	.53*	.68**	1.00	
96/97	17	63.1	4.4	.67**	.31	.51*	1.00

1) From May in the first year till May in the second year (farms using a non-calendar year accounting period) or from January in the first year till January in the second year (farms with a calendar year accounting period)

Table 4.3 Average, SD, and correlation between 305-d milk production (farm average in kg) for 4 successive years for Dutch dairy farms between 1993 and 1997. P-values: ** < .01; ***<.001

				Correlation matrix			
Year[1)]	No.	Mean	SD	93/94	94/95	95/96	96/97
High 305-d milk production							
93/94	21	8082	501	1.00			
94/95	21	8188	435	.90***	1.00		
95/96	21	8308	654	.84***	.89***	1.00	
96/97	21	8788	598	.83***	.85***	.87***	1.00
Low 305-d milk production							
93/94	18	6900	298	1.00			
94/95	18	6974	293	.69***	1.00		
95/96	18	7233	443	.65**	.84***	1.00	
96/97	18	7617	473	.55**	.70***	.75***	1.00

1) From August in the first year till August in the second year

4.3.2 Friedman: relative variability

For all variables mentioned in Table 4.4, the coefficient of concordance was significant, so we concluded that ranking over the years for gross margin, milk price, returns from cull cows and calves, costs of concentrates, costs of roughage purchased, and total feeding costs was not completely random over years. The coefficient of concordance for 305-day milk production was .82 for the high-producing group and .70 for the low-producing group. Both variables were significant ($P < .001$). This implicates that the relative variability in gross margin tended to be larger than the variability in milk production. The concordance in the high gross margin group tended to be lower for the gross margin than for the underlying factors. This might be due to dependency between the underlying factors. Thus, change in one aspect goes together with a change in another aspect (in the same direction) as well. Calculating the correlation between changes in two variables in two successive years checks this. Most of these correlations were not significant, but significant correlations were found between the change in milk price per 100 kg of milk and the change in returns from cull cows and calves. This correlation coefficient ranged between .14 (not significant) and .32 ($P<.05$), dependent upon the years that were compared. So, farms that had a big decrease in milk price had, on average, a bigger decrease in returns from cull cows than farms that had a small decrease in milk price.

Differences in concordance between variables were rather small, but the variability in the costs of roughage purchased tended to have the smallest concordance (see Table 4.4). However, the costs of roughage purchased were only a small part of the total gross margin. So, in an absolute sense, the influence of variability in costs of roughage purchased on the variability in gross margin might be small.

Table 4.4 Average value, and SD for the groups together for 1996/97, coefficient of concordance (W) and number of farms for the gross margin groups separately over 4 years. P-values: * < .05; ** < .01; *** < .001

			Gross margin group			
			High		Low	
	Mean	SD	W	No.	W	No.
Gross margin / 100 kg milk (in Dfl.)	65.10	5.0	.55**	19	.59*	10
Milk price / 100 kg milk	73.27	2.4	.72***	19	.65**	10
Returns cull cows and calves / 100 kg	7.19	2.6	.71***	19	.51*	10
Costs of concentrates / 100 kg	13.05	2.3	.58**	15	.66**	8
Costs of roughage purchased/ 100 kg	3.15	2.4	.55**	15	.51*	8
Total feeding costs / 100 kg	16.20	3.1	.68***	19	.55*	10

4.3.3 Absolute variability per farm

The standard deviations (SD) over 4 years of the difference between average values and the farm specific values and the coefficient of variation for gross margin, the underlying factors and the milk production are shown in Table 4.5. The coefficients of variation show the same main effects as were found in Table 4.4. The costs of roughage purchased had the highest relative variation (47.1 %), varying from 8.0 to 184.5 % between farms. The SD's in Table 4.5 indicate large differences between farms in variability over years. On average the SD of the gross margin was Dfl. 2.71 per 100 kg of milk. The SD's for the underlying factors show that they all varied over years. The coefficients of concordance and the coefficients of variation indicate that the costs of roughage purchased had the largest relative variability over years (Table 4.4 and Table 4.5). However, the costs of roughage purchased had only a minor effect on gross margin; the average value in 1996/97 is Dfl 3.15 per 100 kg of milk (Table 4.4). The milk price per 100 kg of milk had a much bigger effect on gross margin (the average value is Dfl. 73.27). Due to that, the small relative variability in milk price (as shown by the coefficient of variation in Table 4.5) eventually resulted in the highest SD of all underlying factors.

Table 4.5 Mean and minimum and maximum values of farm-specific standard deviation (in Dfl.) and coefficient of variation of differences between crude average across all farms and the values for the farm for the years 1993 till 1997.

	Standard Deviation			Coefficient of Variation		
	Mean	Min.	Max.	Mean %	Min.	Max.
Gross margin / 100 kg milk	2.71	.56	5.73	3.8	.8	7.9
Milk price / 100 kg milk	1.82	.28	3.45	2.4	.4	4.5
Returns cull cows and calves / 100 kg	1.22	.16	3.33	12.7	1.7	34.5
Costs of concentrates / 100 kg	1.40	.39	3.56	10.6	3.0	27.0
Costs of roughage purchased / 100 kg	1.12	.19	4.39	47.1	8.0	184.5
Total feeding costs / 100 kg	1.73	.19	4.53	11.1	1.2	29.1
305-d milk production (farm average)	204	65	403	2.6	.8	5.1

4.4 DISCUSSION AND CONCLUSION

The hypotheses that rankings of farms based on milk production, gross margin or underlying factors is totally random can be rejected. However, gross margin had lower concordance over years than the 305-day milk production. Correlations were calculated within groups. Therefore, the standard deviations within a group were relatively small. This could have had a negative influence on the concordance. The results are, however, in agreement with the results of Zachariasse (1972) and McGilliard et al. (1990).

The difference between groups selected in 1993/94 and 1994/95 based on gross margin had almost vanished by 1996/97. The average between the two groups only differed 3.58 in 1996/97 compared to 8.34 in 1993/94 (Table 4.2). Differences in milk production between the groups were quite constant over years (around 1100 kg of milk). So, for gross margin regression to the mean was found, contradictory to milk production, which showed no regression to the mean. The difference in correlation between high- and low-milk-producing groups was not expected. This might explain the differences that were found in literature in the production repeatability (Jansen et al., 1987; Mao, 1967).

In relative terms, the costs of roughage purchased was the aspect with the lowest concordance. However, in absolute terms, the costs of roughage purchased were only a small part of the gross margin (see first column Table 4.4). In an absolute sense, almost all underlying factors of the gross margin have the same influence on the total concordance of the gross margin. However, changes in milk price and returns from cull cows and calves were related so this combination of aspects has a relatively big influence on the concordance of the gross margin.

The minimum and maximum values in Table 4.5 indicate that there are major differences between farms in variability over time. The objective of the study was to find out whether studies based on economic and technical data over just 1 year are useful for determining the factors that influence gross margin and milk production. In spite of a concordance and correlations < 1 (Table 4.3), we concluded that milk production of one specific year is a reliable indicator for milk production in other years. Concordances and correlations of gross margin and the underlying factors were lower (Tables 4.2 and 4.4). Therefore, for economic data analysis it would be useful to include data over more than 1 year. McGilliard et al. (1990) say that differences in relationships among and within herds indicate difficulty in attaining herd improvement demonstrated by financial and production averages for single years. Fyfe (1967) suggests that variance associated with random influences can be reduced by averaging over 3 or 4 years. However, this method can only be used when management, and changes in management or other farm-specific parameters are known for all these years. This way, variance can be allocated between that due to changes on the farm and that due to random influences.

Gross margin fluctuated considerably over years (Tables 4.2, 4.4 and 4.5). Most farmers will prefer to obtain a stable income (instead of a highly variable income). So, the variability in gross margin over years can be a useful parameter to examine. This was done for the data that were available for these 4 years (including milk production per ha, 305-day milk production, and farm size), but no significant influence of these aspects was found. So, a high milk production per cow or a larger farm is not a guarantee of a stable gross margin over years. These results indicate that fluctuations in gross margin may be the result of aspects that were not taken into account in the current study. It is not likely that macro-economic factors (for instance changes in government support or EU ruling) influenced these fluctuations, because all farms are situated in the Netherlands. All faced the same macro-economic situation. Factors that might have influenced the fluctuation are:

- The region where the farm is situated. This will influence the weather, soil type, etc. The farmer cannot influence these aspects on an operational or tactical level.
- Changes in management. In 4 years there generally will not be many structural changes at the farms. However, at some farms, management might have changed (e.g., a change in the farm manager). This can result in a change in milk production and gross margin. Unfortunately, this information was not available in the current study.
- Type of management. Different farmers have different attitudes towards risk. This will be reflected in their way of managing the farm. A risk-averse farmer is expected to make different decisions than a risk-neutral or risk-seeking farmer. This might lead to a larger variability in gross margin.

Overall it can be concluded that milk production data over 1 year is a reliable indicator for the typical farm milk production. Economic data, however, show more variability over time, and, therefore, collecting more years of data will increase the usefulness of the data considerably.

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Chapter 5

Comparison of principal components regression and partial least squares to determine the relation between breeding management and 305-day milk production

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ABSTRACT

Advantages and disadvantages of principal components regression (PCR) and partial least squares (PLS) for livestock management research were investigated using a data set where multicollinearity is present and the number of variables was high compared to the number of observations. Out of 70 variables related to breeding management and technical results at dairy farms, 19 were selected for PLS and PCR, based on a correlation of ≥ .25 or ≤ -.25 with 305-day milk production.

Five principal components (PCs) were selected for PC-regression with 305-day milk production being the goal variable. Related variables were combined into one so-called synthetic factor. All synthetic variables were used in a path-analysis. The same path-analysis was worked out with PLS. PLS forms synthetic factors capturing most of the information for the independent X-variables that is useful for predicting the dependent Y-variable(s) while reducing the dimensionality.

Both methodologies showed that milk production per cow is related to critical success factors of the producer, farm size, breeding value for production and conformation. Advantages of PLS are the optimization towards the Y-variable, resulting in a higher R^2, and the possibility to include more than 1 Y-variable. Advantages of PCR are that hypothesis testing can be performed, and that complete optimisation is used in determining the PCs. It is concluded that PLS is a good alternative for PCR when relations are complex and the number of observations is small.

5.1 INTRODUCTION

Livestock management studies often face the problem that multicollinearity is present in the data set, and that the number of variables is large compared to the number of observations. In case of multicollinearity, standard statistical techniques, as linear regression, will give unstable estimates of the regression coefficients which hinders their interpretation. In addition, a large number of variables compared to the number of observations will decrease the degrees of freedom of the residual variance dramatically.

Multicollinearity is often difficult to detect. Afifi and Clark (1984) state that a simple way to check for multicollinearity is to examine the correlations among the independent variables. When priori information is available on relationships between variables and complex relations have to be determined, path-analysis can be a useful tool to use (Rougoor et al., 1997). This methodology, however, can only be used when the number of observations is large compared to the number of variables. Bigras-Poulin (1985), Lafi and Kaneene (1992a), Ferguson et al. (1994), and Webster et al. (1997) used Principal Components Analysis and Principal Components Regression (PCR) to reduce the number of independent variables (i.e. to reduce dimensionality) and to avoid problems regarding multicollinearity.

Faye et al. (1997) used canonical correspondence analysis, which is a generalisation of the principal component analysis. Steenkamp and Van Trijp (1996) were facing the same kind of problems, but used Partial Least Squares (PLS) to reduce dimensionality and multicollinearity. PLS is considered to be useful for describing complex relationships (Fornell and Bookstein, 1982; Fornell et al., 1990). PLS has proved to be successful for forming prediction equations to relate a substance's chemical composition to its near-infrared spectra. However, PLS has hardly been used in livestock management research.

Goal of the current study is to investigate the advantages and disadvantages of PLS and PCR for use in livestock management research. The 2 methodologies are used to estimate the effect of breeding management on 305-day milk production in a path-analysis for a data set with a small number of variables compared to the number of observations and with multicollinearity likely to be present. First, the data that are used in the analysis will be described and PLS and PCR will shortly be introduced. After that, the results that are obtained with both methodologies will be discussed and compared. Advantages and disadvantages of both methodologies will be discussed.

5.2 MATERIALS AND METHODS

5.2.1 Data

The data used in the current paper are part of a bigger project which aims at determining the relation between management and milk production and gross margin. Therefore, management is divided into management in the areas of pasture, feeding, animal health, fertility and breeding. The current article focuses on the data on breeding management and how these are related to the farm average 305-day milk production. Thirty-nine farms were included in the field study. Dairy farms were selected on the basis of gross margin from May 1993 till May 1994 (for farms using a non-calendar year accounting period) or January 1994 to January 1995 (for farms with a calendar year accounting period), and the 305-day milk production between August 1993 and August 1994. A low gross margin was defined as gross margin below Dfl. 77.40 per 100 kg of milk. A high gross margin was defined as a gross margin above 78.40. A low 305-day milk production was defined to be below 7270 kg per cow, above 7450 kg was called 'high'. These cut-off values were chosen that way that the farms were selected out of the 'tails' of the normal distribution. This way, a data set was created which could be used to investigate the relation between variation in management and milk production and gross margin. The farms were selected such that 8 farms had a low gross margin and a low 305-day milk production, 9 farms had a low gross margin and a high 305-day milk production, 10 farms had a high gross margin and a low 305-day milk production, and 12 farms had a high gross margin and a high 305-day milk production. All farms were situated in the Netherlands. Unfortunately, the differences in gross margin between the four groups have become much smaller over the past few years. The groups could not clearly be recognized anymore. Therefore, the analyses were done on individual data, without differentiating between the groups. During the period of data collection one farm dropped out, so analyses were based on data of 38 farms. From May 1996 to May 1997 the farms were visited monthly to collect data. To get insight into the breeding management of the producers, a management questionnaire on breeding decisions was developed and during one of the farm visits exposed to the producer. Questions focused on the breeding goal of the producer, the sire selection and the use of natural service sires. The producer was also asked to indicate what the critical success factors (CSFs) were at his farm regarding production and breeding. Milk production data of the farms, as well as data on breeding values of cows at the herds, were made available by the Royal Dutch Cattle Syndicate (NRS). Their data set includes about 80 % of all Dutch dairy cows. A first selection of variables was based on simple linear correlation of ≥ .25 or ≤ -.25 with farm average 305-day milk production. Table 1 gives an overview of the 19 variables that were selected for the multivariate analyses out of a total of 70 variables. The CSFs are measured on a 6-point-scale form 'not important' to 'very important'. Theoretically spoken, these variables are ordinal variables. However, an increasing score indicates 'more important'. Therefore, the variables are assumed to be continuous. To indicate whether multicollinearity is likely to be present in the data set, simple linear correlations between the 19 variables is carried out.

The number of variables was large compared to the number of farms (our unit of observation). Therefore, the variables were grouped into so-called 'synthetic factors'. The calculation of synthetic variables from the underlying variables differed between PLS and PCR. This will be discussed when these methodologies are discussed.

Figure 5.1 gives the null-path model for the path-analysis. For both methodologies (PLS and PCR) the researcher has to use prior knowledge and intuition to define the synthetic factors and the null-path model. The specification of the synthetic factors was based upon a logical separation of different parts and levels of breeding management. The design of the null-path model was based on the framework as described by Rougoor et al. (1998). The decision-making process (business goals and CSFs) influences biological and technical aspects and processes (breeding value, use of natural service and age at calving), which in turn influences the 305-day milk production. Farm size, in turn, might have influenced the average breeding value of cows on the farm. The path diagram was analysed by PLS and PCR. To get comparable results, for both methodologies the rule was applied that only arrows with a standardised path coefficient bigger than .20 were kept in the model.

Table 5.1 Description of variables used in the multivariate analyses and their average value for the 38 farms.

Synthetic Factor	Variable	Description of variable	Avg. Value
Critical Success Factors (CSF)	Production	CSF 'milk production per cow' on a 0 (not mentioned) to 5 (most important) scale	2.20
	Culling	CSF 'culling policy' on a 0 to 5 scale	.69
	Winter milk	CSF '% of milk produced in winter' on a 0 to 5 scale	.58
Breeding Goal (BG) Farmer	Kg milk	% of points farmer gives to 'kg milk' as a breeding goal at his farm[1]	14.56
	Udder	% of points farmer gives to 'udder'	10.35
Farm Size	No. Inseminated	No. of inseminated cows	13.5
	Total no. of cows	Total number of cows at the farm	65.1
	Avg. no of mc	Average no. of cows that are not dried off	55.4
Use Natural Service	Cows %	% of cows inseminated with natural service sires	3%
Breeding Value Production	BV Milk	Avg. breeding value of cows for kg of milk	213 kg
	BV Fat	Avg breeding value of cows for kg of fat	6.8 kg
	BV INET	Avg. breeding value of cows for INET[2]	81.3
Breeding Value Conformation	Development	Avg. breeding value of cows for 'development'	100.2
	Type	Avg. breeding value of cows for 'type'	100.1
	Udder	Avg. breeding value of cows for 'udder'	100.1
	Legs	Avg. breeding value of cows for 'legs'	100.7
	Total	Avg. breeding value of cows 'total conformation'	100.2
Age at Calving	Age_heifers	Expected age of calving of heifers	787 days
	Calving_Age	Average age of dairy cows at calving	1485 days
Milk Production	305-day	Farm average 305-day milk production	8342 kg

1) Farmer is asked to divide 100 points over different genetic aspects, as he is taking into account for the breeding of his cows.

2) INET = weighed averaged of the breeding values for kg milk, kg fat and kg protein, based on the price paid for these different components.

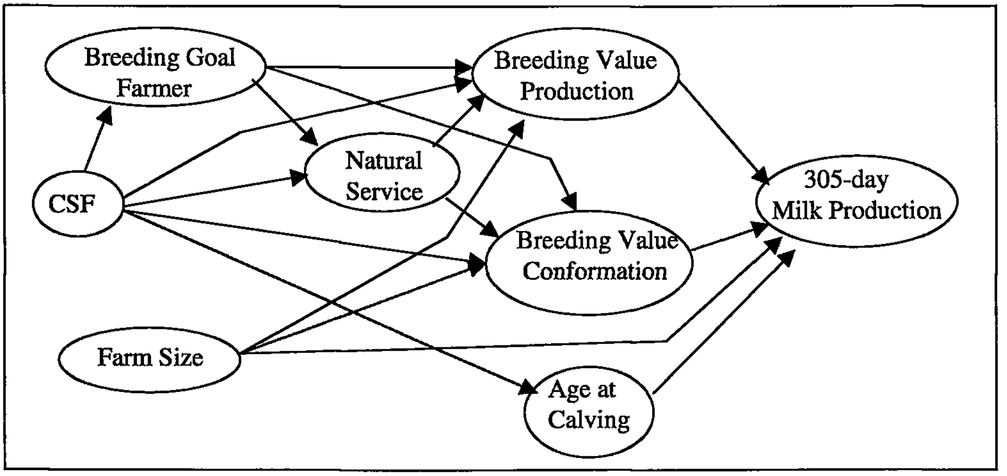

Figure 5.1 Null-path model of relation between breeding management and 305-day milk production.

5.2.2 Principal Components Regression (PCR)

Principal component analysis, a statistical technique originated by Hotelling (1933), is performed in order to simplify the description of a set of interrelated variables (Afifi and Clark, 1984). It allows the transformation of a set of correlated explanatory X-variables into an equal number of uncorrelated variables. These new variables, the so-called principal components (PCs), are all linear combinations of the original correlated X-variables. The PCs are arranged in decreasing order of contribution to variance. Dimensionality can be reduced by selecting only a couple of PCs with a high contribution to variance. The number of PCs selected may be determined by examining the proportion of total variance explained by each component, or by the cumulative proportion of total variance explained. A rule of thumb adopted by many investigators is to select only the PCs explaining at least 100/P percent of the total variance, with P being the total number of variables (Afifi and Clark, 1984). This selection criterion was also used in the current paper. Besides the percentage of variance explained, the eigen values of the PCs can be of use to decide how many PCs to include in the PCR of the PCs on the Y-variable (the 305-day milk production). The eigen value is the variance of that PC. When an eigen value is close to zero, it means that multicollinearity is present among the original variables and that PC can be excluded from the regression. These 2 selection criteria (both using a so-called top-down approach) do not include PCs with small contribution to variance in the regression. This results in a reliable estimate of the regression parameters. The selected PCs were utilised as uncorrelated explanatory variables in the regression model. Parameter estimates were generated by the equation:

$$305\text{-day milk production} = a + b_1 * (PC_1) + b_2 * (PC_2) + \ldots b_n * (PC_n) + e \quad (1)$$

where a is the intercept term, b_i is the regression coefficient, PC_i is the principal component i, n is the number of PCs included in the regression, and e is the residual (error) term. These estimates of the regression coefficients were used to reconstitute regression coefficients for the explanatory variables, as was done by Lafi and Kaneene (1992b):

$$RCvar(j) = (loadPC_{1,var(j)}) * b_1 + (loadPC_{2,var(j)}) * b_2 + \ldots\ldots (loadPC_{n,var(j)}) * b_n \quad (2)$$

where RCvar(j) is the standardized reconstituted regression coefficient of variable j, $loadPC_{i,var(j)}$ is the loading of variable j on PC_i, and b_i is the regression coefficient as was estimated in (1). Due to these transformations, these explanatory variables (the PCs) are corrected in such a way as to minimize the effect of multicollinearity. The reconstituted regression coefficients were used to construct the synthetic factors. This way, dimensionality could be reduced without losing much of the information. Besides that, interpretability will be increased (Afifi and Clark, 1984). The synthetic variables were used in a multivariate path-analysis. Standardized path-coefficients were calculated as described by Rougoor et al. (1997). The procedures PCP and MODEL of the statistical package Genstat (Payne et al., 1995) were used to do the calculations.

5.2.3 Partial Least Squares (PLS)

PLS is a methodology that can be used for theory confirmation, but can also be used to suggest where relationships might or might not exist and to suggest propositions for later testing. It intents to form so called 'latent variables' (in our case these are the synthetic factors, for instance 'Breeding Goal Producer') that capture most of the information for the independent X-variables (i.e. the 2 breeding goals 'Kg milk' and 'Udder') that is useful for predicting the dependent Y-variables (in our case the '305-day milk production'). In the meantime PLS reduces the dimensionality of the regression problem by using fewer synthetic factors than the number of X-variables. Major difference between PCR and PLS is that with PLS the data values of both the X- and Y-variables influence the construction of the synthetic factors. In the previous paragraph it was explained that the PCs in a PCR are determined without taking into account the Y-variable (Garthwaite, 1994). Another difference between the two methodologies is that PLS has the opportunity to take into account more than one Y-variable at the same time (however, this option will not be used in the current paper).

Input of the PLS-model are the raw data, the set-up of the synthetic factors and the set-up of the null-path model. PLS estimates the relations between these data and factors. It distinguishes between different components of the path model. The relationships between the synthetic factors are the so-called inner relations, for instance the relation between the synthetic factors 'CSF' and 'Breeding Goal Producer'. These are given by the inner path coefficients, ranging from –1 (a strong negative relationship) to +1 (a strong positive relationship). Relations between the variables and the synthetic factors are the outer relations, for instance the relation between the breeding goal 'Kg milk' and the synthetic factor 'Breeding Goal Producer'. These are given by the factor loadings. Factor loadings can vary between –1 (indicating a very strong negative relationship; all variance of that variable is captured in that synthetic factor) and +1 (a very strong positive relationship). These are estimated in such a way that the model is optimal in the inner part (i.e. between the synthetic factors) as well as the outer part (i.e. towards the X- and Y-variables). PLS seeks values for the factor loadings and structural parameters that minimize residual variance for the synthetic factors and the X- and Y-variables. This way, a synthetic factor is estimated to be the best predictable variable of its X-variables as well as the best predictor of subsequent dependent synthetic variables or Y-variables (Steenkamp and Van Trijp, 1996).

The PLS algorithm proceeds in 3 stages. In the first stage a sequence of ordinary least squares (OLS) regressions, linear operations and square root extractions is used in an iterative process to obtain explicit estimation of each synthetic factor and of its case values. The second stage of the PLS algorithm is a non-iterative OLS-regression and uses the estimates of the synthetic factors in the first stage to estimate the inner and outer relations, without location parameters. The third step of the algorithm is also a non-iterative OLS-regression and estimates the location parameters of the synthetic factors and the structural relations estimated in the first two stages (Wold, 1982). A detailed overview of these 3 steps is given by Wold (1985).

No distributional assumptions are made in PLS. Therefore, the traditional statistical testing methods are not well suited. The variance extracted measures the amount of variance of the X- or Y-variable that is captured by the synthetic factor. This variable can vary from 0 to +1. The average variance extracted (AVE) is the average of the variances extracted of all X- or Y-variables of one specific synthetic factor. A high AVE indicates that the amount of variance captured by the synthetic factor is big compared with the amount of unexplained variance of the X- or Y-variables. It is a measure to evaluate the relationship between the synthetic factor and its X-variables: the outer model. This can be used to evaluate the goodness of measurement model, that is, reliability of the synthetic factors (Fornell and Cha, 1994). The R^2 measures the explanatory power of the relations between the different synthetic factors. It shows how well a synthetic factor is predicted by other synthetic factors. This value is dependent upon the set-up of the path-model. The predictive value of the model can be shown by the Stone-Geisser test or by jack knifing. The Stone-Geisser test calculates a criterion Q^2 that indicates how well the observed values can be reconstructed by the model. It is evaluated as an R^2 in OLS without loss of degrees of freedom. The general form of the Q^2 is $Q^2 = 1 - E/O$, where E is the sum of squares of the prediction errors and O is the sum of squares of the errors from the prediction given by the mean of the remaining data points.

When $Q^2 > 0$ it indicates that there is predictive relevance of the model, whereas $Q^2 < 0$ suggests lack of relevance. Jack knifing can be used to obtain standard deviations of the parameter estimates (Miller, 1974). This is done by estimating the parameters N times in a data set with N observations, each time cutting off just one observation. The different estimates for the same parameter, then, are used to compute the mean and SD of that parameter. Jack knifing provides information about the precision of the parameter estimates. The PLS-model was estimated with the LVPLS 1.8 program (Lohmöller, 1987).

5.3 RESULTS

5.3.1 Correlation between variables

Simple correlation coefficients between variables in Table 5.1 are given in Appendix 5.1. They show that especially within a synthetic variable the correlation could be high, so multicollinearity is likely to exist. The correlations between variables within the synthetic variable 'Breeding Value Conformation', for instance, varied between .65 and .94. Afifi and Clark (1984) stated that when two variables are highly correlated (greater than .95), it may be simplest to use only one of them, since one variable conveys essentially all of the information contained in the other. However, all correlations were smaller than .95 in this case. Besides that, the presence of these big correlations might emphasise differences between PLS and PCR, so all variables were retained in the analysis.

5.3.2 Principal Components Regression (PCR)

The percentage of variance explained by the 19 PCs and the eigen values of these PCs are shown in Table 5.2. These results also showed that multicollinearity is present in the dataset, because component nineteen had an eigen value close to zero (.01). When the rule of thumb was used that a PC has to explain at least 100/P % of the variance to be included in the regression, the percentage of variance explained by one PC has to be at least 100/19 = 5.26 %. Only the first 5 of the original 19 PCs could satisfy this criterion (see Table 5.2). These 5 PCs together explained 74.14 % of the variance in the data set. These 5 PCs were used in a linear regression. The coefficients were then transformed back to the original variables on a standardized and on their original scale. These regression coefficients are shown in Table 5.3. Because the regression coefficients were reconstituted, no significance values were available for these variables. The standardized regression coefficients were used to compare the outcome with the outcome of the PLS-modelling. The regression coefficients based on the original scale could be used to interpret the results.

The regression coefficients on the original scale were used to calculate the synthetic variables, which were used in a multivariate path-analysis. Figure 5.2 shows the outcome of this path-analysis. The R^2 showed that the model could explain 36 % of the differences in milk production. The synthetic factor 'Age at Calving' was not used by the model because all path coefficients to and from this factor were smaller than .20. Table 5.3 and Figure 5.2 show that milk production was higher on farms with managers who thought that 'milk production per cow' was a CSF for their farm. At these farms the breeding value for confirmation was higher. The breeding goal of the producer indicated, however, that these producers put relatively much emphasis on the quality of the udder and less on the kg of milk.

Table 5.2 Percentage of variance explained and the eigen values of the 19 Principal Components.

Principal Component	PC_1	PC_2	PC_3	PC_4	PC_5	PC_6	PC_7	PC_8	PC_9	PC_{10}
% variation	37.17	15.77	9.23	6.23	5.74	5.18	4.60	3.96	3.26	2.38
Eigen Value	7.06	3.00	1.75	1.18	1.09	.98	.88	.75	.62	.45
	PC_{11}	PC_{12}	PC_{13}	PC_{14}	PC_{15}	PC_{16}	PC_{17}	PC_{18}	PC_{19}	
% variation	2.06	1.62	.82	.74	.48	.31	.24	.19	.03	
Eigen Value	.39	.31	.16	.14	.09	.06	.05	.04	.01	

Table 5.3 Results of PC Regression on 305-day milk production with 5 PCs included.

Variable	Regression coefficients on standardized scale	Regression coefficients on original scale
CSF-Production	.1550	64.749[1)]
CSF-Culling	.0643	35.300
CSF-Winter milk	-.1261	-77.733
BG-Kg milk	-.0457	-3.046[2)]
BG-Udder	.0250	2.524
Farm Size-No inseminated	-.1550	-16.689[3)]
Farm Size-Total no of cows	-.0928	-3.743
Farm Size-Avg. no of mc	-.0902	-4.211
Use natural service – Cow %	-.0558	-435.510[4)]
BV Milk	.0594	.290[5)]
BV Fat	.0606	8.054
BV INET	.1069	1.631[6)]
BV-Development	.0014	.679[7)]
BV-Type	.0385	15.873
BV-Udder	.0136	5.347
BV-Legs	.0295	18.136
BV-Total	.0186	6.601
Age_heifers	-.1847	-4.250[8)]
Calving_Age	-.0910	-.479

1) Change in farm average 305-day milk production per point change in CSF
2) Ditto per percent change in breeding goal
3) Ditto per extra cow
4) Ditto per percent change in use of natural service sires
5) Ditto per kg change in breeding value
6) Ditto per point change in INET
7) Ditto per point change in breeding value
8) Ditto per day change in age.

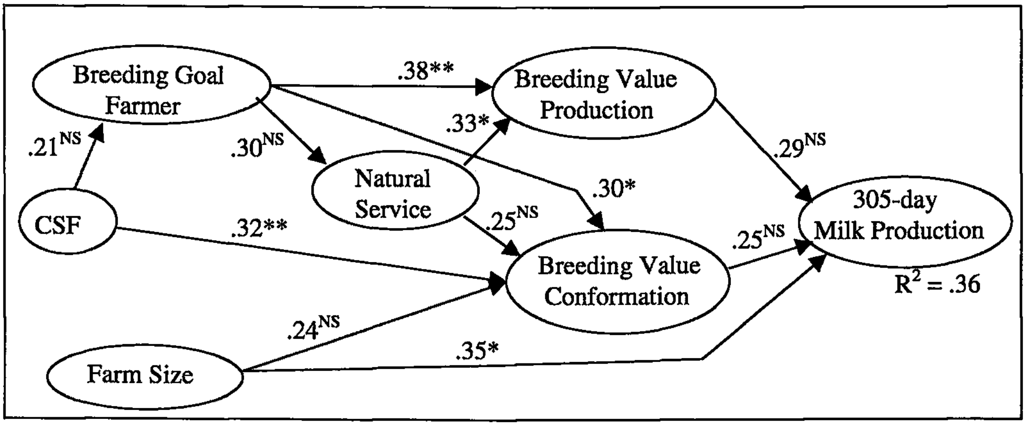

Figure 5.2 Path coefficients for PCR-modelling. NS = not significant; * = P<.05; ** = P<.01.

5.3.3 Partial Least Squares (PLS)

Table 5.4 provides the factor loadings for each of the measures. The R^2 of each synthetic factor, the variance extracted for each variable, and the average variance extracted for each synthetic factor are given. In this model, the age at calving was also not used, because the path coefficient was here also lower than .20. The model explained 47 % of the differences in milk production.

Figure 5.3 gives a graphical representation of the PLS-model with the inner path coefficients. Contrary to the PCR-model, no significance values are given here, because traditional statistical testing methods are not well suited. The Stone-Geisser test criterion Q^2 was used as an alternative method to evaluate the model. It had a value of .31 indicating that the model had predictive relevance, because it was bigger than zero. The same main results as with PCR were found with PLS. Small differences were found in the relation between the synthetic factors 'Natural Service Sires' and 'Breeding Value Conformation'. PCR found a path coefficient of .25, whereas in the PLS-model it was smaller than .20 and therefore deleted. Besides that, in the PLS-model, direct effects of the synthetic factor 'Critical Success Factors' on 'Breeding Value Production' and 'Natural Service Sires' were found, whereas in the PCR-model these path coefficients were too small.

Table 5.4 Measurement part of the PLS-model.

• **Synthetic factor** *Variable*	Factor loading	Mult. R^2	(Average) Variance extracted
• **Critical Success Factor**		NA[1]	**.45**
Milk Production	*.39*		*.15*
Culling	*.60*		*.35*
Winter milk	*-.91*		*.83*
• **Breeding Goal**		.06	**.59**
Kg milk	*-.81*		*.65*
Udder	*.72*		*.52*
• **Use Natural Service Sires**		.16	**NA**[2]
Cow %	*-1.00*		
• **Farm Size**		NA	**.87**
No. Inseminated	*-.90*		*.80*
Total no. of cows	*-.94*		*.89*
Avg. No. milking cows	*-.95*		*.90*
• **Breeding Value Production**		.36	**.91**
Milk	*.94*		*.88*
Fat	*.96*		*.92*
INET	*.97*		*.95*
• **Breeding Value Conformation**		NA	**1.00**
Development	*1.00*		*1.00*
Type	*1.00*		*1.00*
Udder	*1.00*		*1.00*
Legs	*1.00*		*1.00*
Total	*1.00*		*1.00*
• **Milk Production**		.47	**NA**
305-day milk production	*1.00*		

[1] NA = not available; this LV was not predicted by any other LV

[2] NA = not available; only single indicator

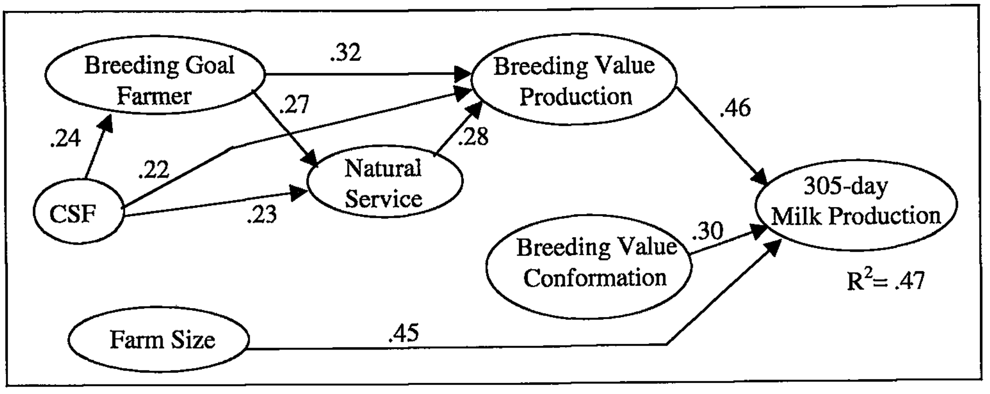

Figure 5.3 Structural path coefficients for PLS-modelling.

5.4 DISCUSSION

5.4.1 Breeding management

The path coefficient diagrams (Figures 5.2 and 5.3) showed the same main effects. Milk production per cow was directly related to farm size (bigger farms had a lower milk production; the regression coefficients and loadings were negative for this synthetic factor), to breeding value for conformation (higher breeding value for conformation gave a higher milk production), and to breeding value for production (a higher breeding value for production gave a higher milk production). These variables, in turn, were related to goals and CSFs of the producer, indicating that milk production is not only related to technical parameters, but also to the attitude of the producer. So, with respect to the aim of the data collection to determine the relationship between breeding management and 305-day milk production, it can be concluded that the producers' breeding management was related with the 305-day milk production. Surprisingly, it was found that farmers who stated that they focused mainly on 'kg of milk' as a breeding goal, had a lower breeding value for milk production and they realised a lower 305-day production than producers who stated that they also took into account 'udder' into their breeding strategy. A second aspect that comes forward is the use of natural services sires. Table 5.1 shows that natural services were rarely used by the producers in the research group: only 3 % of the cows was inseminated with natural service sires. However, it still was related with the breeding value. Producers who made more use of artificial insemination, had cows with a higher breeding value and, related with that, a higher 305-day milk production.

The CSFs of the producer were related to the breeding goal of the producer, which in turn was related to the breeding value for production through the selection decision. Differences between PCR and PLS came out for the synthetic factor 'Breeding Value Conformation'. The underlying variables of this factor were highly related to each other (correlations between .65 and .94. See Appendix 5.1). PLS deals with that by making one synthetic factor out of it, which has a high loading on all these variables. PCR, in turn, tries to minimize multicollinearity by taking one variable more into account than the other one. Table 5.2 shows that especially 'Breeding Value Legs' and 'Breeding Value Type' were included in this factor in the PCR. Because the factor 'Breeding Value Conformation' was built up differently in the 2 models, the relationships towards the other synthetic factors were also different.

5.4.2 Comparing the methods

Wold (1985) states that PLS is useful when the main focus of the study shifts from individual variables and parameters to packages of variables and aggregate parameters. He stated that 'in large, complex models with latent variables PLS is virtually without competition'. Rossa (1982) showed a map of statistical methods with regard to the complexity of the problem and their degree of prior information and concluded that PCR and PLS are both useful for complex problems. However, for PLS–modelling more prior information is needed, because the researcher has to design a path diagram with expected relationships on forehand.

Helland and Almøy (1994) compared PCR and PLS and concluded that there is not one method that dominates the other, and that the difference between the methods is typically small when the number of observations is large. PCR does well when the eigen values from the irrelevant components are extremely small or extremely large. PLS does well for intermediate irrelevant eigen values (Helland and Almøy, 1994). In case of multicollinearity, the eigen values might not be dominating ones. In that case PLS becomes closer to ordinary least squares, which is a desirable property of PLS. Garthwaite (1994) compared PLS with four other methods, including PCR, and concluded that PLS is a useful method for forming prediction equations when there are a large number of explanatory variables.

The R^2 of the milk production models differed considerably between the 2 methodologies: .36 for the PCR-model and .47 for the PLS-model. This can be explained by differences in optimizing techniques employed in deriving the synthetic factors. PLS forms the synthetic factors by using the covariance between the X- and Y-variables already, whereas with PCR the PCs are formed based on the X-variables only. As a result of that, the synthetic factors in PLS explain differences in the Y-variable better than PCR can do. In the current PCR 14 PCs were eliminated, based on their low eigen value. Another option is to eliminate components that have low correlation with the response variable. This results in a larger R^2 (.45 in this case when 5 PCs with the highest correlation with 305-day milk production were selected). However, the elimination procedure that was used in this study guarantees variance reduction in the X-variables, but using the alternative method does not (Mason and Gunst, 1985), and the alternative method gives less stable results (Xie and Kalivas, 1997).

The results of the two analyses showed some advantages and disadvantages of both methodologies. PLS has a clear advantage that it is optimizing towards the Y-variable right from the beginning, whereas with PCR some variance in the data set might be left out that still has a reasonable effect on the Y-variable. As a result of that, the percentage of variance that can be explained with the model is bigger for PLS. PCR, on the contrary, has a well-developed theory, which makes it possible to estimate P-values within the model. This makes the model statistically more attractive than PLS that lacks a good statistical inferential base. This could probably be overcome by using data permutation to generate distributions under the null hypothesis (Churchill and Doerge, 1994). Besides that, the regression coefficients of PCR on the original scale can be interpreted more easily. In PCR the synthetic factors were based on regression coefficients on milk production. In the path-analysis, however, some synthetic factors were not related to milk production straightforwardly. In that case, it is not logical to calculate the synthetic factors this way. PLS is than more sufficient; the synthetic factors were formed based on their surrounding synthetic factors. Due to the way the analysis was set up, PLS can be generalized to a multivariate set-up very easily.

Before choosing a methodology to analyze a certain data set, other aspects of PLS and PCR have to be compared as well. Advantages that did not come out of the current analyses but which are useful to take into account are that in PLS the investigator is free to define more than one Y-variable, that the number of variables can be large compared to the number of observations, and that no distributional assumptions are made. This last aspect makes more data sets suitable for PLS-analysis. However, at the same time it implicates the disadvantage that significance values cannot be calculated. A disadvantage of PLS is that it is a partial procedure in the sense that each step of the estimation minimizes a residual variance with respect to a subset of X-, Y- and synthetic variables (Steenkamp and Van Trijp, 1996). So, there is no total residual variance or other overall optimum criterion that is strictly optimized (Jöreskog and Wold, 1982). The requirements, advantages and disadvantages of both methodologies are summarized in Table 5.5.

Table 5.5 Requirements and (dis)advantages of Principal Component Regression (PCR) and Partial Least Squares (PLS).

	PCR	PLS
Requirements		
Possibilities complexity path-analysis	Not complex	Very complex
Degree of prior-information required	Not much	Much
# cases : No. of variables	# cases >> # variables	# cases <, =, or > # variables
Assumption on distribution variables	Normal distribution	Distribution-free
Number of Y-variables	= 1	>= 1
(Dis)advantages		
Multicollinearity	Accounted for	Accounted for
Analysis	Complete	Partial
Y-variable included in optimisation	No	Yes
Calculation P-values	Possible	Not possible

5.5 CONCLUSIONS

It can be concluded that PLS is a useful alternative to PCR in livestock management research, to explain complex relationships, but the advantage over PCR are not large. This implies that it is not possible to give a general advice on what methodology to use. For each data set the researcher has to decide what methodology fits best. To decide which methodology to use, the researcher has to take into account the requirements of both methodologies mentioned in Table 5.5. This includes the complexity of the path-analysis, the degree of prior-information that is available, the number of variables compared to the number of observations, the distribution of the variables, and the number of Y-variables. In case the comparison does not give a clear answer which methodology to choose, advantages and disadvantages mentioned in Table 5.5 can be used to make a founded choice. In the case of complex relationships, such as present in the bigger data set in this project, Table 5.5 shows that in PLS is the best methodology to choose, because PCR cannot handle very complex path-analyses.

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Appendix 5.1 Linear correlations between variables used in the multivariate analysis (see Table 5.1 for description of variables).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1) Production	1.00																			
(2) Culling	.27	1.00																		
(3) Winter milk	-.27	-.23	1.00																	
(4) Kg milk	-.16	-.07	.17	1.00																
(5) Udder	.00	.09	-.16	-.17	1.00															
(6) No. insem.	-.05	-.04	.12	-.18	-.25	1.00														
(7) No. of cows	.05	.06	.02	-.31	-.32	.73	1.00													
(8) No. of mc	.02	.05	.12	-.22	-.37	.73	.93	1.00												
(9) Cows %	.16	-.10	.32	.18	-.33	-.07	.10	.21	1.00											
(10) BV Milk	.11	.35	-.24	-.43	.24	.06	.10	.04	-.41	1.00										
(11) BV Fat	.01	.19	-.32	-.36	.26	-.04	.02	-.05	-.44	.83	1.00									
(12) BV INET	.11	.25	-.33	-.48	.22	-.06	.05	.00	-.44	.86	.92	1.00								
(13) Developm.	.15	.34	-.40	-.31	.54	-.20	-.20	-.32	-.20	.58	.59	.53	1.00							
(14) Type	.28	.35	-.36	-.26	.43	-.21	-.18	-.31	-.22	.59	.57	.54	.88	1.00						
(15) Udder	.27	.34	-.42	-.05	.42	-.14	-.23	-.35	-.25	.41	.38	.35	.74	.83	1.00					
(16) Legs	.11	.26	-.25	-.32	.49	-.16	-.13	-.24	-.58	.66	.63	.64	.67	.72	.65	1.00				
(17) Total	.21	.37	-.39	-.15	.47	-.23	-.24	-.37	-.33	.53	.54	.50	.85	.94	.93	.80	1.00			
(18) Age_heifers	.06	.00	.06	.05	-.22	.14	.05	.08	.33	-.11	-.13	-.21	.07	-.04	-.02	-.09	-.03	1.00		
(19) Calving_age	-.27	-.07	.01	.20	-.18	.14	.09	.12	.08	-.43	-.33	-.37	-.35	-.53	-.35	-.46	-.41	.15	1.00	
(20) 305-day	.26	.27	-.28	-.34	.32	-.42	-.30	-.40	-.31	.45	.41	.44	.39	.52	.50	.43	.51	-.31	-.26	1.00

Chapter 6

Influence of pasture and feeding management on technical and economic results of dairy farms

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ABSTRACT

A field study of 38 dairy farms was set up to determine the relationships between feeding management, pasture management and gross margin and feed costs per 100 kg of milk, 305-day milk production, and nitrogen loss per ha. Data of the farms were (among other things) on management (based on questionnaires), grassland calendar, milk production and economic data for the period of May 1996 till May 1997. Partial Least Squares (PLS) was used to analyze the data, because of the large number of variables relative to the number of farms. The R^2 of the models ranged between .32 (nitrogen loss model) and .62 (gross margin model). The nitrogen loss model did not have predictive relevance. The PLS-model for feed costs resulted in the hypotheses that (1) a high percentage of pasture that cannot be grazed by the cows results in an increase in feed costs, (2) a high percentage of grazings lasting longer than 4 days increases feed costs, (3) mistakes in set-up of the paddocks cannot be compensated for by exact planning, and (4) farmers who have not organized their grazing management well, also tend to have worse results as to their silage management. The milk production model showed that a high milk production per cow is realized on farms with too low a number of growing days for cutting.

6.1 INTRODUCTION

During the past couple of years, net farm income has decreased on Dutch dairy farms, partly due to a declining milk price. However, differences in gross margin between farms are rather big (Rougoor et al., 1997). Particularly, differences in pasture and feeding management are expected to have an important effect on gross margin. Therefore, optimizing pasture and feeding management might be a way to maximize economic results. In this paper, a description of management will be used as has been introduced by Rougoor et al. (1998). They state that personal aspects influence farmer's decision making, which includes planning, implementation and control. The decision-making process eventually determines, together with environmental influences, farm results. In the literature, only few references can be found on the relationships between management of pasture, milk production, and economic results. Moreover, most of the literature focuses on just one aspect of these relationships. Fisher and Roberts (1995), for instance, examined the effects of grazing intensities on milk production in the UK. They concluded that on intensively grazed swards the cows produced significantly less milk. Fisher and Dowdeswell (1995) studied the effects of different grazing management on herbage intake and milk production in the UK. The results suggested that severe grazing of swards in early season could improve herbage intake and milk production. In Denmark Kristensen et al. (1997) also found that a high grazing intensity had a negative effect on milk production and live weight gain. These results, however, are hard to compare with the situation in the Netherlands, due to differences in grazing practices. Higher grazing intensity in the Netherlands leads to a lower cutting percentage and not to a limited herbage allowance. In England more emphasis is put on making silage than on grazing. In that case, a higher grazing intensity results in a limited herbage allowance. Corrall et al. (1982) looked at another aspect of pasture management. They evaluated the effect of conservation strategies on the costs per ton of silage, and found strong effects of management options on the results. Doyle et al. (1983) evaluated the same aspect but in a situation where cutting and grazing were integrated, contradictory to Corrall et al. (1982) who treated the areas required for conservation and grazing separately. Doyle et al. (1983) found that cutting strategies aimed at making low-digestibility silage could not automatically be regarded as the most profitable. Dobbelaar et al. (1992) determined the relationship between initial sward height and grazing period, whereas Hanson et al. (1998) studied the profitability of moderate intensive grazing systems compared with extensive grazing systems. This short overview already shows the diversity of the studies and of the results on relationships between pasture management, milk production and economic results.

There is no literature available on the relationship between feeding management and economic results. Literature on the relationship between feeding management and milk production is more common. Waheed et al. (1977) investigated the relationship between 20 feeding management factors and milk production. Significant effects on herd differences in milk production were found for the interaction of the source of summer roughage (corn silage, hay, pasture, other sources, or combinations, etc.) and the amount of grain that was fed to lactating cows. Gibson (1984) reviewed 23 papers on the relation between frequency of feeding and milk production. All these papers differed regarding feeding frequencies that were compared, making it hard to draw a useful conclusion. The average increase in milk production was found to be 2.7% as a response to increased frequency of feeding. Sargeant et al. (1997) analysed data of 500 questionnaires on the relationships between management and milk production. They found a significant association between milk protein production and the use of forage analysis, together with the assistance of a nutritional consultant to formulate the ration.

Differences in grazing and feeding systems make it difficult to compare results from different studies. Besides that, almost all studies have only considered one isolated aspect of pasture or feeding management and the effect of this on milk production. No study was found where the influence of pasture and feeding management on milk production as well as on economic results was studied intensively. The objective of the current study was to integrate the different segments as mentioned above, and to determine the influence of pasture and feeding management on gross margin, milk production and nitrogen loss. Dutch farmers have to deal with a milk quota system. Therefore, gross margin is expressed per 100 kg of milk, because the total amount of milk produced is the limiting factor. Because of legal restrictions on environmental pollution per ha in the Netherlands, mineral loss should be minimized as well. Therefore, the influence of management on nitrogen losses is also studied. In the current study variance in milk quota per ha is small between farms. In that case a minimization in mineral losses per kg of milk is almost equal to a minimization per ha. Therefore, mineral losses are expressed per ha, in accordance with the way legal restrictions are formalized in the Netherlands. The objective of this paper has been split into three topics:

1. What is the relationship between pasture management, feeding management and milk production?
2. What is the relationship between pasture management, feeding management, and gross margin?
3. What is the relationship between pasture and feeding management and nitrogen loss per ha?

Feed costs are expected to influence gross margin the most. Therefore, the relationship between management and feed costs will be considered as well. Not much information was available beforehand, and many factors are interrelated. Therefore, the ultimate goal of the study was to define some hypotheses in this area. First, data collection is described. The statistical method Partial Least Squares (PLS) was used for the analysis, and will also be described. The models were used to formulate some hypotheses. The feed costs model turned out to show more interesting hypotheses than the other models. For that reason, the feed costs model is worked out in detail. Results and their statistical power are discussed. The model results on gross margin, milk production and nitrogen losses are not worked out completely, but are discussed in general. The hypotheses that have been formulated are described in the second part of the results section.

6.2 MATERIALS AND METHODS

6.2.1 Data collection

Thirty-nine dairy farms were selected on the basis of gross margin of May 1993 till May 1994 (for farms using a non-calendar year accounting period) or January 1994 till January 1995 (for farms using a calendar year accounting period), and the 305-day milk production between August 1993 and August 1994. Rougoor et al. (1997) showed that milk quota per ha has a great influence on gross margin per 100 kg of milk. Therefore, only farms were selected with a milk quota per ha between 10500 to 14500 kg. The gross margin is the gross returns minus costs from purchased feed per 100 kg of milk. The farms were selected through a stratified sample such that:

- 8 farms had a gross margin of below Dfl. 77.40 per 100 kg of milk and a 305-day milk production of below 7270 kg;
- 9 farms had a gross margin of below Dfl. 77.40 per 100 kg of milk and a 305-day milk production of above 7450 kg;

- 10 farms had a gross margin of above Dfl. 78.40 per 100 kg of milk and a 305-day milk production of below 7270 kg;
- 12 farms had a gross margin of above Dfl. 78.40 per 100 kg of milk and a 305-day milk production of above 7450 kg.

Rougoor et al. (1999) showed that, unfortunately, the differences in gross margin between the four groups mentioned above have become much smaller over the past few years. The groups could not clearly be recognized anymore. Therefore, the analyses were done on individual data, without differentiating between the four groups. During the period of data collection one farm dropped out, so analyses are based on data of 38 farms.

The farms were visited monthly during the period of May 1996 till May 1997. Data were recorded on different subjects: pasture, feeding, animal health, fertility and breeding (i.e. sire selection). Table 6.1 shows the different kinds of collected information. Classification of data collection is based on Rougoor et al. (1998). The table is not exhaustive but shows the most important data. Many technical data could be obtained from institutions which collect these data in a systematic way. Besides these existing data, technical data were collected by single on-farm investigations and longitudinal on-farm observations, i.e. repetitive data collection throughout the year. Examples of single on-farm investigations are the amount of silage harvested form the pasture and a classification of the cleanness of the cowshed. Longitudinal on-farm observations relate mostly to data that were collected and kept up-to-date by the farmer, like the grassland calendar, recording the activities on the pasture: cutting, grazing, fertilizing, etc. These data were copied during the monthly visits.

There were no existing farm data available on farmer's management abilities. Information on decision making in the different areas was gathered by questionnaires and interviews. The questionnaires focused on management functions, i.e. planning, implementation and control. Additionally, management was measured during an evening workshop (an off-farm experiment). The farmers were asked to write down their business goals in general and the critical success factors of the different research areas. This was done as described in detail by Huirne et al. (1997).

This paper focuses on pasture and feeding data. The questionnaire on pasture management included questions on grazing, fertilizing, planning the use of the paddocks, maintenance of pasture, harvesting, and aspects taken into account by the farmer to judge the quality of the paddocks. The questionnaire on feeding management focused on the supply of colostrum, rearing of calves, planning of the use of silage, feeding of dried-off cows, planning of the concentrate use and minerals and the evaluation of feeding strategies by the farmer. 'Home grown' silage was analysed by standard lab techniques. The amount of dry matter (DM), and amount of VEM (energy-standard in a net energy system; Van Es, 1978) and DVE (sum of digestible feed and microbial true protein available in the small intestine; Tamminga et al., 1994) per kg of DM were measured. The amount of silage harvested from the pasture was estimated by volume. An overview of nitrogen and phosphorus input and output was made on the basis of the information on purchases of concentrates, fertilizers, etc. Data on milk production were obtained from the Royal Dutch Cattle Syndicate (NRS) and included 3 to 6 weekly milk productions on a per cow basis. Economic results were obtained from the GIBO group, one of the major Dutch accountancy agencies.

Table 6.1 Type of data collection from May 1996 till May 1997.

Subject	Existing farm data	Single on-farm investigations	Longitudinal on-farm observations	off-farm experiments
Management				
- overall		questionnaire		Business goals
- pasture		interview		Critical success factors
- feeding		interview		Critical success factors
- animal health		interview		Critical success factors
- fertility		interview		Critical success factors
- breeding		interview		Critical success factors
Technical				
- pasture	GIBO[1)]	sward height	Grassland calendar	
- feeding	Blgg[2)], GIBO	amount of silage	Feed purchase	
- animal health	bill of veterinarian	cleanness cowshed	Cases of mastitis	
- fertility	NRS[3)]			
- breeding	NRS			
- milk production	NRS			
Economic	GIBO			

1) GIBO group, accountancy agency
2) Laboratory for soil and crop testing (Blgg Oosterbeek)
3) Royal Dutch Cattle Syndicate (NRS)

6.2.2 Descriptive statistics

Almost all farms in our data set used rotational grazing. Essential characteristics of this system are that paddocks are grazed during a limited number of days, with the purpose to offer cows a sequence of paddocks with 1500-2000 kg DM grass per ha. Boxem (1982) stated that paddocks being grazed for a period of 4 days at a max is optimal. Second characteristic is that grass not needed for grazing is cut for conservation (Dobbelaar, 1988).

A first selection of the data was based on simple linear correlation. Goal variables are the 305-day milk production (i.e. the farm average 305-day milk production from May 1996 till May 1997), gross margin per 100 kg of milk for that period, and nitrogen loss in kg N per ha. Only variables that had a correlation of $\leq -.25$ or $\geq .25$ with a 305-day milk production, gross margin or nitrogen loss were selected for the multivariate analyses. In this way, only 30 variables out of a total of more than 200 related to pasture or feeding management were selected for the multivariate model on gross margin, and 29 variables for the feed costs model. Table 6.2 shows some general information on the farms.

Table 6.2 Average and the standard deviation (SD) of the selection criteria (305-day milk production and gross margin) and other farm specific variables for May 1996 till May 1997 for the 38 farms included in the study.

	Average	SD
Average 305-day milk production (kg)	8342	764
Average gross margin (Dfl./100 kg milk)	65.10	5.00
Farm size (ha)	42.2	12.6
Milk quota (*1000 kg per farm)	518	14
Number of labour equivalents at the farm	1.6	.5
No. of days cows graze in the same paddock	6.9	7.3
No. of days cows are housed per year	175	24

6.2.3 Choice of statistical method

A major limitation of the current data set is the small number of farms compared with the large number of variables. Partial Least Squares (PLS) is a statistical method that can deal with this problem. PLS is considered especially useful for constructing prediction equations when there are many explanatory variables and comparatively few sample data (Garthwaite, 1994). The intention of PLS is to form so-called latent variables (LVs) that capture most of the information in the X-variables that is useful for predicting the Y-variables, while reducing the dimensionality of the regression problem by using fewer LVs than X-variables. The variables that are measured in the field, the X- and Y-variables, are the so-called manifest variables (MVs). PLS can even handle situations where the number of cases is smaller than the number of X-variables. Major difference between principal components regression (PCR) and PLS is that with PCR, LVs are determined solely by the data values of the X-variables, whereas with PLS, the data values of both the X- and Y-variables influence the construction of LVs (Garthwaite, 1994).

A null-path model with the LVs and their relationships has to be constructed. This null-path model includes all the relations that will be tested. Using prior knowledge and intuition the investigator is free to specify the LVs, to design the relations between the LVs, and to compile a selection of MVs for each LV (Wold, 1985). An arrow scheme can be used to show the groupings of the MVs. Arrows between LVs in the scheme represent hypothetical relationships. PLS distinguishes different components of the path model: inner and outer relationships. Inner relationships are the relationships between the LVs. These are given by the inner path coefficients, ranging from –1 tot +1. Outer relationships define the estimated LVs as the weighted linear aggregates of their MVs (Steenkamp and Van Trijp, 1996), which are the so-called factor loadings. These are estimated in such a way that the LV-estimates are optimal in the inner, as well as in the outer model. Estimation of the LVs involves both the factor loading and the inner path coefficients. The optimization criterion is minimization of residual variances. PLS seeks values for the factor loadings and path coefficients that minimize residual variance for the LVs and the MVs. The concept of 'neighbouring LVs' is used. An LV is estimated to be the best predictable variable of its predictors as well as the best predictor of subsequent dependent variables (Steenkamp and Van Trijp, 1996). PLS estimation algorithm proceeds in three stages, which have been described in detail by Steenkamp and Van Trijp (1996) and Wold (1985).

6.2.4 Limitations and statistical power of PLS

PLS can be a powerful method because of the minimal demands on measurement scales, sample size and residual distribution. As a rule of thumb the sample size should be equal to the larger of the following: (1) five to ten times the number of MVs of the largest LV, or (2) five to ten times the largest number of structural paths directed at a particular LV in the structural model. In our case (with 38 farms) this indicates a maximum number of MVs for each LV of 4 to 8 and a maximum of 4 to 8 structural paths directed at a particular LV. This limitation has been taken into account in the set-up of the null-path model.

No distributional assumptions are made in PLS. Therefore, the traditional statistical testing methods based upon assumptions about statistical distributions are not well suited. The average variance extracted (AVE) measures the amount of variance that is captured by the LV in relation to the amount of variance due to measurement error. Fornell and Larcker (1981) suggest that AVEs of the LVs should be greater than the correlations among the LVs to fully satisfy the requirements for discriminant validity. The R^2 is a measure of the inner model. It measures the explanatory power of the inner structural model. It shows how well an LV is predicted by other LVs. The Stone-Geisser test follows a blindfolding procedure. Part of the data matrix is omitted while parameters are estimated. Then the omitted part is reconstructed by the estimated parameters. This procedure is repeated until each and every data point is omitted and reconstructed once. The Stone Geisser test criterion, Q^2, indicates how well the observed values can be reconstructed by the model. It can be used to evaluate the predictive relevance of the model. $Q^2 > 0$ indicates that there is predictive relevance, whereas $Q^2 < 0$ suggests lack of relevance. There are different kinds of Q^2 measures. In the current study the blindfolding redundancy measure was used. This measure was constructed by the redundancy prediction (Fornell and Cha, 1994).

The PLS model was estimated with the LVPLS 1.8 program (Lohmöller, 1987). Models were set up for milk production, gross margin, feed costs and nitrogen surplus. The model of feed costs showed the most interesting results, and is discussed in detail. The results of the other 3 models are discussed in general.

6.2.5 Basic PLS model for feed costs

Table 6.3 shows the variables, with a description, that were included in the model. The specification of the LVs is based upon a logical separation of different parts and levels of feeding and pasture management. Eight LVs were included in the model, with 'Feed costs' being the goal variable, and the other LVs explanatory variables. These explanatory LVs partly concern management ('Decision Making' and 'Business Goals'), partly set-up of the farm ('Farm'), and are partly technical ('Silage making', 'Grazing', 'Feeding' and 'Feed purchasing'). These LVs were used in the path-analysis.

As said before, when using PLS, the investigator is free to use prior knowledge and intuition to design the inner relations, and to compile a selection of indicators (i.e. MVs) for each LV. The LVs are not independent. This dependency is put into the model by arrows. To define a null-path model, the framework as described by Rougoor et al. (1998) was used. The decision-making process (business goals and decision making) influences biological and technical aspects and processes (grazing, silage making, feeding, and feed purchasing). These aspects and processes can also influence one another (it was assumed, for instance, that grazing would influence the amount of feed purchased) and the feed costs per 100 kg of milk. The relationships that have been included in the null-path model are shown in Figure 6.1.

6.3 RESULTS

6.3.1 Feed Costs

6.3.1.1 Outcome of the model

Table 6.4 provides the factor loadings for each of the measures, the R^2 of each LV and the variance extracted for each of the MVs, as well as the average variance extracted (AVE) for each of the LVs. The higher the absolute value of the factor loading, the more important that MV for its LV. The R^2 shows that 60% of the variance in feed costs can be explained from the 7 explanatory LVs. A high AVE indicates that the amount of variance captured by the LV is large compared with the amount of variance due to measurement errors. Table 6.4 shows that this is the case for the LVs 'Business goals', 'Feeding', and 'Feed purchasing'. Unfortunately, the other explanatory LVs show a relatively great variance due to measurement errors.

Table 6.3 Description of manifest variables used in the analysis with feed costs being the goal variable.

Latent Variable	Manifest Variable	Description of Manifest Variable	Avg. Value
Farm	Corn %	Percentage of land used for corn for silage	12 %
	Intensity	GVE per ha[1)]	2.12 GVE
	Pasture no grazing	Percentage of pasture that cannot be used for grazing by the dairy cows (because of distance or barriers)	21 %
Decision Making (DM)	Plan week	Number of weeks pasture use is planned in advance	2.03 weeks
	Pasture imp	Importance of pasture management for earning money according the farmer; 1 (unimportant) - 6 (important) scale[2)]	4.55
	Know-how VEM	Estimate of farmer of VEM-contents of 'home grown' silage compared with VEM-contents of silage at other farms[3)]	12.54
	Feeding aspects	No. of aspects farmer takes into account regarding feeding problems (i.e. changes in herd, weather, feed ration, grazing)	1.71
	Corn aspects	No. of aspects farmer takes into account regarding purchase of corn silage (i.e. price, ratio balance, experience)	1.62
Business Goals	Silage	Importance of goal 'improve quality 'home grown' silage' according to the farmer[4)]	3.91
	Contract work	Importance of goal 'decrease amount of contract work'[4)]	2.27
	Soil	Importance of goal 'improve soil quality'[4)]	3.67
Silage making	VEM	Amount of VEM per kg 'home grown' silage	886
	Cutting%-1	Cutting percentage of first cut	46.6 %
	Wilting period	Average number of days between cutting and ensiling	1.6 days
	Cutting-July	Number of growing days for cutting stage in the period 20th June – 20th July	29.9 days
Grazing	Grazing-June	Number of growing days for grazing stage in the period May 20th till June 20th	21.3 days
	Flexible	Use of flexible fencing for grazing (% of all grazings)	38.9 %
	Grazing-grazing	% grazing followed by grazing[5)]	47 %
	Grazing-cutting	% grazing followed by cutting, and cutting => grazing[5)]	44 %
	Grazing > 4 days	% grazings that lasted longer than 4 days	57 %
	Min surface	surface of smallest paddock for milking cows	1.3 ha
Feeding	Conc/cow	Kg of concentrates given per cow per year	2335 kg
	Push on	Times a day feed is pushed on towards the animals	2.8 times
Feed purchasing	N-conc-ha	Purchases of N from concentrates in kg per ha	98 kg
	N-roughage-ha	Purchases of N from roughage in kg per ha	14 kg
	P-conc-ha	Purchases of P_2O_5 from concentrates per kg per ha	37 kg
	P-roughage-ha	Purchases of P_2O_5 from roughage per kg per ha	4 kg
Feed costs	Feed costs	Costs of purchased feed per 100 kg of milk	Dfl. 16.11

1) GVE = Dutch 'cow equivalent unit'; 1 cow = 1 GVE; 1 heifer = .439 GVE; 1 calf = .220 GVE.

2) The farmer was asked to order management in the areas of feeding, pasture, fertility, animal health, milk production and culling as to importance.

3) Value between -100 (total underestimation of own results) and 100 (total overestimation of own results).

4) A score of 1 indicates not important at all, a score of 5 indicates very important.

5) (grazing - grazing) + (grazing - cutting) + (cutting - grazing) + (cutting - cutting) = 100% (advice: alternative grazing and cutting).

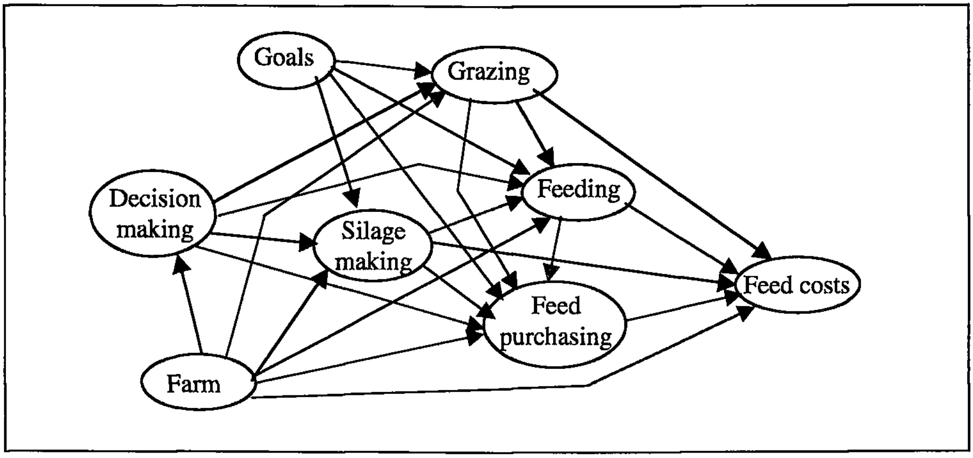

Figure 6.1 Null-path model of the PLS-modelling.

Figure 6.2 shows a graphical representation of the structural parameters in the feed costs model. Only relationships with an inner structural path-coefficient > .20 or < -.20 were included in the final model. The LV 'Decision making' is highly related to 'Grazing' and 'Silage making', and, via these 2 LVs, to feed costs. 'Feed purchasing' is a central element in the model. The LVs 'Farm', 'Grazing', 'Feeding' and 'Silage making' are related to it. As could be expected, 'Feed purchasing' is highly related to feed costs.

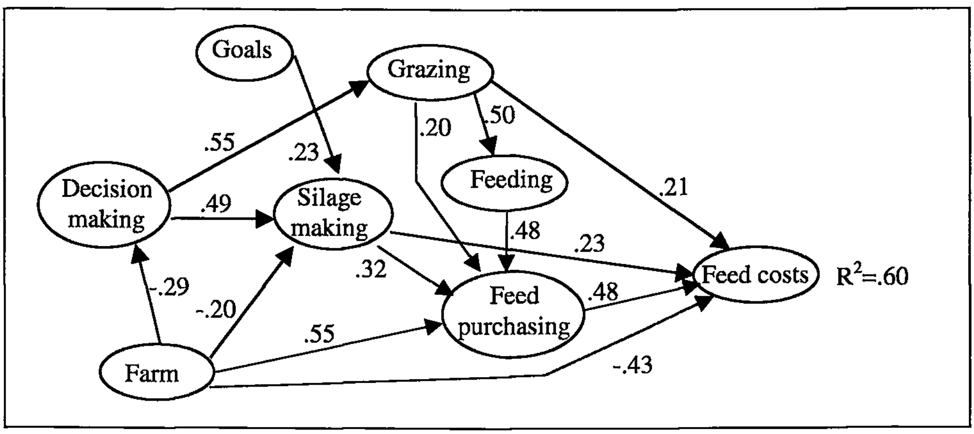

Figure 6.2 Inner structural path coefficients of feed costs model.

Table 6.4 Outcome of the PLS model for feed costs being the goal variable.

• **Latent Variable** *Manifest Variable*	Factor Loading	Mult. R^2	(Average) Variance Extracted
• **Farm**		NA[1)]	**.41**
Corn %	*.69*		*.48*
Intensity	*.48*		*.23*
Pasture no grazing	*-.71*		*.51*
• **Decision Making**		.08	**.27**
Plan week	*.39*		*.15*
Pasture imp	*-.72*		*.52*
Know-how VEM	*.42*		*.18*
Feeding aspects	*.65*		*.42*
Corn aspects	*.24*		*.06*
• **Business Goals**		NA	**.58**
Goal silage	*.77*		*.60*
Goal contract work	*.77*		*.59*
Goal soil	*.73*		*.54*
• **Silage making**		.43	**.30**
VEM	*.20*		*.04*
Cutting%-1	*.73*		*.53*
Wilting period	*.66*		*.43*
Cutting-July	*.43*		*.18*
• **Grazing**		.30	**.39**
Grazing-June	*.42*		*.18*
Flexible	*.25*		*.06*
Grazing-grazing	*-.79*		*.63*
Grazing-cutting	*.68*		*.46*
Grazing > 4 days	*.72*		*.51*
Min surface	*.71*		*.51*
• **Feeding**		.25	**.64**
Conc/cow	*.82*		*.68*
Push on	*-.78*		*.60*
• **Feed purchasing**		.62	**.47**
N-conc-ha	*.88*		*.77*
N-roughage-ha	*.47*		*.23*
P-conc-ha	*.84*		*.70*
P-roughage-ha	*.45*		*.21*
• **Feed costs**		.60	NA[2)]
Feed costs	*1.00*[3)]		

1) NA = not available; this LV was not predicted by any other LV
2) Not available; only single indicator.
3) Constrained to one (single indicator)

The significance of the model can be determined by the average variance extracted (AVE), the R^2, and the Q^2. Table 6.5 shows the outcome of the different variables for the feed costs model as well as for the other models, which are not discussed in detail here. The feed costs model and the gross margin model turn out to have the highest explanatory value of the inner model; the R^2 and the Q^2 are the highest for these models. The AVE, a measure of the outer model, is the highest for the gross margin model. A lower AVE makes it harder to meet the criterion that the AVEs should be greater than the correlations among the LVs. The feed costs model has rather low AVEs. So, the requirements for discriminant validity could not be satisfied completely for this model. The model on nitrogen loss has a negative value for Q^2, so this model has no predictive relevance. Therefore, this model was not used in the second part of the research; the formulation of hypotheses.

Table 6.5 Value of different parameters to interpret the statistical power of the models.

	AVE min/max	R^2 goal parameter	Q^2
Feed costs	.27 / .64	.60	.42
Gross margin	.43 / .94	.62	.28
Milk production	.27 / .57	.50	.15
Nitrogen loss	.28 / .67	.32	-.12

6.3.1.2 Influence of farm structure

The LV 'Farm' plays an important role in the feed costs model. This LV is determined by the intensity of the farm, measured in GVE per ha, the percentage of land in use for corn, and the percentage of the pasture that cannot be used for grazing by the cows, due to distance or barriers between barn and paddock (a highway for instance). This variable has a direct negative relationship with feed costs. So, farms with much pasture that cannot be grazed by the cows have a lower score on the LV 'Farm', resulting in higher feed costs. To get more insight into which aspects of the feed costs are related to the MV 'Pasture no grazing', this variable is related to different aspects of the feed costs. It turned out that farms with more pasture that cannot be grazed by the cows spent more money on purchasing silage. It is unclear why they bought more silage: they had the same amount and quality of silage from their own farm, and they did not have a higher milk quota per ha. The variable 'Pasture no grazing' was not included in the models of milk production and gross margin, because correlation was too low. So, 'Pasture no grazing' has no influence on milk production and the effect on gross margin (via the feed costs) has partly vanished.

'Farm' is positively related to 'Feed purchasing'. So, farms with a lower score on the LV 'Farm' buy less feed per ha, but, as stated before, the feed costs per 100 kg of milk are higher. This seems contradictory, but can be explained by the intensity of the farm. Farms with a high number of GVE per ha, score high on 'Farm' as well. Per ha they have to buy more feed (so the LV 'Feed purchasing' is higher), but per kg of milk they need to buy less feed (so the feed costs are lower). So, despite the small variety in intensity between farms, it still has an impact on the economic results. The MVs 'Intensity' and 'Pasture no grazing' are MVs of the same LV. Their mutual correlation, however, is small (-.16). So, the relationship between 'Pasture no grazing' and feed costs is not due to differences in intensity between farms with much pasture and little pasture that cannot be grazed by the cows respectively.

The LV 'Farm' is also related to the LV 'Silage making'. Farms with much pasture that cannot be grazed by the cows have a higher cutting percentage in the first cut (MV 'Cutting%-1') and the average wilting period (MV 'Wilting period') is longer. Another MV of the LV 'Silage making' is 'VEM'. This variable, however, got a very low factor loading and AVE. So, notwithstanding the path coefficient from the LV 'Farm' to the LV 'Silage making', no conclusions can be drawn on a possible effect of the LV 'Farm' on the quality of silage. The LV 'Silage making', in turn, is related to feed costs. However, the low factor loading shows that this is only for a very small part the result of a lower silage quality. Most of the relationship between 'Silage making' and 'Feed costs' can be ascribed to differences in wilting period and cutting percentage of the first cut. Higher values for these variables are related to higher feed costs.

6.3.1.3 Pasture management

The LV 'Grazing' includes the MVs 'Grazing > 4 days', and 'Min surface'. These two variables are related to each other (correlation is .49). The grazings last too long, because the surface of the paddocks is too big. The model shows that this is related to higher feed costs. The LV 'Grazing' is also highly related to the LV 'Decision making'. This LV can be seen as a representative of a certain attitude towards pasture management. The MVs included in this LV give insight into the broader view of the farmer regarding pasture management. Farmers who take many aspects into account regarding problems with feeding, who think that grassland is not that important for earning money, but still plan the use of their paddocks many weeks ahead and have a good knowledge about the quality of their silage, score high on this LV. So, in spite of the fact they think pasture is not that important, they seem to plan quite well. However, these farmers have higher feed costs, partly due to the higher score on the LV 'Grazing'. So, the hypothesis can be formulated that mistakes in set-up of the paddocks cannot be compensated for by exact planning. Besides that, it indicates that farmers should not underestimate the importance of pasture management for economic results. An underestimation will result in poorer pasture management and higher feed costs.

In the null-path model (Figure 6.1) only relationships that can be expected from a biological point of view were included or relationships that could be based on common knowledge. A relationship between 'Grazing' and 'Silage making' was not included, for we expected independence between these two aspects. The correlation between the two LVs, however, turns out to be .31. It supports the finding that pasture management is an attitude of the farmer that is reflected in different aspects of farm management; in grazing management as well as in silage management. Farmers who organize their grazing management well (the paddocks are the right size), will also have better results as to their silage management (a shorter wilting period). This results in lower feed costs per 100 kg of milk (roughage costs as well as costs of concentrates). No influence was found on milk production or gross margin. These relationships are shown in Table 6.6, where the 38 farms are split into 19 farms with the lowest grazing percentage > 4 days and 19 farms with the highest grazing percentage > 4 days.

Table 6.6 Average value of pasture variables of 38 farms divided into 2 groups, based on percentage of grazings lasting longer than 4 days.

Grazing % > 4 days	VEM silage / kg DM	DVE silage / kg DM	Wilting period	Feed costs / 100 kg of milk
35 %	898	78.2 g	1.5 days	Dfl. 14.78
80 %	877	74.2 g	1.8 days	Dfl. 17.50

6.3.2 Milk production

Figure 6.3 shows the inner structural path coefficients of the model on a 305-day milk production. Because of limited space, the set-ups of the LVs will not be discussed in detail, but some aspects highlighted. The model includes the number of growing days for grazing in June and for cutting in June, July and August, as a representation of pasture management. These variables are grouped together in the LV 'Growing days'. All MVs have a positive factor loading on this LV, with numbers of growing days for cutting and grazing in June being the MVs with the highest factor loadings. The LV 'Growing days' is negatively related to production (correlation is -.42). This implicates that farms with more growing days have a lower milk production. Growing days for grazing in June was included in the feed costs model and the gross margin model as well. These two economic models, however, show a less clear relationship between growing days and economic returns, than for growing days and milk production. In the gross margin model, the MV growing days has a positive relation with gross margin. In the feed costs model, however, a positive relation with feed costs can be found, indicating a negative relation with gross margin. A reason for this difference can be that the relationship is not linear. An economically optimal number of growing days is expected. Before this optimum, the relationship between growing days and gross margin is positive and after this optimum the relation has a negative sign. The model cannot trace this, because in the PLS-analysis only linear relationships are included. As a result, both economic models showed a weak linear relationship; factor loadings and AVEs of the MV 'Grazing-June' are low in both economic models.

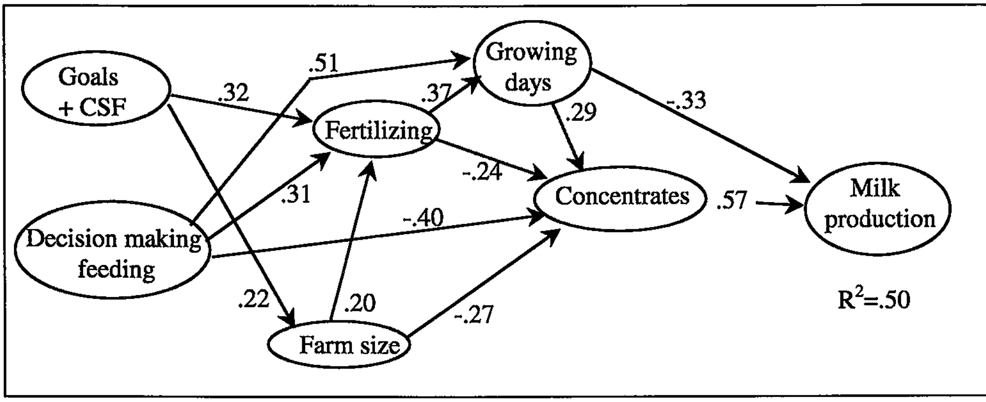

Figure 6.3 Inner structural path coefficients of 305-day milk production model.

Combining the models of feed costs, gross margin and milk production arrives at the conclusion that farms with a high milk production have a number of growing days that is lower than optimal from an economic point of view. The advantage of a higher milk production for the feed costs (i.e. less feed necessary for maintenance) has disappeared because the grass is cut at too young a stage. So, farms that realize a high milk production per cow might be afraid of a decreasing quality of their grass; they actually use grass that is too young. They want to avoid the risk of waiting too long resulting in the grass quality getting too low. As a result of that, energy and protein content is high, but quantity is suboptimal. This especially holds for ensiled grass, which is harvested too young. The correlation matrixes partly support this. The correlation between growing days for cutting in June and VEM and DVE-contents of the silage is –.40 and –.39 respectively. So, younger grass has a better quality. The amount of silage that is harvested per cutting per ha is indeed higher for older grass: a correlation between growing days in June for cutting and this amount is .40. Unfortunately, it is not possible to make a direct comparison between growing days and total amount that is harvested per ha per year, due to differences in intensity between farms. Milk quota per ha is one of the MVs of the LV 'Farm size'. It has a negative factor loading. So, from Figure 6.3 can be concluded that less intense farms, with a high score on the LV 'Farm size', have, on average, a few more growing days. Besides that, data on quantity of silage have to be interpreted with caution, because only the volume was measured. Density of the silage will also differ between farms. It is unknown how these differences in density have influenced the current data. The correlations between growing days for cutting in July and August and amount that is harvested are smaller than for growing days in June. This is in agreement with the factor loadings of the LVs. Number of growing days in June has the highest factor loading. So, the other numbers of growing days are not that crucial.

To support the hypothesis that high-producing farmers cut the grass at too young a stage, the farms have been divided into 3 groups (see Table 6.7). The division is based on the number of growing days for cutting in June. The numbers are in agreement with the hypothesis. The group in the middle has a number of growing days that is closest to the theoretically optimum of about 28 days (Handbook for dairy farming, 1997). Compared with the group with fewer growing days they only lose some quality, but they gain quantity and gross margin. The group with the highest number of growing days definitely waits too long; quality of the silage, expressed in VEM and DVE, is lower. Due to that, milk production and gross margin are lower as well. Table 6.7 also supports the statement that the relationship between growing days and gross margin is not linear, but that an optimum can be found.

Table 6.7 Average values of pasture variables for 38 farms divided into three groups based on number of growing days for cutting in June.

Growing days cutting June	No. of farms	Milk quota / ha	VEM silage / kg DM	DVE silage / kg DM	Quantity of silage / cut / ha	Milk production (305-day)	Gross margin / 100 kg milk
19.6 days	13	13401 kg	903	79.2 g	9.7 m^3	8557 kg	Dfl. 64.98
27.8 days	12	12936 kg	891	76.0 g	10.4 m^3	8358 kg	Dfl. 66.60
39.3 days	13	12142 kg	864	72.7 g	13.9 m^3	8091 kg	Dfl. 63.83

6.4 DISCUSSION AND CONCLUSION

The analyses showed that pasture management and feeding management have a reasonable influence on feed costs and on gross margin, whereas the effect on milk production and nitrogen loss is rather small. The results of the model on nitrogen loss are rather disappointing. Some influences of feeding and pasture management were expected, but could not be traced. So, no hypotheses could be formulated as to this subject. Hypotheses that are put forward on the relationship between pasture management, feeding management and economic results are:

1. An increase in percentage of pasture that can be used for grazing will decrease feed costs per 100 kg of milk;
2. Paddocks have to be set up in such a way that grazings do not last longer than 4 days. This will decrease feed costs;
3. Mistakes in this set-up of the paddocks cannot be compensated for by exact planning. Feed costs remain high;
4. Farmers who have not organized their grazing management well, also have worse results concerning their silage management, resulting in higher feed costs. So, both aspects can be seen as indicators of pasture management in general.

In the literature only a small number of references can be found referring to these hypotheses. Boxem (1982) and Dobbelaar (1988) mention that it is important that grazings do not last longer than 4 days. However, these studies did not include economic data, so they could not prove this hypothesis.

The explanatory power of the milk production model was lower than that of the economic models. However, one clear hypothesis could be formulated:

5. High milk production per cow is realized on farms with too low a number of growing days for cutting. As a result of that, economic results are below optimal.

No literature was found that could support this hypothesis. The current study was set up as a cross-sectional study. As a result of that, causes and effects cannot be determined. Only relationships can be measured, and based on logical thinking some hypotheses can be worked out on the underlying causes and effects. Testing these hypotheses needs a different research set-up. To state, for instance, the hypothesis that a high number of grazings lasting longer than 4 days results in higher feed costs, a case–control research has to be set up where farms are studied over a couple of years. In this way, the effect of merely the length of grazing a paddock on economic results can be studied. For each of the hypotheses different research would be necessary. The current study indicates that different steps in decision making, as defined by Kay and Edwards (1994), influence economic results: planning (i.e. the MV 'Plan week'), collect information (i.e. the MV 'Know–how VEM'), identify alternative solutions (i.e. the MV 'Feeding aspects').

The results show that the first aspect of pasture management a farmer has to take care of is the set-up of the paddocks. When this set-up is worked out correctly, a good planning of the use of the paddocks, for 4 days in a row at the most, will give the best results. Besides that, a farmer who wants to increase milk production per cow to reduce feed costs per 100 kg of milk cannot achieve this by cutting the grass at a very early stage, when energy and protein content is high. In that way feed costs will remain at the same level, because of a decrease in quantity of silage. Therefore, a farmer has to take the risk that milk production will not always remain high because of a little lower quality of the silage. That, however, is the only way to combine a high milk production with a high gross margin.

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Chapter 7

Relationships between dairy cow mastitis and fertility management and farm performance

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ABSTRACT

A field study was carried out on 38 dairy farms in the Netherlands to determine the relationship between mastitis and fertility management with 305-day milk production and gross margin. Questionnaires were used to get insight into the farmers' management. Out of 150 variables related to mastitis and fertility management, and technical and economic results, 44 variables were selected, based on correlation of ≥ .25 or ≤ -.25 with milk production and/or gross margin. These variables were used in 2 separate Partial Least Squares (PLS) analyses. PLS has the advantage that it can handle a large number of variables in relation to the number of cases.

The PLS-model as to 305-day milk production explained 54 % of the variance in 305-day milk production and showed a positive relation between 305-day milk production and know-how of the farmer regarding bulk somatic cell count (BSCC), the effort level of the farmer for BSCC, and hygiene of the milking parlour. Fertility was negatively related to 305-day milk production, in spite of a relatively good fertility management at high-producing farms. Forty-six percent of the variance in gross margin could be explained by the PLS-model. Fertility management did not seem to affect gross margin. Knowledge of BSCC and calving interval (CI) had a positive effect on gross margin. This knowledge seemed a general parameter for good economic results, because it was correlated with different aspects of gross margin.

7.1 INTRODUCTION

Relationships between management, and technical and economic results on dairy farms are rather complex. The current paper is part of a research with the purpose to get a better insight into these relationships under practical conditions, with a major focus on 305-day milk production per cow and gross margin per 100 kg of milk. Management was divided into management of pasture, feeding, breeding, animal health and fertility. The major focus was on operational management: the day-to-day decision making. The current paper discusses the results of the areas of mastitis and fertility. Much research has been done on segments of the complex of relationships between management and technical and economic results within these areas. However, there is no literature where the different aspects are integrated and their mutual relations discussed.

In this paper, the description of management as has been introduced by Rougoor et al. (1998) will be used. The description states that the personal aspects of the manager interact with his decision-making process, which includes planning, implementation, and control. The decision-making process, as well as all kinds of environmental influences, eventually determines farm results. Because of a milk quota system in the European Union, gross margin is expressed per 100 kg of milk and calculated as the gross returns minus feed costs from purchased feed per 100 kg of milk. Maximizing income under quota restrictions is equal to maximizing income per 100 kg of milk.

The ultimate goal was to formulate some hypotheses as to the areas of mastitis and fertility management and the relation with farm performance. Therefore, data were collected very intensively and the farms were visited monthly to get insight in the decision-making processes. Due to that, the number of farms that could be included in the study was limited. First, a short description of participating farms is given, and an introduction of the methodology discussed. Results of the models as to 305-day milk production and gross margin will be worked out and discussed. Lastly, the hypotheses are summarized.

7.2 MATERIALS AND METHODS

7.2.1 General data collection

Dairy farms were selected on the basis of gross margin of May 1993 till May 1994 (for farms using a non-calendar year accounting period) or January 1994 till January 1995 (for farms with a calendar year accounting period), and the 305-day milk production between August 1993 and August 1994. A low gross margin was defined as a gross margin below Dfl. 77.40 per 100 kg of milk. A high gross margin was defined as a gross margin above 78.40. A low 305-day milk production was defined to be below 7270 kg per cow, above 7450 kg was called 'high'. The farms were selected through a stratified sample such that 8 farms had a low gross margin and a low 305-day milk production, 9 farms had a low gross margin and a high 305-day milk production, 10 farms had a high gross margin and a low 305-day milk production, and 12 farms had a high gross margin and a high 305-day milk production. All farms were situated in the Netherlands.

The farms were visited monthly from May 1996 till May 1997 and data were gathered on management in the areas of pasture, feeding, animal health, fertility and breeding, and on technical and economic data. During the data gathering period 1 farm dropped out, so analyses are based on data of 38 farms. Between 1993 and 1997 there were quite some changes, and, on average, a strong decrease in gross margin within farms. As a result of that, the 4 groups as defined earlier could not be distinguished anymore in 1997 (Rougoor et al., 1999a). Therefore, the analyses were done on the individual data, without distinguishing between the four groups mentioned before. Table 7.1 shows some information on 305-day milk production and gross margin in 1996/97 and other general statistics of the farms. Moreover, the table shows the Dutch average of the variables. The farms turn out to be slightly bigger (i.e. more cows) than the average Dutch farm. All farms in the study had Holstein-Friesian cows. On 37 farms the cows were housed in a free-stall barn. One farm had a tied stall. All farmers milked their cows twice a day. Twenty-two farmers had a personal computer, 10 of whom used a management program on their computer to help with their daily dairy management. All farmers used artificial insemination to breed their cows. The Royal

Dutch Cattle Syndicate (NRS) has made data available on milk production, fertility, and BSCC. In the current study, farm average 305-day milk yield was used. Economic results were obtained from the GIBO group, one of the major Dutch accountancy agencies. Data collection is described in more detail by Rougoor et al. (1999b).

Table 7.1 Average, standard deviation (SD) and minimum and maximum values of some farm-specific variables for the period May 1996 till May 1997 for the 38 farms included in the study and the Dutch average.

	Avg.	SD	Min	Max	Dutch avg.
Average gross margin (Dfl./100 kg milk)[1]	65.10	5.00	56.31	75.98	66.89[3]
Average 305-day milk production (kg)	8342	764	6798	9883	7951[4]
Percentage of fat in the milk	4.46	.16	4.01	4.73	4.42[4]
Total length of lactation (days)	327	16	295	358	334[4]
Number of cows	67	19	30	105	59[3]
Cases of clinical mastitis per 100 cows[2]	32	14	12	68	NA[5]
Total veterinary costs (Dfl./cow)	132	50	31	245	151[3]

1) For farms using a non-calendar year accounting period based on May 1996 – May 1997. For farms with a calendar year accounting period based on January 1996 – January 1997.
2) Based on observations of the farmer on cases of clinical mastitis.
3) Based on economic information system for dairy farms (DELAR 1996/97)
4) Based on data from KNRS
5) NA = not available

7.2.2 Mastitis and fertility management

Management data on mastitis and fertility were obtained by questionnaires and by observations during the monthly visits. The questionnaire on mastitis management focused on the decision making regarding mastitis and mastitis prevention, and differentiated between planning, implementation and control. Questions on planning included effort level for bulk somatic cell count, effort level for cases of mastitis, and culling of animals due to mastitis. Implementation was investigated by questions on hygiene, mastitis control, treatment of mastitis, and milking behaviour. Besides, information was available on the milking equipment (age, pulsation, etc.). Different methodologies were used to get insight into the evaluation of the farmer of the mastitis status. The farmer was asked whether and how (i.e. in what type of recording system) he wrote down the cases of mastitis. He was asked whether the somatic cell count of individual cows was discussed with the veterinarian, and whether a bacteriological culture was performed for suspected animals. Every month the farmer was asked how many cases of mastitis there had been on his farm during the past month. However, the reliability of this observation was expected to be low. Therefore, this variable was not included in the analysis. The questionnaire on fertility management again focused on planning, implementation and control. Questions were related to oestrus detection, moment of insemination, hygiene and assistance during calving and evaluation of the farmer of the fertility status of the farm by the use of, for instance, checklists or pregnancy checks. In addition to the farm visits and questionnaires, management was measured during an evening workshop where farmers were asked to write down their business goals and their critical success factors. This was done as described by Huirne et al. (1997).

7.2.3 Methodology

Path analysis is a useful technique to elucidate webs of causation in a multivariate data set (Erb et al., 1981). However, with 'farm' being the unit of measurement, the current data set has only 38 cases. In that case the 'standard' path analysis will run out of degrees of freedom. Partial Least Squares (PLS) is a statistical methodology that can handle situations where the number of variables is large compared with the number of cases (Wold, 1985). The intention of PLS is to form the so-called latent variables (LVs) which capture most of the information in the X-variables (which are called 'manifest variables': MVs) that are useful for predicting the Y-variables. This way, the dimensionality of the regression problem is reduced, because fewer LVs are used than the number of X-variables. With these LVs the null-path model has to be constructed. An arrow scheme can be used to show the expected relationships between the LVs. Using prior knowledge, the investigator is free to specify the LVs out of the X-variables (the MVs) and the relationships between the LVs. The relations between the MVs and the LV is expressed in the factor loadings, which can vary between –1 and +1. The higher the absolute value of the factor loading, the more important that MV is for its LV. A negative sign indicates that a higher value for the MV will result in a lower value for the LV. The factor loadings are estimated in such a way that the LV-estimates are optimal towards the X-variables (the MVs), as well as to the Y-variable(s). Besides these factor loadings, the model estimates the path coefficients. These coefficients also vary between –1 and +1 and are indicators of the strength and direction of the relationship between two LVs. In the current study only relationships with a path coefficient > .20 or < -.20 were included in the final model. For the optimization procedure, PLS uses a sequence of ordinary least squares regressions, linear operations, and square root extractions in an iterative process (Wold, 1985).

Because no distributional assumptions are made in PLS, the traditional statistical testing methods are not appropriate. The average variance extracted (AVE) measures the amount of variance of the MVs that is captured by the LV. This variable can vary from 0 to +1. A high AVE indicates that the amount of variance captured by the LV is big compared with the amount of unexplained variance of the MVs. The R^2 measures the explanatory power of the relations between the different LVs. It shows how well an LV is predicted by other LVs. This value is dependent upon the set-up of the path model. It can also vary between 0 and +1. Another measure of reliability is the Stone-Geisser test. The Stone-Geisser test criterion, Q^2, indicates how well the observed values (the Y-variables in this case) can be reconstructed by the model. It is a value between –1 and +1. $Q^2 > 0$ indicates that there is predictive relevance, whereas $Q^2 < 0$ suggests lack of relevance. There are different kinds of Q^2 measures. In the current study the blindfolding redundancy measure was used. This measure was constructed by the redundancy prediction (Fornell and Cha, 1994). Wold (1985) has given an extensive description of PLS. The PLS-models were estimated with the LVPLS 1.8 program (Lohmöller, 1987). Two separate models were set up for 305-day milk production and gross margin.

7.2.4 Basic PLS-models

Correlation was used to make a first selection of the variables that were to be included in the multivariate analyses. Goal variables were the 305-day milk production (i.e. the farm average 305-day milk production from May 1996 till May 1997), and gross margin for that period. Only variables that had a correlation of ≤ -.25 or ≥ .25 with a 305-day milk production or gross margin were selected for the multivariate analyses. Thirty-one variables out of a total of 150 variables related to mastitis and fertility management were selected for the analyses on 305-day milk production, and 22 variables for the analyses on gross margin (see Appendix 7.1). Examples of management data that were not related to 305-day milk production or gross margin were some aspects regarding the hygiene of the boxes and the hygiene of the milk house, the number of years of experience with heat detection, and the knowledge of the farmer of the different signs of oestrus that can be observed.

Appendix 7.1 shows the 31 variables that are included in the 305-day milk production model, as well as the 22 for the gross margin model. A short description and the average value are given for each variable. The variables for the 305-day milk production analysis were grouped into 13 LVs. This grouping was based upon common knowledge and a separation between aspects that gave insight into the aspiration level of the farmer regarding management (for instance, the LV 'Fertility Management'), management aspects that were measured at the farm (for instance, the LVs 'Hygiene' and 'Milking Equipment'), technical performance (for instance, the LV 'Fertility'), and the goal variable (the LV 'Milk Production'). The LV 'Farm Size' did not fit into one of these categories: it was a production factor that influenced almost all other aspects. Variables included in the LV 'Fertility Management' were all obtained from the questionnaire on fertility management. Variables in the LV 'Mastitis Management' were obtained from the mastitis questionnaire. Data in the LVs 'Business Goals' and 'Critical Success Factors' were gathered during the evening workshop. The variables mentioned here were selected from a total of 37 critical success factors and 10 business goals related to animal health and fertility. All the other goals and critical success factors, which are not mentioned in Appendix 7.1, did not correlate with milk yield. These variables are all expressed on a scale from 'not important' to 'very important', making them ordinal variables. However, an increasing score indicates 'more importance'. Therefore, these variables were assumed to be continuous for the analysis. PLS does not require distributional assumptions for the variables (Wold, 1985), so the non-normality of these variables was not a problem. The same holds for the variables of the LVs 'Know-How' and 'Hygiene'. The variables in the LV 'Know-How' were based on single questions asked during regular farm visits. The LVs in Appendix 7.1 were used to design a null-path model to explain the LV 'Milk Production' out of the other LVs. The LVs are not independent, but will influence each other. The aspiration level, for instance, will influence measured management aspects and technical results, with milk production being one of them. The relationships that were included in the null-path model are shown in Figure 7.1. The top of the figure shows the division of the LVs into aspiration level, measured management, technical performance and goal variable. The 'MP' in brackets behind the LV indicates that it is an LV of the Milk Production model.

Appendix 7.1 also includes an overview of the LVs that were used in the gross margin model. Eleven LVs were included. The LVs in this model were related to the LVs in the model on 305-day milk production. However, Appendix 7.1 shows that the underlying MVs were not always the same. Nine MVs can be found in both models, the other MVs only appear in one of the models. The 'GM' behind the LV indicates that it is an LV of the Gross Margin model. Figure 7.2 shows the relationships between the LVs that were included in the null-path model for the PLS-analysis for gross margin. Management steps were included here as well. The aspiration level of the farmer influences his management, which, in turn, influences the technical performance. This technical performance eventually determines the economic results.

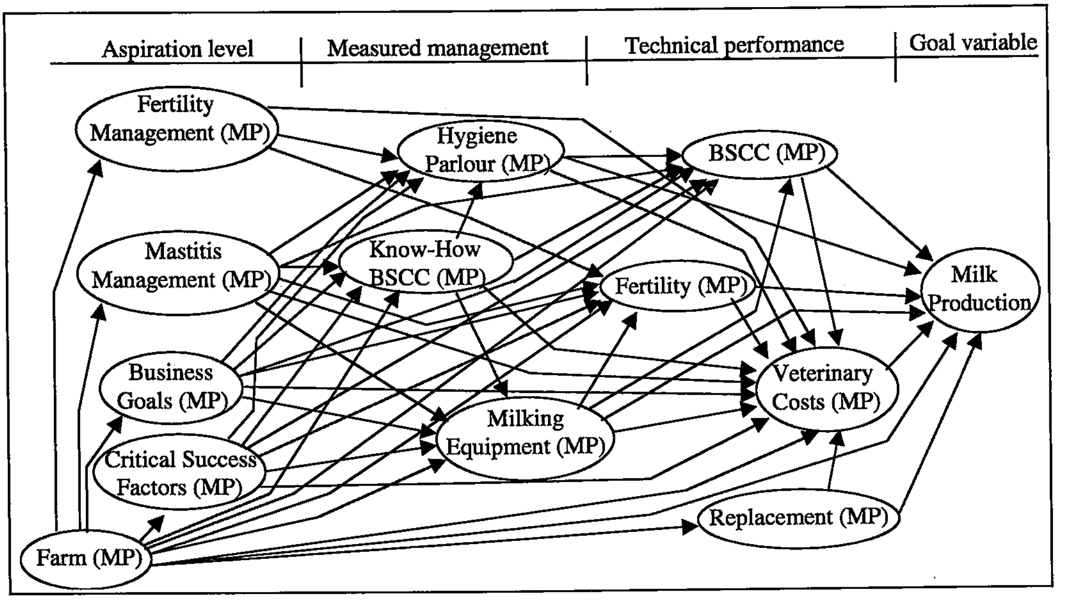

Figure 7.1 Null path-model of the PLS-modelling ast 305-day milk production. LVs are shown in ovals (MP = Milk Production).

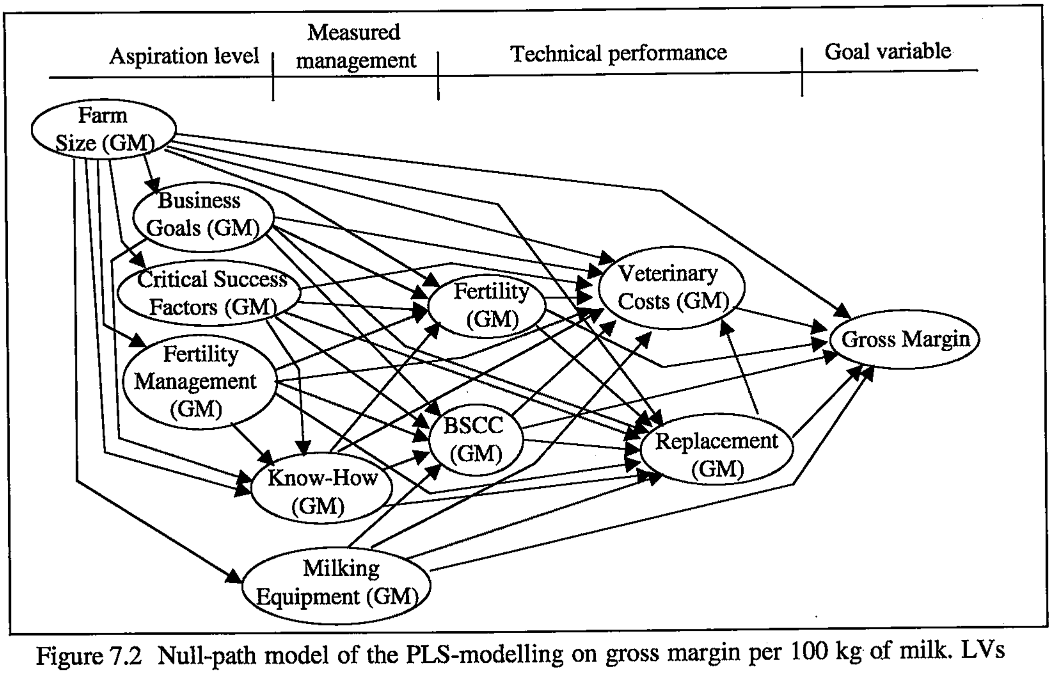

Figure 7.2 Null-path model of the PLS-modelling on gross margin per 100 kg of milk. LVs are shown in ovals (GM = Gross Margin).

7.3 RESULTS

7.3.1 305-day milk production

7.3.1.1 Outcome of the model

Table 7.2 shows the factor loadings for each of the MVs, the R^2 of each LV, and the variance extracted for each of the MVs, as well as the average variance extracted (AVE) for each LV of the 305-day milk production model. The LVs 'Replacement (MP)', 'BSCC (MP)', and 'Veterinary Costs (MP)' were not used by the model because the path coefficients of arrows towards and from these LVs were all $< |.20|$. The factor loadings show that the MV 'AI-classes' is the most important aspect of the LV 'Fertility Management (MP)'. The R^2 in Table 7.2 shows what part of the variance in the LV is explained by other LVs. Five percent of differences in 'Fertility Management (MP)', for instance, could be explained by the LV 'Farm Size' (the only LV that could influence 'Fertility Management (MP); see Figure 7.1) and 54 % of the variance in 305-day milk production could be explained out of the 9 remaining explanatory LVs. Some of the LVs had an AVE bigger than .50. Table 7.2 shows that this was not the case for the explanatory LVs 'Fertility Management (MP)', 'Business Goals (MP)', 'Critical Success Factors (MP)' and 'Fertility (MP)'. Less than 50 % of their variance was explained.

Figure 7.3 shows a graphical representation of the path coefficients of the model. The aspiration level of the farmer had an impact on measured management and technical performance. The LVs 'Mastitis Management (MP)' and 'Fertility Management (MP)' were negatively related to the LV 'Fertility (MP)', which, in turn, was highly negatively related to the 305-day milk production. The LVs 'Hygiene Parlour (MP)', 'Farm Size (MP)' and 'Milking Equipment (MP)' were also directly related to 305-day milk production at farm level. The LV 'Critical Success Factors (MP)' is indirectly positively related with 305-day milk production. This indicated that high-producing farmers had a different attitude towards 305-day milk production per cow than low-producing farmers. Farmers who state that 'no diseases within high-producing herd' was an important critical success factor for their farm, score higher on the LV 'Critical Success Factors (MP)'. This was related to a better score on the LV 'Know-How (MP)', a lower score on the LVs 'Fertility (MP)', and 'Milking Equipment', and, eventually, a higher 305-day milk production.

The significance of the model was determined by the average variance extracted (AVE), the R^2 and the Q^2. The AVEs and the R^2 are given in Table 7.2. Fornell and Larcker (1981) indicated that the AVE should be bigger than the correlations among the LVs (which are not shown here) to fully satisfy the requirements for discriminant validity. The LVs 'Critical Success Factors (MP)' and 'Fertility (MP)' could not completely meet this criterion, whereas the other LVs could. Q^2 is .31, which is bigger than zero, and thus indicates that the model has predictive relevance.

Table 7.2 Measurement part of the PLS-model with 305-day milk production being the goal variable (explanation of variables in Appendix 7.1).

• **Latent Variable** / *Manifest Variable*	Factor loading	Mult. R^2	(Average) Variance Extracted
• **Fertility Management (MP)**		.05	**.40**
Heat per day	*-.22*		*.05*
AI-time	*.75*		*.56*
Ins_early	*-.51*		*.26*
AI-classes	*.86*		*.74*
• **Mastitis Management (MP)**		NA[1]	**.68**
BSCCGoal	*.90*		*.81*
Scorehealth	*.74*		*.55*
• **Business Goals (MP)**		.04	**.33**
Goal_Mastitis	*.43*		*.23*
Goal_NR%	*.55*		*.35*
Goal_Autumn	*-.69*		*.43*
• **Critical Success Factors CSF (MP)**		NA	**.17**
Cow Calendar	*.01*		*.00*
Health Program	*.31*		*.10*
High-Producing	*.59*		*.35*
AI_registered	*-.23*		*.05*
Check Lists	*-.60*		*.36*
• **Know-How BSCC (MP)**		.23	**.91**
Know-HowBSCC	*-.96*		*.92*
Abs(know-how)	*-.94*		*.89*
• **Farm Size (MP)**		NA	**NA[2]**
Total cows	*1.00[3]*		
• **Milking Equipment (MP)**		.45	**.50**
Pulsation	*-.66*		*.43*
Teat lining	*-.75*		*.56*
• **Hygiene Parlour (MP)**		.11	**NA**
Milking Parlour	*1.00*		
• **Fertility (MP)**		.34	**.38**
Non-Return rate	*.73*		*.54*
Inseminations/pregnancy	*-.71*		*.51*
Calving interval(CI)	*-.58*		*.34*
Calving heifers	*.57*		*.33*
Calving age	*.46*		*.16*
• **Milk Production**		.54	**NA**
Avg 305-day	*1.00*		

1) NA = not available; this LV was not predicted by any other LV
2) Not available; only single indicator
3) Constrained to one (single indicator)

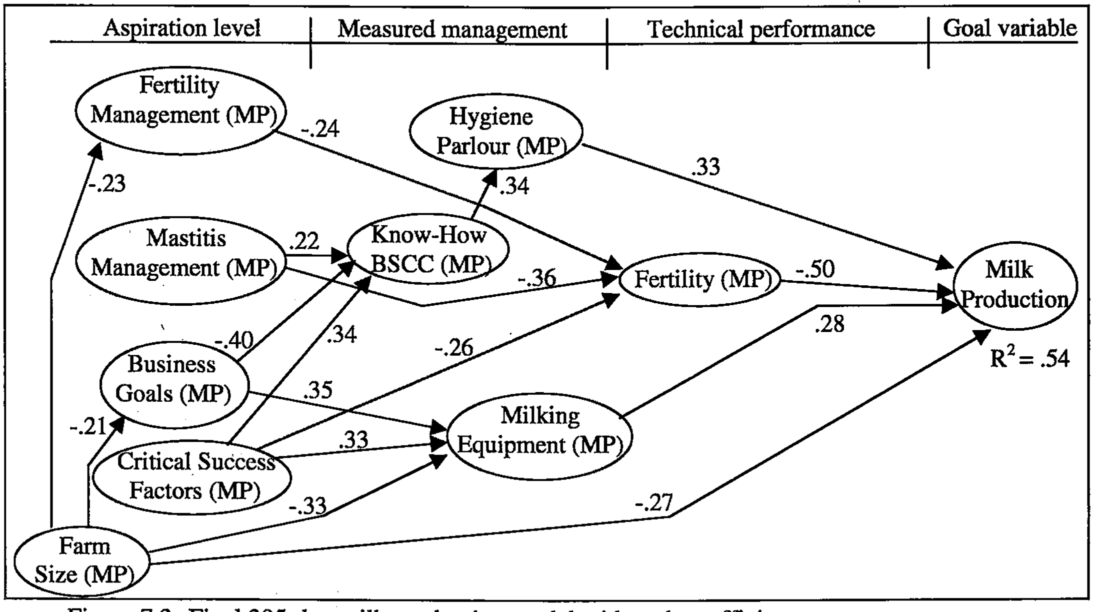

Figure 7.3 Final 305-day milk production model with path coefficients.

7.3.1.2 Mastitis management related to milk production

Appendix 7.1 and Table 7.2 show that mastitis management related to a high 305-day milk production per cow includes (1) a high effort level for BSCC on the farm (MV 'BSCCgoal'), and (2) interest of the farmer in animal health management (MV 'Scorehealth'). All other variables of the mastitis management questionnaire were not related to 305-day milk production. The LV 'Know-How BSCC (MP)' showed that farmers who scored high on the LV 'Mastitis Management (MP)' had a better knowledge of BSCC at their farm. The farmers were asked to indicate whether the BSCC on their farms should fall within the 25 % best farms, or the 25 % second best, etc. The variable Abs(know-how) indicated how big the difference was between the 'guess' of the farmer regarding BSCC and reality, without differentiating between over- and underestimation of the results. A better knowledge was related with a better hygiene which, in turn, was related with a higher 305-day milk production.

Figure 7.3 shows that the LV 'Mastitis Management (MP)' was indirectly positively related with 305-day milk production. Part of the LV 'Mastitis Management (MP)' was the MV 'Scorehealth'. This MV indicated interest of the farmer in animal health management. It was based on four statements regarding health management. When a farmer indicated that he called for a veterinarian rather quickly and that he might treat a cow longer than economically speaking would be optimal, he had a high score on this variable.

7.3.1.3 Fertility management related to milk production

Table 7.2 indicates that fertility management related to a high 305-day milk production per cow includes (1) a relatively long period between calving and the intention to start with insemination (MV 'AI-time'), (2) differentiating between many different animal groups regarding the moment of first insemination (for instance, high-producing cows, heifers, cows in bad condition, etc.) (MV 'AI-classes'), and (3) a more optimal moment of insemination (from a physiological point of view) (MV 'Ins_early'). The MV 'Heat per day', had very low extracted variance, so it did not have predictive relevance. Figure 7.3 shows that this fertility management was directly negatively related to the LV 'Fertility (MP)'. Fertility was expressed in many different parameters. The 3 most important aspects of this LV were the MVs 'Non-Return rate', 'inseminations per pregnancy', and 'CI'. A high score on LV 'Fertility' indicated a good fertility: a high Non-Return rate, a low number of inseminations per pregnancy and a short CI. Surprisingly, the measured number of days between calving and first insemination was not correlated to a 305-day milk production, and therefore not included in the PLS-analysis. So, low-producing farms had the intention to start earlier with inseminations (as shown by the MV 'AI-time'), but in practice they did not start earlier.

The average value of 'AI-time' was 68 days (Appendix 7.1). However, the measured interval from calving to first insemination was 84 days on average. The positive relation between MV 'AI-time' and LV 'Milk Production' indicated that farmers with a high-producing herd stated that the moment of first insemination was after more than 68 days, whereas farmers with a low-producing herd said that it was less than 68 days. So, farmers with a high-producing herd made a better estimate of the situation at their farm (i.e. their 'guess' was closer to 84 days). Besides, the MV 'Ins_early' showed that in high-producing herds the cows were inseminated at a more optimal moment from a physiological point of view, also indicating a better management. This better management was expected to result in a higher Non-Return rate and a lower number of inseminations per pregnancy. In practice, however, the opposite was the case. The LV 'Fertility (MP)' was highly negatively related to 305-day milk production, indicating that high-producing farms had a lower Non-Return rate, needed more inseminations per pregnancy and longer CI (Figure 7.3).

7.3.2 Gross margin

7.3.2.1 Outcome of the model

Table 7.3 shows the results of the PLS-model for gross margin per 100 kg of milk. The R^2 of the LV 'Gross Margin' showed that the remaining explanatory LVs explained 46 % of the differences in gross margin. From three LVs the AVEs were smaller than .50. So, in these cases the unexplained variance was more than 50%. However, all AVEs were bigger than the correlations among the LVs, indicating that the requirements for discriminant validity could fully be satisfied. The Stone-Geisser test showed that the gross margin model has predictive relevance, because Q^2 is .28.

Table 7.3 Measurement part of the PLS-model with gross margin being the goal variable (explanation of variables in Appendix 7.1).

• **Latent Variable** *Manifest Variable*	Factor loading	Mult. R2	(Avg) Variance Extracted
• **Business Goals (GM)**		NA[1]	**.35**
Goaltime	*.55*		.30
Goalvetcosts	*.80*		.65
GoalNR%	*-.33*		.11
• **Critical Success Factors CSF (GM)**		NA	**.47**
Culling	*-.31*		.10
Check_lists	*-.92*		.85
• **Know-How (GM)**		.09	**.71**
Know-How BSCC	*-.92*		.85
Abs(Know-How)	*-.94*		.88
Know-How CI	*-.63*		.40
• **Farm Size (GM)**		NA	**.85**
No_pregnant	*.92*		.85
No of hectares	*.93*		.86
• **Milk Equipment (GM)**		NA	**NA**[2]
Age	*1.00*[3]		
• **Bulk Somatic Cell Count (GM)**		.14	**.96**
Avg BSCC	*.98*		.97
Max BSCC	*.98*		.96
• **Replacement (GM)**		.33	**.67**
Age at culling	*.79*		.63
Young stock per cow	*-.85*		.72
• **Veterinary Costs (GM)**		.32	**.59**
Health control	*.62*		.38
Othercosts	*.89*		.80
• **Fertility (GM)**		.21	**.48**
Calv-ins	*-.64*		.41
Calving_heifers	*-.56*		.32
Drying-off period	*-.84*		.71
• **Gross Margin**		.46	**NA**
Gross margin	*1.00*		

[1] NA = not available; this LV was not predicted by any other LV
[2] Not available; only single indicator
[3] Constrained to one (single indicator)

Figure 7.4 provides the figure of the estimates of the parameters of the gross margin model. The LV 'Gross Margin' was directly related with the production factor 'Farm Size

(GM)'. Besides, a direct relation was found with some LVs that indicate the technical performance: 'Veterinary Costs (GM)', 'Fertility (GM)' and 'Replacement (GM)'. Figure 7.4 shows that bigger farms (i.e. farms with a higher score on the LV 'Farm Size (GM)') had slightly better results. The direct arrow in Figure 7.4 from 'Farm Size (GM)' to 'Gross Margin' shows that there was a direct relation between farm size and gross margin (economies of scale). Besides, the LV 'Farm Size (GM)' was directly positively related with the LVs 'Veterinary Costs (GM)' and 'Know-How (GM)', indicating that bigger farms spent more money on herd health control programs and had a better knowledge. The LV 'Veterinary Costs (GM)' was directly positively related to a 305-day milk production, whereas the LV 'Know-How (GM)' was indirectly positively related to a 305-day milk production. No relationship between the LVs 'Fertility (GM)' and 'Veterinary Costs (GM)' was found, whereas a rather big relation was found in the previous model between fertility and veterinary costs. This was due to differences in set-up of the LV 'Veterinary Costs'. In the current model 'Veterinary Costs (GM)' only included 'health control' and 'other veterinary costs', whereas fertility was found to influence curative costs and costs of visits.

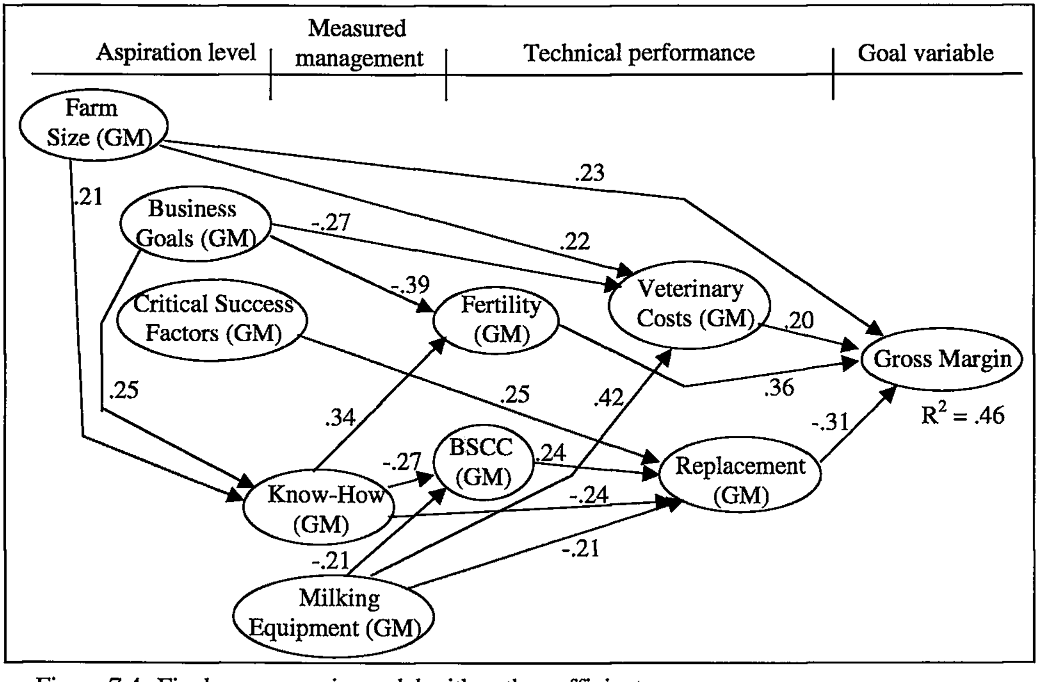

Figure 7.4 Final gross margin model with path coefficients.

7.3.2.2 Mastitis management related to gross margin

Figure 7.2 and Appendix 7.1 show that no LV 'Mastitis Management' was included in the gross margin model. However, some other LVs related to mastitis management did have a relation with gross margin. Figure 7.4 shows that knowledge about BSCC was related with a lower BSCC. A lower BSCC, in turn, was indirectly related with a higher gross margin. The relationship between the LV 'BSCC (GM)' and the LV 'Gross Margin' was not a direct one, but 'flew' via 'Replacement (GM)'. So, farms with a high BSCC culled their cows on average at an older age. Due to that they had to raise less calves for replacement. To get a better understanding of the scale of differences between farms related to the knowledge of the farmer Table 7.4 is included. It shows the gross margin and its underlying aspects, the BSCC and the CI for the 15 farms with a high score on the LV 'Know-How (GM)', compared with the gross margin for 15 farms with a lower score on this LV. Eight farms were not included in this table, because one or more of the underlying MVs were missing. This table underlines that a good knowlegde was positively related to the technical and economic results of the farm.

Table 7.4 Average values of economic parameters (expressed in Dfl. per 100 kg of milk) for 30 farms (8 farms are excluded due to missing values), divided into two groups of each 15 farms based upon the score for the LV 'Know-How (GM)'.

LV 'Know-How (GM)'	Milk price (Dfl./100 kg)	Feed costs (Dfl./100 kg)	Returns cull cows and calves (Dfl./100 kg)	Gross Margin (Dfl./100 kg)	BSCC (cells $*10^3$ /ml)	CI (days)
High	73.63	15.78	8.16	66.74	168	391
Low	72.63	16.56	6.24	63.08	182	394

7.3.2.3 Fertility management related to gross margin

The LV 'Fertility Management (GM)' was not used by the model, because all the path coefficients from this LV to other LVs were smaller than |.20|. So, no influence of fertility management on the gross margin could be determined. However, other aspects related to fertility management did influence the gross margin. Figure 7.4 shows that the LV 'Know-How (GM)', which includes CI, was related to a better fertility. This, in turn, resulted in a higher gross margin. In case of a longer drying-off period (the MV 'Drying-off period') and a longer interval between calving and first insemination (the MV 'Calv-ins'), farms scored lower on the LV 'Fertility' (see Table 7.3). Figure 7.4 shows that in that case the gross margin was lower. The LV 'Replacement (GM)' was directly negatively related with gross margin. The average age of culling was 1985 days (see Appendix 7.1), whereas Van Arendonk (1985) calculated that in case of an average rate of involuntary culling, an average herd life of 42.9 months (1305 days) is optimal. Given that heifers calve on average at an age of 2 years, the optimal age of culling is 2035 days. So, average culling practice seemed to be close to the optimum. Table 7.3 showed that culling too late (i.e. a high score on the MV

'Age at culling') resulted in a high score on the LV 'Replacement'. This resulted in a lower gross margin.

7.4 DISCUSSION

7.4.1 Model results

The analyses showed that mastitis and fertility management and all kinds of related aspects could explain 54 % of differences in a 305-day milk production among 38 farms. The gross margin model explained 46 % of the differences in gross margin. PLS turned out to be a useful tool to analyze complex relationships between a limited number of farms. This way, a path-diagram could be worked out without losing statistical power because of a loss of degrees of freedom. The current study is a cross-sectional study. Due to that, only relations can be determined, not causality. Therefore, the 2 PLS-models that were described can be used to define some hypotheses on relationships, but these hypotheses can only be made plausible; they cannot be proven. Besides, the set-up of the LVs and the path diagram is based upon common knowledge, which is subjective. This way, only relations that were put into the model can be determined.

When the models as to 305-day milk production and gross margin were compared, the Q^2 of the models and the R^2 of the predicted LVs showed that the 305-day milk production model had the most predictive power. So, as expected, the impact of mastitis and fertility management on the technical parameter 305-day milk production was bigger than its impact on the economic parameter gross margin. The LV 'Fertility Management (GM)' disappeared out of the gross margin model and the LV 'Mastitis Management' was not included. It can be that there was really no impact of fertility management on gross margin. However, the data showed that technical results regarding fertility were related to gross margin. Besides, Olds et al. (1979b), Dijkhuizen et al. (1985), and Jalvingh et al. (1993) did find an effect of fertility on economic returns as well. Much literature also suggested an influence of fertility management on fertility results. Cowen et al. (1989), for instance, studied the effect of management on fertility and concluded that a combination of signs of oestrus detection and large herd sizes had a positive association with some measures of reproductive fertility. Rosenberg and Cowen (1990) found that the more extensive the use of records, the larger the average number of days open and the services per conception (indicating lower reproductive efficiency). They did not discuss their unexpected results. Webster et al. (1997) found that the age of the farmer, the use of cow cards, and the number of people that check oestrus influenced fertility at herd level. Numerous studies have emphasized the importance of good management in oestrus detection and postcalving breeding (Barr, 1975; Kelly and Holman 1975). Barr (1975) concluded that dairymen lose twice as many days due to missed heat periods as due to failure to conceive. The finding that high-producing cows show more mild or silent oestrus periods (Morrow et al., 1966) emphasizes that good management is specifically important for high-producing herds. This conclusion is in accordance with the finding in the current study that fertility management seemed slightly better at high-producing farms, but fertility results were worse.

The reason for not finding clear relations between fertility management and fertility might be that the questionnaire on fertility management might not always have given useful and reliable answers. This statement is supported by the findings regarding hygiene. The LV 'Hygiene Parlour (MP)' only included the hygiene in the milking parlour observed in May 1996. Originally, there were other variables related to hygiene in the data set as well. Questions were included on frequency of cleaning of the milking parlour, cleaning of the boxes, cleaning after calving, and shaving of the cows. These variables were also measured on a reasonably continuous scale, but had no correlation with 305-day milk production or gross margin. The correlation between these questions and the observations on milking parlour and milk house ranged between -.38 and .47, with an average of -.04, indicating that farmers which said to do their cleaning very well, did not have cleaner parlours. So, questioning might not be a good way to get insight into hygiene practices. This can be the case for fertility management as well. Farmers know how heat detection should be applied in the farm. However, practice might be slightly different from the know-how. In that case, the outcome is biased by social desirability (Oppenheim, 1992). Other research methodologies (for instance, measurements of time spent on heat detection) have to be applied to get a better insight into the effect of heat detection on fertility and economic results.

Farm selection was based on differences in gross margin and milk production among farms. In the analysis this distinction was abandoned, because differences between the original groups had actually almost disappeared over time; farms had moved towards Dutch average again. Relations between management, gross margin and milk production in the farms under study are not expected to be completely different from average Dutch dairy farmers. Therefore, the hypotheses that have been brought forward in this study are expected to hold for other dairy farmers in the Netherlands as well.

7.4.2 Hypotheses

Our results regarding the relationship between mastitis and fertility management with 305-day milk production, and gross margin can be 'translated' into the following hypotheses:

1. Knowledge of the results of the farm (the BSCC and CI) compared with other farms is positively related with milk production and hygiene and improves the results in these areas (i.e. lower BSCC and CI).
2. Knowledge of BSCC and CI is a general indicator of the farmers' attitude. Farmers with good knowledge in these areas also have better results in other areas, resulting in a higher

milk price, lower feed costs, higher returns from cull cows and calves, and, as a result of all this, higher gross margin.

3. Big farms have better managers. Besides the 'advantage of scale' they have better knowledge, resulting in better economic returns.
4. High milk production is realized by farmers with a 'tight' effort level for BSCC. Besides, these farmers are better aware of what they are actually doing (i.e. deciding) and what is going on at their farm.
5. High milk production is realized by farmers who are interested in animal health management and who are willing to spend money on the veterinarian. They have another attitude towards animal health and production level than farmers with a low-producing herd.
6. Fertility results are worse at high-producing farms. However, fertility management seems to be slightly better at high-producing farms. So, a negative relationship between milk production and fertility (Non-Return rate, inseminations per pregnancy, and CI) might be a source of these fertility differences between farms.

Not much literature is available to support hypotheses 1 to 5, but they are in agreement with the general management theory that it is important to have good knowledge and clear goals (i.e. a 'tight' effort level) (Kay and Edwards, 1994). Both models show the different steps in the decision-making process. Goals and interests are established, information is gathered, eventually resulting in certain technical and economic results. Some literature was found that is in accordance with aspects of hypothesis 1. The influence of management on udder health, the incidence of mastitis, or the level of bulk somatic cell count was studied by Goodger et al. (1988), Goodger et al. (1993), Faye et al. (1997), Barkema et al. (1998), and Ekman (1998). Barkema et al. (1998) studied management practices associated with level of bulk somatic cell count (BSCC). One of the aspects found was that in herds with low BSCC, more attention was paid to hygiene than in herds with higher BSCC. Ekman (1998) also concluded that farms with low BSCC were cleaner.

Hypothesis 6 is in agreement with most of the literature. Olds et al. (1979a), Laben et al. (1982), Hillers et al. (1984), Badinga et al. (1985), Cassell et al. (1992) and Ouweltjes et al. (1996) determined the relationship between fertility and milk production. Nebel and McGilliard (1993) gave a review on literature regarding the interactions of high milk production and reproductive performance. They stated that higher milk production is associated phenotypically and genetically with reduced reproductive performance in lactating cows. Daily managerial decisions should have a considerable impact on reproductive performance. They observed that management inefficiency was not likely to be the entire source of decreased fertility in high-producing herds or cows, however. Laben et al. (1982) indicated that good management might overshadow the influence of production on fertility; effective oestrus detection was mentioned as a probable major factor. They mentioned that high-producing cows are at a delicate balance between normality and metabolic disturbances.

Inadequate energy and mineral imbalance are nutritional factors associated with reduced fertility. It influences the onset of oestrus (Butler et al., 1981; Staples et al., 1990).

7.5 CONCLUSIONS

The current study gave some insight into the effect of management on technical and economic results and showed that some general ideas on management can be stated in practice. PLS turned out to be a useful methodology to analyze this kind of data set. The results suggest that a farmer will get better results when he knows what is going on at his farm. Besides, interest in animal health and willingness to spend time on the animals are important characteristics of farmers who have a high-producing herd. However, a lot of aspects are still unclear. What other knowledge and skills, besides knowledge of BSCC and CI, does a farmer need to get good results? Moreover, not the knowledge itself will give better results, but the decision making might be better. So, it might be interesting to try to measure the quality of the decision making itself. The current study showed that the usefulness of questionnaires on management practices is debatable. During the development of a questionnaire the researcher has to be aware of the problem of social desirability. When the questionnaire is used, it is necessary to combine it with longitudinal observations. These observations can be used to check some of the answers on the questionnaire and get insight into the reliability of the data set.

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Appendix 7.1 Description of manifest variables used in the analyses, and the average value of the variable. 'X' indicates the variable included in this analysis, with MP being the Milk Production model and GM the Gross Margin model.

Latent variable Manifest var.	Description of manifest variable	Avg. Value	PLS-MP	PLS-GM
	GOAL VARIABLES			
Milk Production (from May 1996 till May 1997)				
Avg 305-day	Avg-305 day milk production	8342 kg	X	
Gross Margin				
Gross Margin	Gross Returns – costs of purchased feed / 100 kg of milk	Dfl. 65.10		X
	ASPIRATION LEVEL			
Fertility Management				
Heat per day	Maximum minutes spent per day on heat detection[1)]	56 min.	X	X
Length obs	Maximum minutes heat detection each time	13.4 min		X
AI-time	Days after calving that farmer has planned to start with insemination	68 days	X	
Ins_early	Moment of insemination related to heat detection: 1= optimal (physiological), 3 = suboptimal	1.6	X	
AI-classes	No. of groups farmers distinguish for determining moment of insemination in days after calving[2)]	1.5	X	
Health Management				
BSCCgoal	Effort level bulk somatic cell count (*1000). 1=none, 2= '<400', 3='<250', 4='<200', 5='<150', 6='<100'.	3.7	X	
Scorehealth	Interest of farmer in animal health management on a 1 to 5 scale[3)]	3.4	X	
Business Goals (on a 1 (unimportant) to 5 (very important) scale)				
Goal_Mastitis	Importance of goal 'decrease mastitis'	4.6	X	
Goal_NR%	Importance of goal 'increase non return percentage'	4.1	X	X
Goal_Autumn	Importance of goal 'autumn calving pattern'	3.4	X	
Goal_Time	Importance of goal 'time and attention for herd'	4.0		X
Goal_Vetcost	Importance of goal 'keep veterinary costs low'	4.1		X
Critical Success Factors (CSF) (on a 0 (not mentioned) to 5 (most important) scale)				
Cow Calendar	CSF 'use of cow calendar'	1.0	X	
Health Program	CSF 'involved in herd health control program'	0.6	X	
High-Producing	CSF 'no diseases within high-producing herd'	0.8	X	
AI_registered	CSF 'registration of inseminations'	0.5	X	
Check Lists	CSF 'use of check lists'	0.5	X	X
Culling	CSF 'no culling of animals due to disease'	0.7		X
	MEASURED MANAGEMENT			
Know How				
Know-HowBSCC	Estimate of farmer of bulk somatic cell count (BSCC) at his farm compared to BSCC at other farms[4)]	11.7	X	X
Abs(know-how)	Accuracy of estimate: ABS(Know HowBSCC). So, a low score indicates a good know how	16.2	X	X
Know-HowCI	Estimate of farmer of calving interval at his farm compared to calving interval at other farms[4)]	-4.5		X

Appendix 7.1 (continued)

Latent variable Manifest var.	Description of manifest variable	Avg. Value	PLS-MP	PLS-GM
Milking Equipment				
Pulsation	No. of pulsations per minute	57.6	X	
Teat lining	New teat lining: 1 = each 2000-2500 milkings, 2=2500-3000, 3=3000-3500, 4=3500-4000, 5= >4000.	3.1	X	
Age	Age of milking equipment in years	9		X
Hygiene Parlour (situation in May 1996)				
Milking Parlour	Hygiene of milking parlour: 1=dirty, 4=clean[5)]	2.5	X	
TECHNICAL PERFORMANCE				
Fertility (based on period September 1996 – September 1997)				
Non-Return rate	Non Return rate at 56 days	61.2 %	X	
Ins. /pregnancy	Number of inseminations per pregnancy	1.92	X	
CI	Calving interval of total herd	393 days	X	
Calving heifers	Expected age of calving heifers in days	787 days	X	X
Calving age	Average age of calving in days of all cows in herd	1485 days	X	
Calv-ins	Interval calving – 1st insemination	84.5 days		X
Drying-off period	Avg. drying-off period (in days) of total herd	64 days		X
Bulk Somatic Cell Count (BSCC) (from May 1996 till May 1997 in 10^3 cells/ml)				
Avg. BSCC	Average bulk somatic cell count (BSCC)	179	X	X
Max. BSCC	Maximal BSCC	269	X	X
Replacement (based on period September 1996 till September 1997)				
Age at culling	Average age of culled cows	1985 days		X
Young stock/cow	Young stock (i.e. till first calving) per milking cow	0.92	X	X
Veterinary Costs (per dairy cow from May 1996 till May 1997)				
Curative	Curative veterinary costs	Dfl. 50.33	X	
Visit	Costs of visits (without herd health control program)	Dfl. 18.45	X	
Health control	Costs of herd health control program	Dfl. 5.07		X
Othercosts	Vet costs, not curative, preventive or herd health control program (i.e. blood samples for export)	Dfl. 2.75		X
Total	Total veterinary costs[6)]	Dfl. 132.21	X	
PRODUCTION FACTOR				
Farm Size				
Total cows	Total number of dairy cows at the farm (October 1996)	67 cows	X	
No_pregnant	Number of pregnant cows (September 13th 1997)	29 cows		X
No of hectares	Size of the farm in hectares (October 1996)	41.2 ha		X

1) This is based on questions, not measurements: (maximum minutes each time) * (maximum number of times per day)

2) Groups can be based on number of lactation, production of the cow, condition of the cow, etc.

3) Farmer was asked to indicate the extent to which he agreed or disagreed with 4 statements on interest in animal health management. 'Scorehealth' is an average of these statements. A 1 indicates not much interest, whereas a 5 indicates high interest.

4) Value between –100 (total underestimation of own results, indicating that farmer is doing better (i.e. lower BSCC or CI) than he assumes) and 100 (total overestimation of own results; he is doing worse)

5) Judged by researcher during regular farm visit (based on scoring manual Barkema et al., 1998).

6) Total veterinary costs = curative + visit + healthcontrol + othercosts + costs for treatment and prevention of mastitis + preventive costs. The last 2 aspects are not included separately, because they were not related to milk yield or gross margin.

Chapter 8

OVERALL ANALYSIS AND GENERAL DISCUSSION

8.1 INTRODUCTION

The major objective of the research project was to determine those management capacities, including personal characteristics, that a dairy farmer needs in choosing the appropriate milk production level to optimize his or her economic performance. First, the relationships between technical and economic results were determined (Chapter 2). Chapter 3 defines how a farmers' management capacity can be defined and measured. Management capacities influence the decision-making process. This process influences the biological processes at the farm, which in turn determine the farm results. The influence of experience and/or age of the farmer is not straightforward. The influences of other personal aspects have rarely been studied. No study was found that includes all aspects of management capacity (biography, drives and motivations, abilities and capabilities, planning, implementation and control). In Chapter 3 it is stated that longitudinal data are necessary to follow different steps in the decision-making process. Although this might be true in many cases, practical experience in the field showed that it is hard to get a good insight into the different steps of the decision-making process of a farmer. Farmers are not always aware of the fact that they make a certain decision, and the different steps of the decision-making process (as defined by Kay and Edwards, 1994) are not always clearly recognizable. This makes it complicated to gather data on these different aspects.

The knowledge that was gained in Chapters 2 and 3 was used to set up an explorative field study. Chapter 2 shows, for instance, the large influence of the amount of milk quota per ha on gross margin. So, for the field study, only farms with approximately the same quota per ha were selected. Figure 3.1 was used as a checklist to determine whether all aspects of management were included in the field study. Personal aspects of the manager (for instance, goals, know-how, education), as well as the decision-making process (by questionnaires), technical and biological processes (for instance, grassland calendar, milk production data), and farm results were measured. Chapter 4 shows that the repeatability of milk production and economic data at farm level was sufficient to justify the use of one year of data. In Chapter 5 Principal Components Regression and Partial Least Squares (PLS) are compared and evaluated as to their usefulness for the current study. PLS turned out to be a useful methodology for the situation with a small number of cases and complex relations between the variables, as was the case in our data set. Chapters 5, 6 and 7 show the hypotheses that could be derived from the PLS-analyses of the dataset. Different models were tested to explain milk production and gross margin. Major results concerning relationships between management and farm performance were discussed in these chapters. Hypotheses were brought forward for the usefulness of knowledge of the farm, as a general indicator of animal health management, and the different aspects of pasture management that influence gross margin and milk production. Results brought forward are briefly summarized here. In the area of breeding management and 305-day milk production (Chapter 5) these include:

- Milk production per cow is positively related to the breeding value for production and conformation.

In the area of pasture and feeding management and feed costs (Chapter 6):

- A high percentage of pasture that cannot be grazed by the cows is related to an increase in feed costs;
- A high percentage of grazings lasting longer than 4 days is related to higher feed costs;
- Mistakes in paddock set-up cannot be compensated for by exact planning;
- Farmers who have not organized their grazing management well, also have worse results as to their silage management;

In the area of pasture and feeding management and a 305-day milk production (Chapter 6):

- A high milk production per cow is realized on farms with too low a number of growing days for cutting, resulting in high quality, but low quantity of grass.

In the area of mastitis and fertility management and a 305-day milk production (Chapter 7):

- Knowledge of the results of the farm compared with other farms is positively related to milk production per cow and hygiene of the milking parlour and to better results in these areas;
- High milk production per cow is realized by farmers with a 'tight' effort level for bulk somatic cell count (BSCC);
- High milk production per cow is realized by farmers who are interested in animal health management and who are willing to spend money on the veterinarian;
- Fertility results are worse at high-producing farms. However, fertility management looks slightly better at high-producing farms.

In the area of mastitis and fertility management and gross margin (Chapter 7):

- Knowledge of BSCC and calving interval (CI) is a general indicator of the attitude of the farmer. Farmers with good results in these areas also have better results in other areas, resulting in a higher milk price, lower feed costs, higher returns from cull cows and calves, and, as a result of all this, a higher gross margin;
- Large farms have better managers. Besides positive scale effects they have more know-how, resulting in better economic returns.

8.2 INTEGRATED ANALYSIS: AN OVERALL MODEL

The results of the individual models were used as a starting point to achieve the main research objective, which was to determine those management capacities that a dairy farmer needs in choosing the appropriate milk production level to optimize his or her economic performance. One possibility of PLS that was not used in the previous chapters is that more than one Y-variable can be included into the same model (Wold, 1985). To integrate different areas of management and the two goal variables (milk production and gross margin) and to study the above-mentioned relationships simultaneously, an overall model (including breeding management, pasture management, and feeding management as well as animal health and fertility management, and gross margin as well as milk production) was constructed. Details on the statistical technique PLS are given in paragraph 5.2.3. In the overall model, a Latent Variable (LV) which included a 305-day milk production as well as gross margin per 100 kg of milk was used as goal-LV. This overall model will now be discussed and the results compared with the separate models. Finally, these overall results will be compared with the outcome of the literature review in Chapter 3, aimed at exploring the management characteristics that are necessary for an optimal combination of milk production and gross margin.

In order to limit loss of statistical power in the overall PLS-model as much as possible, some extra criteria were used to make a selection of variables:

- Variables needed to have a logical, straightforward relation with 'management';
- Variables were not allowed to have a direct mathematical relation with one of the goal variables;
- Variables as were described in Chapter 5, 6 or 7, specifically related to feeding, pasture, mastitis or fertility, needed to be included in one of the previous models, with at least 10 % of the variance extracted;
- Some variables related to general management were added.

Eventually 87 variables were found suitable to be used in the overall PLS-model, while 32 variables could not satisfy these criteria. In general, the same LVs were constructed as was done in the five separate models discussed in Chapters 5, 6 and 7. In this way, 27 explaining LVs and 1 goal-LV were formed. The 2 variables included in the goal-LV, 305-day milk production and gross margin per 100 kg of milk, were positively related to each other. Due to that, the loading of these variables on the goal-LV had necessarily the same sign; they both had a positive factor loading on the goal-LV. Because of this same sign, the model was only capable to show variables that were related to a high milk production AND a high gross margin and, related to that, variables related to a low milk production AND a low gross margin. This overall model was compared with the five separate models discussed in Chapters 5, 6 and 7. The results are shown in Figure 8.1. In the centre of the figure, all 38 farms included in the study were plotted. The outer part of the figure shows the variables that are related to the goal variables. The variables were placed in a 2-dimensional space, dependent on their relation with a 305-day milk production (X-axis) and gross margin per 100 kg of milk (Y-axis). The plotting of the farms showed that there was no clear grouping of farms; they are distributed all over the graph. So, it cannot be concluded that there were different groups of farms with each their own very specific characteristics. Each farmer had his/her own characteristics, but the variables indicate that some characteristics were more common in a certain part of the plot than others.

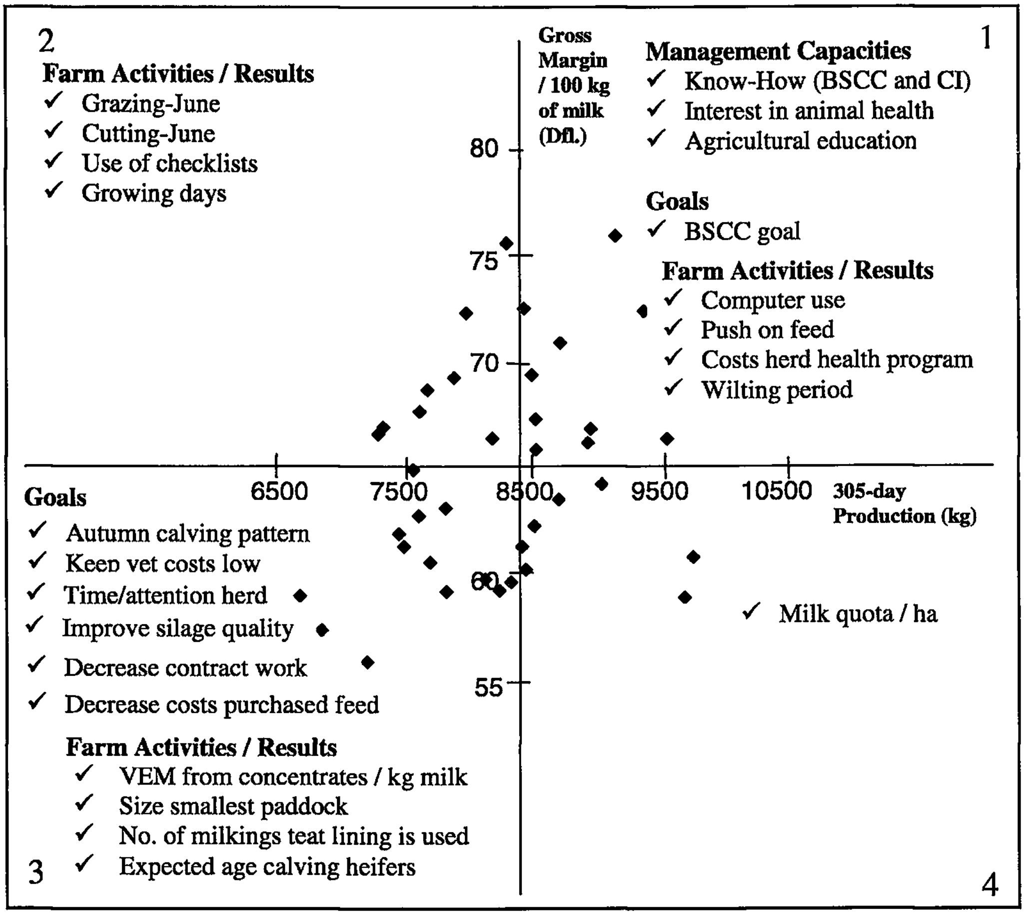

Figure 8.1 Plot of 38 farms based on a 305-day milk production and gross margin per 100 kg of milk and mapping of management characteristics and technical variables with regard to their relation with these variables.

Relationships that came up in the overall analysis could easily be put in the figure. Due tot the positive loadings of the 2 goal variables on the goal-LV, only variables that belonged in Quadrant 1 (high / high) or in Quadrant 3 (low / low) could be determined. Some variables, however, did not come out of the overall model because they were only related to gross margin or to a 305-day milk production. Some variables had a positive relation with one of the goal variables and a negative relation with the other goal variable (this could be concluded from a comparison between the gross margin model and the milk production model). In that case the variable was placed in Quadrant 2 (low production / high gross margin) or 4 (high production / low gross margin). The origin of Figure 8.1 reflects a farm with average 305-day milk production and average gross margin per 100 kg of milk of the 38 dairy farms. The relevant variables, given per quadrant, will be explained in the next sections.

8.2.1 First Quadrant: high gross margin and high milk production

Figure 8.1 shows that the farmers' management capacities (i.e. personal characteristics and skills, see Chapter 3) seemed to play a key role in the situation where gross margin, as well as milk production, was relatively high. Farmers with the following management capacities realized this situation: a good know-how of performance of the animals (i.e. correctness of the estimates of the farmers regarding BSCC and CI at their farms), a high interest in animal health management, and an adequate agricultural education. To see whether these variables are general indicators of 'good management', the correlation with other aspects was determined. The best estimation of the BSCC was given by older (i.e. more experienced) managers with hygienic, large farms with a low BSCC, who made considerable use of computers.

A second category in Figure 8.1 is 'goals'. Quadrant 1 farmers have a 'tight' goal for the BSCC at their farms (i.e. they want to realize a low BSCC). Farmers with a 'tight' effort level for BSCC were the older managers, had a better know-how of the BSCC at their farm, and a high interest in animal health management. Besides that, they scored higher on hygiene of the milking parlour as well. These farmers seemed to look critically at their own results and they were willing to increase the results of their farm by keeping track of what was going on at the farm.

It can be concluded that a good know-how of and having a tight effort level for the BSCC can be seen as general indicators of good management. Table 7.4 (Chapter 7) showed that farmers with a good score on the LV 'Know-how' realized a better milk price, lower feed costs, and higher returns from cull cows and calves. This is in agreement with the finding here that farmers who had a good know-how, scored better on other management variables as well. This resulted in better economic results in each area of dairy farming.

The level of agricultural education, also mentioned in Figure 8.1 as management capacity of a Quadrant 1 farmer, was also positively related to milk production and gross margin. This is in agreement with the findings from literature (Chapter 3) that education has a positive influence on farm results. Education was, however, hardly related to other management variables. This suggests that it is not a general indicator of good management.

Overall it can be concluded that know-how, about general aspects and about one's own farm, is important. Chapter 3 showed that a slightly positive effect of know-how on farm results was also found in the literature. Know-how in general can be gained by education or by experience (i.e. age of the farmer). Age of the farmer was related to management aspects from Quadrant 1 in Figure 8.1, but was not included in the models themselves because no direct correlation was found between milk production nor between gross margin. The literature review in Chapter 3 showed the same dualism. Some studies found a positive effect, whereas others did not find any effect or even any negative effect of age and/or experience on farm results. This might be a result of the range of ages that was included in the different studies. Until a certain age, results might increase due to an increase in experience. However, at a certain age, farmers have much experience and their increasing age might result in a worse physical condition. At that age, a negative relation between age and results can be expected.

Besides know-how, farmers have to be motivated to try to increase the results of the farm. They can use computers as a source of information, have tight effort levels, make use of the knowledge of the veterinarian, etc. When all these aspects are taken care of, the farmer is likely to be a 'Quadrant 1 farmer'. It is interesting to see that having a tight effort level for BSCC seemed to be a general indicator of good management, because it is in fact a very specific management tool on the dairy farm. In the literature it has not been discussed before as a more general management tool. The farmers in the current study were all willing to participate in this study, so there might be some self-selection bias, resulting in lower differences between farmers than would be the case in a totally random selection.

The last cluster of variables in Quadrant 1 is the actual farm activities and results. One of the activities mentioned here is 'Computer use'. Computer use was determined by counting the number of activities that was done with the computer, for instance, bookkeeping, management information, supply of concentrates, information on milk production per cow from the NRS, and feeding advice. It is also a general indicator of good management, related to hygiene of the milking parlour, the BSCC, know-how, and the amount of money that was spent on a herd health program. Computer use was also slightly positively related to farm size. Large farms made more use of computers than small ones. Farm size was also included in the PLS-analysis, so the relation between computer use and the goal-LV was corrected for this relation with farm size.

Farmers who obtained a high milk production and a high gross margin tended to push on the feed towards the cows more often than farmers who had worse results. Besides, the wilting period was shorter on the Quadrant 1 farms. Involvement in a herd health program (expressed by the costs per cow per year spent on a herd health program) was related to gross margin (correlation is .29) and also slightly to milk production (correlation is .18). The set-up of the field study was a cross-sectional study. This implicates that only relationships can be determined, not causality (Thrusfield, 1995). It is not clear whether involvement in a herd health program resulted in higher gross margin and a higher milk production or whether farmers with a high milk production and a high gross margin were more willing to participate in such a program. To get a better insight into these relations, correlations between the costs of a herd health program and other management variables were determined. Costs of a herd health program were higher on farms with a farmer who made use of computers on a regular basis, with a high score on hygiene of the milking parlour, and with interest in animal health management. So, there is a relation between involvement in a herd health program and interest in animal health management. It could be expected that these farmers were willing to take actions to improve results in this area. Due to this relation it is difficult to differentiate between the effect of the herd health program on milk production and gross margin and the effect of management as such.

8.2.2 Third Quadrant: low gross margin and low milk production

Aspects in Quadrant 3 were related to a low gross margin and a low milk production. In this quadrant the same distinction was made between management capacities, goals and actual farm activities and results as was done for Quadrant 1. However, no management capacities were defined that fit in this quadrant. This quadrant is the counterpart of Quadrant 1, indicating that the farmers in Quadrant 3 could be characterized by the fact that they did NOT have the management capacities mentioned in Quadrant 1, and vice versa.

Quadrant 3 shows a list of goals that were mentioned by these farmers to be important for their farm. Each farmer was asked to indicate on a list of 46 goals whether each individual goal was important or not (on a 1 to 5 scale). The list of goals in Quadrant 3 shows that farmers in this situation were aware of the fact that they had to improve their situation. They indeed had to decrease the costs of purchased feed to get better economic results. Another goal was 'time and attention for the herd' (Figure 8.1). The figure shows, however, that Quadrant 1 farmers spent more time on their animals than Quadrant 3 farmers did. Another important goal was to produce better silage quality. It turned out that farmers with worse silage quality put more emphasis on this goal. In 8.2.1 it is discussed that Quadrant 1 farmers had a good know-how of certain aspects of their farm. The results here show that Quadrant 3 farmers were aware of some weak points at their farms as well. Unfortunately, the current data cannot be used to determine whether the farmers in Quadrant 3 were only aware of the situation or whether they were working on it as well. Therefore, farm results over a couple of years are necessary. Then it can be seen whether these farmers really have achieved their goals or not. Farmers in Quadrant 3 also had a low agricultural education, and did not use the computer that often.

Quadrant 3 also shows variables in the category 'farm activities and results'. The variable 'VEM from concentrates / kg milk' showed that at these farms the use of concentrates per kg of milk was high, resulting in high feed costs. The variable 'size smallest paddock' can also be found in Quadrant 3. This indicates that farms with paddocks that were too large, had worse results. This was highly related to the percentage of grazings that last longer than 4 days. It stresses the importance of a correct set-up of the paddock, as discussed in Chapter 6. The variable 'number of milkings teat lining is used' shows the importance of replacing the teat lining on a regular basis. The variable 'expected age of calving heifers' was not used by the total model, but the variable was included in the gross margin as well as in the milk production model. If the expected age of calving heifers was high, gross margin and milk production turned out to be low.

8.2.3 Second Quadrant: high gross margin and low milk production

Quadrant 2 shows variables that were related to a high gross margin and a low milk production. No variables could be found that fit in the category 'management capacities' nor in 'goals'. Some 'farm activities' were found here that are related to pasture management. Correlations between different pasture management aspects were relatively low, so in this case it was harder to talk about 'good pasture management' in general than was the case for the variables in Quadrant 1. The number of growing days for grazing and cutting in the period May 20th till June 20th emerged as important factors in the second quadrant (Figure 8.1). The relationship between these variables and milk production and gross margin was discussed in Chapter 6. More growing days were related to a lower milk production. The relation with gross margin is non-linear, but an economically optimal number of growing days could be determined. Therefore, this variable is put in Quadrant 2. Use of checklists was positively related to gross margin and negatively to milk production and was therefore assigned to this quadrant as well.

8.2.4 Fourth Quadrant: low gross margin and high milk production

Not many variables could be determined that belonged in the fourth quadrant. Milk quota per ha was the only 'clear' one (Figure 8.1). If the intensity of a farm was high, gross margin was lower, because the farmer had to buy more feed, and the milk production was higher, because that would decrease the number of cows per ha.

8.2.5 Relations with one of the goal variables

Several variables discussed in the previous paragraphs are animal health variables. This is due to the fact that these animal health variables were clearly related to milk production and to gross margin. In Chapter 6 it was shown that pasture management is also important for a high gross margin. However, the relation with milk production was less clear for these pasture management variables. Therefore, most of these variables were not included in Figure 8.1. However, these factors as such form useful tools to improve economic farm results.

The percentage of grazings lasting longer than 4 days was related to gross margin. This variable turned out to be a good general indicator of the quality of pasture management at the farm, as was discussed in paragraph 6.3.1.3. If the percentage of grazings that last longer than 4 days was small, the wilting period was short (correlation is .31), the farmer had a good agricultural education (correlation is -.28) and used the computer for different aspects of the farm (correlation is -.33). The results showed that focusing on the number of growing days and the amount of grazings that last longer than 4 days is a way to maximize gross margin for farmers who do not meet the characteristics of a farmer as mentioned in Quadrant 1. These farmers should not concentrate on increasing milk production. They had better focus on pasture management and a correct set-up of the paddocks and try to increase the gross margin in this way.

Different variables were found that were related to production but not clearly to gross margin. These variables were mostly feeding variables. High-producing farms had on average more expensive concentrates, fed more concentrates per cow per day and had a relatively high percentage of land cropped with corn.

8.2.6 Conclusions of the overall model

Many variables that were measured in the field have not been mentioned at all until now, because no relation could be found with gross margin or milk production. Some general measurements of 'quality of planning' and 'quality of control' are examples of variables that did not show any relation with the goal variables. The outcome in the current study showed that more questions specifically related to dairy farm management were necessary to be able to distinguish between the quality of planning and control of dairy farm management. General measurements did not distinguish sufficiently. The current results suggested that the attitude and personality of the farmer had their influence on many aspects of the farm. This is supported by findings of, for instance, Ekman (1998) who described that personal traits are related to the BSCC of the farms, Barkema (1998) who studied the relation between management style and BSCC, and Beaudeau et al. (1996) who described relations between culling criteria and personal characteristics.

Overall it can be concluded that animal health management was positively related to gross margin and milk production level. Pasture management had the largest relation with gross margin, whereas feeding and breeding management had a major relation with milk production level. Farm size was a general positive factor for gross margin. Intensity (milk quota per ha) had a positive relation with production level, but related negatively to gross margin.

8.3 IMPACT OF CURRENT STUDY

8.3.1 Gains of current study

Most of the research questions as described in Chapter 1 could be answered in the current study. In Chapter 2 relationships between technical parameters and economic and environmental effects were determined. The field study was set up later, and made it possible to determine how management of the farmer was related to these parameters. In this study more quantified data and relations were determined on pasture management and the technical results in this area. Until now, no quantitative data in the area of pasture management have been available. A limitation of the current study is the use of gross margin (gross returns minus costs of purchased feed) per 100 kg of milk as an indicator of economic farm performance. The relation between management, milk production and other costs was not studied.

Comparable research for arable farming has been done by Zachariasse (1974). He focused more on technical data and measurements than was done in the current research, where fewer technical data, but more data were collected by questionnaires. Zachariasse (1974) concluded that differences in yield between farms originate from the period in which a farmer has a large influence. So, a great deal of the variance in yield per hectare could be attributed to differences in management capacity. The current study also showed a big influence of management capacity on farm results. However, in the current study this finding has mostly emanated from data on the management capacity itself, instead of focusing on technical results.

A major difference between the 'style of farming' concept of Van der Ploeg (1994) and the current study is the way the management capacity is determined. A typical characteristic of the style of farming concept of Van der Ploeg is that it entails self-classification of farmers. In the current study, farmers were classified as to aspects that were measured or determined by the researcher. It might be interesting to ask the 38 farmers to classify themselves with this 'style of farming' concept and to compare this self-classification with the management capacity as was defined in the current study.

With the current study, insight was gained into the importance of characteristics of the farmer for farm results. Knowledge about the importance of different management aspects on gross margin and a 305-day milk production was expanded (see Figure 8.1). Unfortunately, the relations between management and mineral losses per ha could not be determined because this model had no predictive power (see Chapter 6). Therefore, mineral losses are not part of this general discussion. The results of Chapter 2 indirectly show, however, that management has an influence on mineral losses. There it was found, for instance, that the number of youngstock, the milk production per cow and the amount of concentrates were related to nitrogen losses per ha. These variables, in turn, are the result of decision making of the farmer. However, we were not able to appoint and quantify what decision-making aspects determine these variables.

A stratified sample of farms was selected for the study. This stratification was abandoned in the analyses. Due to this stratification, point estimates would be less accurate. However, the goal of the study was to define hypotheses. Less emphasis was put on the exact point estimates. The hypotheses are expected to be applicable to a broader scope of Dutch dairy farms, because relations between management, gross margin and milk production are expected not to be completely different among Dutch dairy farms.

The study showed (again) that management is hard to measure. For instance, it cannot be concluded that only one or two specific variables have to be measured to have a complete insight into the decision-making capacity of the farmer. Different farmers have different interests and these differences partly determine what the best strategy is for that farmer to obtain good results. Different stages of decision making (planning, implementation and control) turned out to be hard to separate. On one and the same day, a farmer has to plan, to implement and to control as to different aspects of the farm. It turned out to be complicated to get a detailed insight into these different steps.

8.3.2 Recommendations and discussion

More years of data

Chapter 4 showed that repeatability of economic data over time is limited, but significantly different from zero. It could be concluded that milk production data over 1 yr is a reliable indicator for the average farm production. However, gross margin fluctuated considerably over time. This variation resulted in the current study in a shift of farms from one quadrant (as defined in Figure 8.1) to another between years. Therefore, it is preferred to base economic research on data over more than 1 year. The repeatability is an indicator of what part of the variance in this variable is due to differences in 'stable' (i.e. constant over years within a farm) parameters between farms. A repeatability bigger than zero indicates that analyses of 1 year of data are useful, because part of the differences is stable over time. When economic results and milk production level would be totally dependent on these stable parameters, repeatability would be 100 %. A smaller repeatability indicates that farm results are also dependent on 'unstable' parameters. These parameters can be changes in weather, market prices, etc. McGilliard et al. (1990) included year-effect in models to explain different financial variables. They found that years accounted for 18 to 37 % of the variation in milk receipts, total receipts, total expenses, and other expenses per cow. The year-effect was smaller than 15 % for 10 other financial variables. In Chapter 4 the coefficient of concordance was calculated. A coefficient of zero indicates that the ranking of farms would be totally random over time, whereas a coefficient of 1 indicates that ranking would be the same every year. The coefficient of concordance for 4 years of economic data varied between .55 and .72. If data were available on more years in the current study, the year-effect could be determined. A certain management aspect might be of different importance for the economic results in different years, but it is very unlikely that relationships would be totally the opposite. The current data set could be extended to check this statement. Therefore, it is necessary to gather data on gross margin of the 38 farms in other years. Besides that, an interview with each farmer would be necessary to determine whether there have been changes in farm set-up and farm management over this period of time (regarding farm size, total amount of milk quota, change of manager of the farm, etc.). If almost the same results were found, it could be made plausible that the management parameters are not much influenced by year-effects.

In Chapters 5, 6 and 7 all kinds of effects were determined. Because only data of 1 year were available, it is impossible to determine whether these effects are stable over time. In case more years of data are available, a differentiation can be made between variables that have the same effect every year, and variables that are influenced by a year-effect. Due to, for instance, the weather, a specific aspect can be more or less important in one specific year than it would be in other years. A clear example of this is the presence of a sprinkler irrigation installation. In a very wet year this will not influence the results at all, whereas in a very dry year this equipment can determine the results to a great extent.

Selection of farms

Despite the concerns at the start of the study with respect to the relatively low number of farms compared with the number of variables, we trust that the number of farms was large enough to achieve the goal of the study. It is hard to give a general answer to the question how many cases are necessary for a certain study. The number of cases is dependent on the goal of the study. If the researcher is interested in very small differences, he or she will need more cases than in the situation where the researcher is only interested in main effects and tendencies (Mead and Curnow, 1986). The current study was an explorative study. Therefore, the major interest was to find out which aspects might influence milk production and gross margin. Quantification of the relations between parameters got less emphasis in the study. For that purpose, more farms would be necessary. For all models, the Q^2 was calculated. This parameter is calculated by splitting the data set into an estimation set and a confirmation set. Almost all the models, except for the model on nitrogen losses, had a $Q^2 > 0$, indicating predictive power. So, the current sample size seemed large enough to achieve the goal of the study. We believe that more will be gained in future research by extending the study over time (i.e. 3 or more years in a row, as discussed in one of the previous paragraphs) instead of increasing the number of farms.

At the start of the field study, farms were selected from the extremes of gross margin and milk production per cow. Given limited budget and time, this seemed to be a useful methodology to maximize differences between farms and to define hypotheses. As was said before, however, if the goal of the study is to quantify the relations between variables more precisely, a random sample will be more appropriate.

Methodologies

For the current type of study, Partial Least Squares was a useful tool that can be used in future research as well. In Chapter 5 the advantages and disadvantages of Principal

Component Regression (PCA) and PLS were discussed. Especially in the situation where the number of variables is large compared with the number of cases and the relationships under study are complex, PLS seems useful. Other methodologies, like regression analysis, face the problem that the limited number of cases reduces the degrees of freedom drastically. Due to that, these models will have no statistical power.

Attention needs to be paid to the methodology to quantify 'management'. In the current study different methodologies were used to determine the same management variable. Correlations between these findings were low. This can partly be due to the way the variables were formulated and coded. Goals were, for instance, coded on a scale from 1 (unimportant) to 5 (important). Linearity of this scaling was assumed, but is debatable. It is unclear whether a change on the scale from 1 to 2 implicates the same difference in importance as a change from 4 to 5. Besides that, it is unclear whether a scale from 1 to 5 is appropriate or whether, for instance, a scale from 1 to 10 should be preferred. More research on this aspect would be a useful contribution to management research. Another reason of the low correlation between different methodologies to quantify management might be that questioning is not a good way to get insight into certain management practices. Farmers might have given socially desirable answers (Oppenheim, 1992), and the answers might be influenced by the interviewer (Noordhuizen et al., 1997). Schukken et al. (1989) mentioned that some management procedures on dairy farms vary from day to day. So, data on these traits will show inconsistencies. They found that the mean percentage of error in management questions was 14.2 %. Scholl et al. (1994) advised to avoid formulating individual questions that are intended to ascertain several factors at once. Besides, they stated that it might be advantageous to formulate more detailed polytomous questions and then to combine the categories to obtain the desired dichotomies. Use of other methodologies might also be a way to get more reliable data. Examples of data that cannot be influenced by social desirability are the questions about know-how. The farmer could not pretend a better knowledge in these cases. However, this methodology almost looks like a 'test'. Because of the dependency upon the willingness of farmers to participate in the study, the researcher has to find an optimal combination of friendly and useful methodologies.

8.4 MAIN CONCLUSIONS

Main conclusions focus on the objectives of the study, and the methodologies used. Conclusions regarding the objectives of the study:

- To achieve a high milk production level and a high gross margin per kg of milk, the characteristics of the farmer were a central element of 'the key to success'. A good know-how of the results at the farm and a preference for animal health management compared with other management areas are of major importance. Due to their interest, these farmers were also more often involved in a herd health program. This implies that a high production per cow is not a good economic option for each farmer. Before farmers decide to aim for a high milk production level, they have to work out for themselves whether or not they are able to give the herd the attention and interest that is needed.

- Farmers who prefer pasture management above other management areas, and who want to improve economic results, should maintain their focus on optimizing the use of pasture instead of shifting too much to maximizing milk production per cow.
- A correct set-up of the paddocks, based on number of cows and a grazing system of 4 days, is a first requirement for good pasture management for Dutch conditions. The next step is correct planning.
- Knowledge of herd management parameters (bulk somatic cell count and calving interval) are general indicators of good management. Farmers with good knowledge in these fields score better in these and other areas, resulting in better economic returns.
- An adequate agricultural education of the farmer can help to improve farm results. However, it is no key to success.

The following conclusions can be drawn related to the methodologies used:

- Partial Least Squares is a useful methodology to be used in empirical research with a relatively small number of cases and complex relationships among the variables.
- Questionnaires combined with longitudinal observations can be a useful technique to check for social desirability in answering questions. This way, insight is gained into the quality of the data set.
- Longitudinal observations are particularly useful to study technical processes at farm level. Pasture use, for instance, can only be evaluated when data are gathered during the entire growing season.
- Repeatability of economic data showed that collecting data over more years is preferable. That way, insight is gained into relations that are stable over time, and relations that are influenced by a year-effect.

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Summary

Introduction

Dairy farms in a similar situation can have quite different economic results. These differences in economic performance are expected to be dependent on differences in management capacity of the farmer next to differences in production conditions. Milk production per cow is often seen as an important management tool to maximize economic returns and to minimize mineral losses. Feed costs per 100 kg of milk will go down and due to that mineral losses will decrease. However, it is not clear whether this is a useful tool for each farmer or whether certain management capacities are necessary to be able to combine a high milk production level with good economic results. Overall objective of the current research project was to determine what management and personal characteristics a dairy farmer needs to achieve a certain milk production level and good economic results. The research was mainly focused on operational decisions that have to be made in this respect on a day-by-day basis. The economic results were measured by the gross returns minus the feed costs of purchased feed per 100 kg of milk (the gross margin).

Technical relationships

Decision making of the farmer will influence the technical results of a farm, which in turn influence economic results. A first step to answer the research question was to find out how technical results influenced economic results. This has been described in Chapter 2. Path analysis was used to model multivariate relations between milk production, reproductive parameters, cow replacement, milk contents, farm characteristics, gross margin and N-surplus. Data from an economic information system and data from the Royal Dutch Cattle Syndicate (NRS) were available of 478 farms. Two models were constructed: one to analyse gross margin per 100 kg of milk, and one to analyse N-surplus per ha.

The gross margin model showed that at farm level a 305-day milk production per cow was related to reproductive parameters, the replacement rate and gross margin per 100 kg of milk. Besides milk production, gross margin is highly dependent on quota per ha, concentrates per cow per year, percentage of protein in milk and amount of silage bought per ha. Number of inseminations per pregnancy, births per cow per year, youngstock per ha and the replacement rate had small, but significant influences on gross margin.

N-surplus per ha was found to be highly dependent on milk quota per ha and the amount of concentrates per cow per year. Weaker, but still significant relationships were found with replacement rate, youngstock per ha and milk production per cow. So, gross margin and N-surplus are dependent on several technical variables. These technical variables are determined

by the management capacities of the farmer. Therefore, the next chapters focused on this management.

Defining management

Textbooks and articles on farm management stress the importance of management capacities of farmers with respect to their farm results. However, explicit definitions together with an elaboration of this concept are hard to find. In Chapter 3 literature has been reviewed to define 'management capacity'. Aspects of management capacity were grouped into personal aspects, consisting of farmers' drives and motivations (for instance, 'reduce veterinary costs' or 'increase silage quality'), farmers' abilities and capabilities and their biographies such as age and education, and aspects of the decision-making process, consisting of practices and procedures with respect to planning, implementation and control of decisions at the farm. Frontier production functions have widely been used in recent literature to estimate technical and economic efficiency of farms. However, in explaining differences in efficiency most studies do not go further than adding a biographical variable (e.g. level of education). A next step would be to include aspects of the decision-making process. Longitudinal on-farm observations, which give possibilities of studying the dynamic aspects of the decision making, could be a useful tool to further analyse the concept of management capacity.

Field study

A field study was set up on 38 farms which were visited monthly between May 1996 and May 1997. Selection of farms was based on a 305-day milk production and gross margin per 100 kg of milk in 1993/1994. Aim was to get 4 groups of about 10 farms that differed as much as possible with respect to milk production level and gross margin (high/high, low/low, high/low, low/high). The NRS (Royal Dutch Cattle Syndicate) made milk production data available and the GIBO accountancy group supplied economic data of these farms. Questionnaires were used to get insight into feeding, pasture, mastitis, fertility and breeding management on these farms. Besides, farmers recorded all pasture activities on a grassland calendar, they wrote down all the purchases of feed, and veterinary bills were copied. These data were collected monthly at the farms. Chapters 4 to 8 describe and discuss the results of this field study. Relations between management capacity of the farmer and the technical and economic farm results were worked out.

Repeatability of gross margin and milk production

In Chapter 4 the repeatability of farm average 305-day milk production and gross margin per 100 kg of milk was evaluated for these farms. This was done for the period between the year

1993/1994 and the year of the data gathering (1996/1997). Ranking of gross margin, its underlying variables (i.e. milk price, returns from cull cows and calves, costs of concentrates, and costs of roughage purchases), and the 305-day milk production was not completely random over these 4 years. A distribution-free method of Friedman was used to verify whether the ranking of farms was random over time. Friedman gives an overall index to compare more than 2 years; the coefficient of concordance. This index ranged between .55 and .72 for the 4 years of economic data. The coefficient of concordance was higher for milk production data. For each year and each farm, the difference between average gross margin and farm specific gross margin was calculated. The standard deviation (SD) of these values was calculated for each farm, showing differences between farms in variability in gross margin over years. All the underlying variables showed a deviation over time. So, variability of gross margin can be due to changes in all underlying aspects. It could be concluded that milk production of one specific year is a reliable indicator of milk production in other years. Gross margin, however, fluctuated considerably over years. Therefore, it is preferred to base economic research on data over more than one year.

Choice of statistical methodology

A major problem of the data set of the 38 farms was the large number of variables compared with the number of cases. Besides that, multicollinearity was likely to exist. In Chapter 5 advantages and disadvantages of principal components regression (PCR) and partial least squares (PLS) were investigated to analyse the data set. Both methodologies have the advantage that they can handle multicollinearity and a large number of variables. Out of 70 variables related to breeding management and technical results, 19 were selected for PLS and PCR, based on a correlation of $\geq .25$ or $\leq -.25$ with a 305-day milk production.

Five principal components (PCs) of the principal components analysis were selected for PC-regression with a 305-day milk production being the goal variable. Related variables were combined into one synthetic factor, and were used in a path-analysis. The same path-analysis was worked out with PLS. PLS forms synthetic factors capturing most of the information for the X-variables that is useful for predicting the Y-variables, while reducing the dimensionality by using fewer synthetic variables than the number of X-variables.

Outcomes of both methodologies showed the same main effects. Advantages of PLS are the optimization towards the Y-variable, resulting in a higher R^2, and the possibility of including more than just one Y-variable. Advantages of PCR are that P-values can be calculated, and that optimization is complete, whereas optimization in PLS is partial and lacks a good statistical inferential base. Due to that, P-values cannot easily be calculated. It could be concluded that PLS is the best methodology to choose for the current study. PCR cannot handle very complex path-analyses.

Pasture and feeding management

Relationships between feeding management, pasture management, gross margin, feed costs, 305-day milk production, and nitrogen loss per ha were described in Chapter 6 for the 38 farms in the field study. A first selection of variables was based on simple linear correlations. Only variables that had a correlation of ≤ -.25 or ≥ .25 with 305-day milk production, gross margin or nitrogen loss were selected for the multivariate analyses. Partial Least Squares (PLS) was used to analyse the data. Models were set up for gross margin, feed costs, 305-day milk production, and nitrogen loss. Thirty variables out of a total of more than 200 related to pasture or feeding management were selected for the gross margin model and 29 for the feed costs model. The R^2 of the models ranged between .32 (nitrogen loss model) and .62 (gross margin model). Unfortunately, the nitrogen loss model did not have predictive relevance. The PLS-model for feed costs resulted in the hypotheses that (1) farms with a high percentage of pasture that cannot be grazed by the cows have higher feed costs, (2) farms with a high percentage of grazings lasting longer than 4 days have higher feed costs, (3) farmers which have based the size of the paddocks on the number of cows and the grazing system have better economic returns. Mistakes in set-up of the paddocks cannot be compensated for by exact planning, and (4) farmers who have not organized their grazing management well, also tend to have worse results as to their silage management. The 305-day milk production model showed that a high milk production per cow is realized on farms with too low a number of growing days for cutting, resulting in high quality but low quantity of grass.

Mastitis and fertility management

Chapter 7 describes the results of the field study in the area of mastitis management, fertility management, 305-day milk production and gross margin. The same methodology was used as for the analyses regarding pasture and feeding management. Out of 150 variables related to mastitis management and fertility management, technical results and economic results, 44 variables were selected, based on a correlation with milk production and/or gross margin. The PLS-model on milk production explained 54 % of the variance in 305-day milk production and showed a positive relationship between know-how of the farmer regarding bulk somatic cell count (BSCC), the effort level of the farmer for BSCC, hygiene of the milking parlour and milk production. At farm level, fertility was negatively related to 305-day milk production, in spite of a relatively good fertility management at high-producing farms. Forty-six % of the differences in gross margin could be explained by the PLS-model. Fertility management did not seem to affect gross margin. An influence of know-how on gross margin could be determined. Knowledge of BSCC and calving interval (CI) had a positive effect on gross margin. This knowledge seemed a general parameter for good economic results, because it was correlated with different aspects of gross margin.

Main conclusions

The final step in the study was the development of an overall model to show the relationship between all different fields of management (pasture, feeding, mastitis, fertility and breeding) and gross margin as well as milk production. This way, the characteristics a farmer needs to combine a certain production level with a certain gross margin per 100 kg of milk could be shown. Based on this model, the following conclusion were drawn:

- To achieve a high milk production level and a high gross margin per kg of milk, the characteristics of the farmer were a central element of 'the key to success'. A good know-how of the results at the farm and a preference for animal health management compared with other management areas are of major importance. Due to their interest, these farmers were also more often involved in a herd health program. This implies that a high production per cow is not a good economic option for each farmer. Before farmers decide to aim for a high milk production level, they have to work out for themselves whether or not they are able to give the herd the attention and interest that is needed.
- Farmers who prefer pasture management above other management areas, and who want to improve economic results, should maintain their focus on optimizing the use of pasture instead of shifting too much to maximizing milk production per cow.
- A correct set-up of the paddocks, based on number of cows and a grazing system of 4 days, is a first requirement for good pasture management for Dutch conditions. The next step is correct planning.
- Knowledge of herd management parameters (bulk somatic cell count and calving interval) are general indicators of good management. Farmers with good knowledge in these fields score better in these and other areas, resulting in better economic returns.
- An adequate agricultural education of the farmer can help to improve farm results. However, it is no key to success.

The following conclusions can be drawn related to the methodologies used:

- Partial Least Squares is a useful methodology to be used in empirical research with a relatively small number of cases and complex relationships among the variables.
- Questionnaires combined with longitudinal observations can be a useful technique to check for social desirability in answering questions. This way, insight is gained into the quality of the data set.
- Longitudinal observations are particularly useful to study technical processes at farm level. Pasture use, for instance, can only be evaluated when data are gathered during the entire growing season.
- Repeatability of economic data showed that collecting data over more years is preferable. That way, insight is gained into relations that are stable over time, and relations that are influenced by a year-effect.

Samenvatting

Inleiding

Melkveebedrijven die voor wat betreft locatie, omvang en veeslag sterk overeenkomen, kunnen toch sterk verschillen in economisch resultaat. Deze verschillen worden vaak toegeschreven aan verschillen in managementcapaciteiten van de veehouder. De ene veehouder is nu eenmaal beter in staat zijn of haar bedrijf optimaal te 'managen' dan de andere veehouder. Een veel gehanteerd advies ter verbetering van het bedrijfsresultaat is het verhogen van de melkproductie per koe: de voerkosten per 100 kg melk gaan naar beneden, waardoor het economisch bedrijfsresultaat verbetert en het mineralenoverschot afneemt. Het is echter niet duidelijk of verhoging van de melkproductie per koe voor elke veehouder een goede optie is. Het stelt namelijk de nodige eisen aan het management. Bij een onvoldoende management kan een hoge productie per koe negatieve gevolgen hebben voor bijvoorbeeld de diergezondheid en de vruchtbaarheid, en daarmee voor het economisch resultaat.

Doel van het onderzoek in dit proefschrift was om na te gaan welke managementkwaliteiten en karaktereigenschappen een melkveehouder nodig heeft om een bepaald melkproductieniveau samen te laten gaan met goede economische resultaten. Welk type veehouder kan zijn bedrijf zodanig 'managen', d.w.z. de juiste beslissingen op het juiste moment nemen, dat een hoge 305-dagen productie tevens resulteert in een goed economisch bedrijfsresultaat? Het economisch resultaat wordt in het proefschrift gemeten als opbrengsten minus bijkomende voerkosten per 100 kg melk (het saldo). In het onderzoek is met name ingegaan op operationele beslissingen op het bedrijf, d.w.z. dat het zich richt op de 'dagelijkse' gang van zaken op het bedrijf. Het strategisch management (de lange termijn, bijvoorbeeld het al dan niet besluiten tot aankoop van quotum of grond) is buiten beschouwing gelaten.

Technische relaties

Naast allerlei bedrijfstechnische kenmerken heeft ook het management van de melkveehouder een belangrijke invloed op de technische resultaten. Deze technische resultaten bepalen op hun beurt weer het economisch resultaat en het mineralenoverschot. In hoofdstuk 2 worden relaties tussen de technische resultaten van het bedrijf en het economisch resultaat en het N-overschot besproken. Om dit goed te kunnen doen, is gebruik gemaakt van de zogenaamde 'pad-analyse'. Pad-analyse is een statitistische methodiek waarbij complexe relaties tussen variabelen in de vorm van een stroomdiagram weergegeven en geanalyseerd kunnen worden. Een pijl tussen 2 kenmerken geeft aan dat het ene kenmerk het andere kenmerk beïnvloedt. Tevens kan bepaald worden hoe groot die invloed is. Met behulp van deze methode zijn relaties tussen melkproductie, vruchtbaarheidsresultaten, veevervanging, melksamenstelling, bedrijfskenmerken, saldo per 100 kg melk en N-overschot per ha bepaald. Dit is gedaan voor een groep van 478 melkveebedrijven, waarvan de gegevens afkomstig waren van de GIBO groep (deelboekhouding) en het NRS (productie- en vruchtbaarheids-gegevens).

Eerst is een model opgezet om verschillen in saldo (d.w.z. opbrengst minus bijkomende voerkosten) per 100 kg melk te verklaren. De 305-dagen productie blijkt gerelateerd aan vruchtbaarheidskengetallen, het vervangingspercentage en het saldo per 100 kg melk. Naast het melkproductieniveau, wordt het saldo beïnvloed door het quotum per ha, de krachtvoergift per koe per jaar, het eiwitgehalte in de melk en de hoeveelheid ruwvoer die extra wordt aangekocht per ha. Daarnaast werden kleine, maar significante invloeden op het saldo gevonden van het aantal inseminaties per dracht, het aantal geboorten per koe per jaar, het aantal stuks jongvee per ha en het vervangingspercentage.

Het N-overschot per ha bleek erg afhankelijk van het melkquotum per ha en de hoeveelheid krachtvoer per koe per jaar. Minder sterk, maar wel significant, bleken de effecten van vervangingspercentage, jongvee per ha en melkproductie per koe op het N-overschot per ha.

Het saldo en het N-overschot zijn dus afhankelijk van meerdere technische factoren. Deze technische factoren worden beïnvloed door het management. De logische volgende stap in het onderzoek was dan ook dieper in te gaan op dit management.

Een definitie van management

In tekstboeken over management wordt vaak gesproken over het belang van goede managementcapaciteiten voor een goed bedrijfsresultaat. Concrete definities van management en een uitgebreide beschrijving van wat dit management dan inhoudt, zijn echter moeilijk te vinden. In hoofdstuk 3 is 'managementcapaciteit' nader gedefinieerd en afgebakend. Daarvoor is managementcapaciteit onderverdeeld in persoonskenmerken en aspecten van besluitvorming. Persoonskenmerken zijn bijvoorbeeld de doelstellingen die de veehouder heeft voor zijn bedrijf (bijvoorbeeld de tochtigheidswaarnemingen verbeteren of de kwaliteit van de kuil proberen te verbeteren), zijn aanleg en capaciteiten, zijn leeftijd en opleiding. Besluitvorming kan onderverdeeld worden in planning, uitvoering en evaluatie. Hoe wordt bijvoorbeeld het graslandgebruik gepland, wordt deze planning ook zo uitgevoerd en wordt er achteraf gekeken of dit een juiste beslissing was? Om te bepalen in hoeverre een veehouder het technisch en economisch maximaal mogelijke uit zijn bedrijf haalt, wordt in de wetenschappelijke literatuur veel gebruik gemaakt van de zogenaamde 'frontier production function'. Dit is een methodiek om de technische en economische efficiëntie van bedrijven te berekenen. In de meeste van deze efficiëntiestudies wordt vaak echter niet verder gegaan dan de invloed te bepalen van enkele biografische kenmerken, bijvoorbeeld opleidingsniveau, op het bedrijfsresultaat. Besluitvorming is echter dynamisch. Dit dynamische aspect (hoe verloopt een besluitvormingsproces?) wordt zelden gemeten. Om dit mogelijk te maken, moeten bedrijven langere tijd gevolgd worden, zodat de verschillende stappen in de besluitvorming beoordeeld kunnen worden.

Veldproef

In het kader van de huidige studie is een veldproef opgezet waarbij 38 melkveebedrijven tussen mei 1996 en mei 1997 intensief gevolgd zijn en maandelijks bezocht. Bedrijven zijn geselecteerd voor het onderzoek op basis van de 305-dagen melkproductie per koe en het saldo per 100 kg melk in 1993/94. Van deze bedrijven zijn melkproductiegegevens verkregen van het NRS en economische gegevens van de GIBO-accountancy groep. Er zijn enquêtes afgenomen over voedingsmanagement, graslandmanagement, mastitismanagement, vruchtbaarheidsmanagement en fokkerijmanagement. Hiernaast hield de veehouder een graslandkalender bij, werden alle voeraankopen genoteerd en werden dierenartsrekeningen gekopieerd. Deze gegevens werden maandelijks bij de veehouders opgehaald. De hoofdstukken 4 t/m 8 gaan in op de resultaten van deze veldproef. Relaties zijn gelegd tussen de gemeten managementcapaciteit van de veehouder en het technische en economische bedrijfsresultaat.

Herhaalbaarheid van saldo en productie

In hoofdstuk 4 wordt het verloop van het saldo en de melkproductie voor de 38 bedrijven in de jaren 1993/94 tot 1996/97 besproken. Door bedrijven elk jaar te rangordenen op melkproductie, saldo en de variabelen waaruit het saldo is opgebouwd (melkprijs, omzet en aanwas, krachtvoerkosten, kosten aankoop ruwvoer) en deze rangordening over jaren heen te vergelijken, kan bepaald worden hoe herhaalbaar deze kenmerken in de tijd zijn. Als elk bedrijf elk jaar dezelfde positie inneemt ten opzichte van de andere bedrijven, is de herhaalbaarheid hoog. Als de rangorde van bedrijven echter sterk wisselt tussen jaren, is de herhaalbaarheid laag, en rijst de vraag hoe zinvol het is om naar de resultaten van een eenmalige observatie (een momentopname) te kijken. Dit lijkt dan immers geen goede voorspeller te zijn van de situatie in andere jaren. De rangorde van de bedrijven bleek een zekere herhaalbaarheid te hebben. Er is een totaalindex gebruikt om de rangorde van 4 opeenvolgende jaren te vergelijken; de concordantiecoëfficiënt. Een waarde van 0 geeft aan dat de rangorde van bedrijven elk jaar geheel weer door toeval bepaald zou worden. Een waarde van 1 zou betekenen dat de rangorde elk jaar exact hetzelfde zou zijn. De index varieerde tussen 0.55 en 0.82 voor de verschillende variabelen. Het melkproductieniveau bleek de grootste herhaalbaarheid te hebben. De herhaalbaarheid van economische parameters was kleiner.

De Standaard Deviatie (SD) is een statistische maat voor de variatie in een reeks getallen. Voor elk jaar en voor elk bedrijf is het verschil berekend tussen het gemiddelde saldo van alle bedrijven voor dat jaar en het saldo van dat bedrijf. De SD van deze 4 waarden per bedrijf (van de 4 jaren) liet verschillen tussen bedrijven in variabiliteit tussen jaren zien. Dit betekent dat sommige bedrijven elk jaar ongeveer dezelfde afwijking ten opzichte van het gemiddelde van alle bedrijven hadden, terwijl andere bedrijven het ene jaar bijvoorbeeld een gemiddeld saldo hadden en het andere jaar juist weer een duidelijk lager of hoger saldo realiseerden. Ook de variabelen waaruit het saldo is opgebouwd vertoonden deze verschillen. Dit toont aan dat er niet één variabele verantwoordelijk is voor verschuiving in rangorde van bedrijven over jaren heen, maar dat de oorzaak in elk van de onderliggende variabelen kan liggen. De conclusie is dat melkproductiegegevens van een bepaald jaar een betrouwbare indicatie vormen van de productie in andere jaren. Het saldo varieert echter meer door de jaren heen. Dit impliceert dat economisch onderzoek bij voorkeur gebaseerd zou moeten zijn op meer dan 1 jaar gegevens.

Keuze van statistische methodiek

Er is bewust gekozen om het onderzoek zo op te zetten dat de 38 melkveebedrijven intensief gevolgd en maandelijks bezocht konden worden. Alleen op deze wijze zouden betrouwbare gegevens verkregen kunnen worden die nog niet in al bestaande informatiesystemen worden vastgelegd. Een probleem dat zich hierbij echter voordoet, is dat slechts een beperkt aantal bedrijven gevolgd kan worden. Dit maakt statistische analyse van de gegevens moeilijker. Een tweede eigenschap van de gegevens die kon zorgen voor problemen tijdens de analyses, was zogenaamde multicollineariteit. Multicollineariteit houdt in dat allerlei kenmerken samenhangen. Een voorbeeld hiervan is bijvoorbeeld leeftijd en opleidingsniveau. Jongere veehouders hebben gemiddeld een hoger opleidingsniveau dan oudere. Om te bepalen of leeftijd van invloed is op het bedrijfsresultaat, zal rekening gehouden moeten worden met het opleidingsniveau. In zo'n situatie is het moeilijk uit elkaar te halen of nu het opleidingsniveau dat bedrijfsresultaat beïnvloedt of dat het de leeftijd is. Om hieraan tegemoet te komen, zijn speciale statistische methodieken nodig. In hoofdstuk 5 worden de voor- en nadelen besproken van twee statistische methodieken die mogelijk beide waardevol kunnen zijn in een situatie waarbij het aantal bedrijven t.o.v. het aantal variabelen klein is en er sprake is van multicollineariteit: Partial Least Squares (PLS) en Principal Components Regression (PCR).

Uit een totaal van 70 variabelen die samenhangen met fokkerijmanagement en het technisch resultaat, zijn 19 variabelen geselecteerd voor een analyse m.b.v. PLS en PCR. Beide methodieken zijn gebruikt om te proberen verschillen in 305-dagen productie tussen bedrijven te verklaren. Beide methodieken maken zogenaamde 'synthetische variabelen' aan. Dit zijn kunstmatige variabelen die bestaan uit informatie van een combinatie van andere variabelen. Nadat deze synthetische variabelen zijn gemaakt, worden ze gebruikt in een pad-analyse. PLS en PCR verschillen voornamelijk in de manier waarop de synthetische variabelen worden opgebouwd. Beide methodieken laten in principe dezelfde effecten zien. Het melkproductieniveau van het bedrijf hangt samen met de doelstellingen van de melkveehouder en welke aspecten hij ziet als succesbepalend voor het bedrijf. Veehouders die de doelstelling 'een hoge melkproductie per koe behalen' belangrijk vinden, hebben gemiddeld ook een hogere productie. Voordelen van PLS bleken te zijn dat bij de opzet van de synthetische variabelen direct al rekening wordt gehouden met de te verklaren variabele (in dit geval de melkproductie). Dit heeft tot gevolg dat met het PLS-model de 305-dagen productie beter geschat kan worden. Andere voordelen van PLS zijn dat het in principe mogelijk is meerdere aspecten tegelijkertijd te verklaren en dat het systeem complexe relaties beter kan verklaren dan PCR. Het zou dus bijvoorbeeld mogelijk zijn om de invloed op productie EN op saldo te bepalen, terwijl met PCR maar naar een van beide tegelijk gekeken kan worden. PCR heeft echter ook enkele duidelijke voordelen. Eén daarvan is dat PCR al een wat oudere techniek is en daardoor beter onderbouwd. Hierdoor is het mogelijk te bepalen of uitkomsten significant zijn. Voor PLS is dit (nog) niet mogelijk. Uit de vergelijking van beide analyses en methodieken kwam naar voren dat PLS voor de huidige studie de beste methodiek was. Deze methodiek is dan ook toegepast.

Grasland- en voedingsmanagement

In hoofdstuk 6 worden relaties besproken voor de 38 bedrijven tussen voedingsmanagement, graslandmanagement, 305-dagen productie, voerkosten per 100 kg melk, saldo per 100 kg melk en N-overschot per ha. Van alle bedrijven waren heel veel gegevens beschikbaar die niet allemaal tegelijkertijd geanalyseerd konden worden. Om een eerste selectie van variabelen te maken, is gekeken welke variabele rechtstreeks samenhingen met saldo, melkproductie of N-overschot door de correlatie met deze variabele te bepalen. Als in eerste instantie al geen correlatie kon worden aangetoond, werd de variabele niet meegenomen in het vervolg van de analyse. Partial Least Squares is gebruikt om de data te analyseren. In totaal zijn 4 modellen opgesteld: één om de melkproductie te verklaren, één voor de voerkosten per 100 kg melk, één voor het saldo en één voor het N-overschot per ha. Dertig variabelen zijn geselecteerd om het saldo te verklaren uit een totaal van meer dan 200 variabelen. Negenentwintig variabelen werden opgenomen in het melkproductiemodel. Uit de berekeningen volgt welk deel van de verschillen in bijvoorbeeld de melkproductie verklaard kan worden door het model (de zogenaamde R^2). Een waarde 0 betekent dat het model geen 'zeggingskracht' heeft, er wordt helemaal niets verklaard. Een waarde van 1 betekent dat het model de verschillen in melkproductie tussen bedrijven volledig kan verklaren. Deze waarde varieerde van 0.32 (voor het N-overschot model) tot 0.62 (voor het saldomodel). Met name het voerkostenmodel en het melkproductiemodel gaven interessante resultaten en zijn daarom verder uitgewerkt.

Op basis van het voerkostenmodel konden de volgende relaties onderbouwd worden:

1. Bedrijven met veel veldkavel hebben hogere voerkosten;
2. Bedrijven met veel beweidingen die langer duren dan 4 dagen hebben hogere voerkosten;
3. Bedrijven met een perceelsindeling afgestemd op het aantal dieren en het beweidingssysteem behalen een beter economisch resultaat. Als de perceelsindeling niet in orde is, kan dit niet gecorrigeerd worden door een nauwkeurige planning;
4. Veehouders die hun beweidingsmanagement niet goed op orde hebben, hebben ook een slechtere ruwvoederwinning.

Het melkproductiemodel liet zien dat op bedrijven met een hoge productie, de hergroeiduur voor maaien aan de lage kant is. Hierdoor wordt in het gehele seizoen minder opbrengst van het perceel gehaald dan optimaal zou zijn, waardoor de voerkosten stijgen.

Mastitis- en vruchtbaarheidsmanagement

In hoofdstuk 7 worden de resultaten besproken op het gebied van mastitis- en vruchtbaarheidsmanagement. Ook hier is gekeken hoe dit samenhangt met de 305-dagen productie en het saldo per 100 kg melk. Dezelfde methodiek is gebruikt als in hoofdstuk 6: Partial Least Squares. Op een zelfde wijze als in hoofdstuk 6 is ook hier een eerste selectie gemaakt uit de grote groep variabelen. Uit een totaal van 150 variabelen werden 44 variabelen geselecteerd die samenhingen met productie en/of het saldo.

Het model dat is opgezet om de melkproductie te verklaren, bleek een R^2 van 0.54 te hebben. Relaties die hieruit naar voren kwamen, waren dat veehouders met een goede kennis van het tankcelgetal op het bedrijf, met een strikte doelstelling voor de hoogte van het tankcelgetal en een goede hygiëne van de melkstal een hogere gemiddelde 305-dagen productie realiseerden. Ondanks het feit dat het vruchtbaarheidsmanagement beter leek op hoogproductieve bedrijven, hadden deze bedrijven toch iets slechtere vruchtbaarheids-resultaten.

Het model om het saldo te verklaren had een R^2 van 0.46. In dit model kwam geen enkele variabele voor op het gebied van vruchtbaarheidsmanagement. Vruchtbaarheids-management leek dus geen invloed te hebben op het saldo, hoewel dit wel verwacht was. Mogelijke oorzaak kan zijn dat de veehouders de enquêtes grotendeels beantwoord hebben met in hun achterhoofd het management zoals ze dat in principe zouden willen toepassen op hun bedrijf in plaats van wat ze werkelijk gedaan hebben. Door omstandigheden (bijvoorbeeld drukte) kan het echter moeilijk zijn het geplande management daadwerkelijk uit te voeren. Het verschil tussen wat een veehouder in z'n hoofd heeft en wat hij echt doet is echter moeilijk vast te stellen. In het model werd wel een invloed van kennis op het saldo gevonden. Melkveehouders met een goede kennis van de prestaties van hun bedrijf op het gebied van tankcelgetal en tussenkalftijd hadden een beter saldo dan bedrijven met mindere kennis. Deze kennis van dierkengetallen bleek ook een goede indicator te zijn voor goed management meer in het algemeen. Het had niet enkel een positieve invloed op één onderdeel van het saldo, maar op meerdere: de melkprijs was hoger, de voerkosten waren lager, en de omzet en aanwas was hoger.

Conclusies

De laatste stap die in het onderzoek gezet is, is de ontwikkeling van één totaalmodel waarin de invloed van alle verschillende managementgebieden (grasland, voeding, gezondheid, vruchtbaarheid en fokkerij) op zowel saldo als productie bepaald wordt. Op deze wijze kan schematisch aangegeven worden welke eigenschappen een veehouder nodig heeft om een bepaald productieniveau te kunnen combineren met een bepaald saldo per 100 kg melk. Op basis van dit model kunnen de volgende conclusies getrokken worden:

- Om een hoge productie en een hoog saldo te kunnen bereiken, zijn de management- en karaktereigenschappen van de melkveehouder van groot belang. Interesse in diermanagement en diergezondheid is essentieel. Samenhangend met hun interesses, blijken deze veehouders ook relatief vaak veterinaire bedrijfsbegeleiding te hebben. Dit houdt impliciet in dat een hoge productie geen goede optie is voor veehouders die deze eigenschappen in mindere mate hebben. Voordat een veehouder besluit naar een hoge productie te gaan streven, zal hij eerst voor zichzelf uit moeten maken of hij in staat is om de veestapel die extra tijd en aandacht te geven die het nodig heeft.
- Melkveehouders die met name geïnteresseerd zijn in graslandmanagement doen er verstandig aan zich hier op te blijven richten en zich niet blind te staren op het maximaliseren van de productie per koe. Op deze manier zullen ze in staat zijn toch een goed saldo te behalen;
- Een juiste perceelsindeling is een eerste vereiste voor goed graslandmanagement. Daarnaast is een goede planning van het gebruik van de percelen en een optimale hergroei voor maaien en voor beweiden van belang;
- Kennis van prestaties op het eigen bedrijf (tankmelkcelgetal en tussenkalftijd bijvoorbeeld) kunnen gezien worden als algemene indicatoren voor de kwaliteit van het management op het bedrijf en voor het behalen van een goed saldo en een hoog productieniveau;
- Een goede agrarische opleiding kan een hulp zijn om de bedrijfsresultaten te optimaliseren. Het is echter niet succesbepalend.

Op basis van het totale onderzoek kunnen aanvullend enkele conclusies getrokken worden m.b.t. de gebruikte methodieken:

- Partial Least Squares is een nuttige methode in empirisch onderzoek waarbij allerlei complexe relaties onderzocht worden met een groot aantal variabelen ten opzichte van het aantal bedrijven;

- Bij de opzet van een enquête moet de onderzoeker bedacht zijn op het feit dat mensen geneigd zijn sociaal wenselijke antwoorden te geven. Door de enquête te combineren met waarnemingen op het bedrijf, kunnen sommige antwoorden gecontroleerd worden en kan de betrouwbaarheid van de studie toenemen;
- Bij het verzamelen van informatie over technische processen binnen het bedrijf moeten waarnemingen door de tijd heen genomen worden. De graslandkalender is hier een voorbeeld van;
- De herhaalbaarheid van economische data liet zien dat het verzamelen van gegevens over meerdere jaren de voorkeur heeft. Op die manier kan inzicht verkregen worden in relaties die stabiel zijn over de tijd en relaties die jaarafhankelijk zijn.

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Curriculum Vitae

Catharina Wilhelmina (Carin) Rougoor werd op 23 mei 1969 geboren in Varsseveld, gemeente Wisch. In 1987 behaalde zij het VWO-diploma aan de toenmalige Christelijke Scholengemeenschap Aalten. In september van dat jaar werd begonnen met de studie Zoötechniek aan de Landbouwuniversiteit Wageningen. In november 1992 sloot ze deze studie af, met als afstudeervakken Veehouderij, Agrarische Bedrijfseconomie en Graslandkunde. Haar stage voerde ze uit bij de vakgroep Veterinary Science van Massey University (Nieuw Zeeland). Vanaf januari 1993 tot september 1994 was ze werkzaam bij de toenmalige Vakgroep Agrarische Bedrijfseconomie voor verschillende projecten. Zo heeft ze enkele maanden gewerkt aan het ontwerpen van practicummateriaal voor een internationale PHLO-cursus 'Animal Health Economics'. Hierna heeft ze gewerkt aan een inventarisatie van de kennis op het gebied van diergezondheid en diergeneesmiddelengebruik in de Nederlandse veehouderij. Dit was een opdracht (een zogenaamde programmeringsstudie) vanuit het Ministerie van LNV.

Sinds september 1994 is ze werkzaam bij het Praktijkonderzoek Rundvee, Schapen en Paarden te Lelystad. Het onderzoek dat ze gedurende deze periode heeft uitgevoerd in nauwe samenwerking met de leerstoelgroep Agrarische Bedrijfseconomie van de Landbouwuniversiteit heeft geleid tot dit proefschrift.