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# FARMERS IN SMALL-SCALE AND LARGE-SCALE FARMING IN A NEW PERSPECTIVE
## Objectives, decision making and information requirements

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Agricultural Economics Research Institute (LEI-DLO)

ABSTRACT

FARMERS IN SMALL-SCALE AND LARGE-SCALE FARMING IN A NEW PERSPECTIVE;
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Strategies in agricultural research and policy making have been dominated by technology push principles for many decades. This also used to be the case in development of tools to support farm management, and more in particular the tools based on information technology. Nowadays the idea gains ground that instead of available technology, the farmer as an acting person should be the starting point for development of information products. To support further innovation of information technology, new approaches are needed to develop new views on the farmer, his thinking and his behaviour.
The 43rd EAAE seminar reports on progress in, and new methods and theories on goals, objectives and personal characteristics of farmers, styles of farming, decision making processes and information requirements on the farm. Results from 28 research projects from different groups in 9 countries are reported.

Farmer's behaviour/Information technology/Farm management/Agricultural research/Agricultural policymaking

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# PREFACE

Understanding and supporting agricultural development starts with knowledge about the behaviour of the basic actor: the farmer. For development of tools for farmers in a way that they will be actually used it is necessary to know about the way farmers think and act and how this individual behaviour is influenced by their social and technical environment. More understanding of farmers thinking and acting will be helpful in supplying basic understanding of agricultural economic behaviour at aggregated levels. This knowledge will also be helpful for designing effective policy instruments and their implementation.

For these reasons I am happy to present the results of the 43rd EAAE seminar on objectives, decision making and information requirements of farmers. On this seminar various research groups from Europe and the US have presented the results of interesting ongoing research in this field. The results of this type of research will be beneficial for all that are concerned with the development of a viable and sustainable agriculture.

It is important that the different researchers in this domain create a network in which their results can be shared, discussed and combined. I hope and trust that the seminar contributed to this.

The Director,

The Hague, January 1996

L.C. Zachariasse

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# INTRODUCTION

The objective of the seminar was to present and discuss results of research that focuses on the farmer; his objectives, decision making and information requirements. The idea is that more approriate knowledge of the farmer will facilitate all the work of all that are involved in supporting and influencing the farmers. A more specific focus was on the information requirements of farmers and the concepts that determine them, in order to facilitate a better development of farm information products.

This objective is worked on in various scientific disciplines (economy, (farm) management science, sociology, psychology, extension science, engineering, information science, agronomy, computer science etc.) as can be observed by the papers presented during the seminar. Therefore we explicitly did not make an attempt to structure the programme of the seminar. Basically the same problems or types of problems are investigated in very different approaches with a wide variety of conclusions. All presentations have in common that they contribute one way or another to a better knowledge of the farmer and his information requirements. It is obvious that for structuring the various lines of research we have to be able to integrate these different approaches and thus the scientific disciplines involved. In the end this will facilitate the integration of the results of the research to create more complete pictures of 'the' farmer and his information requirements.

It can be concluded that the state of the art is not yet in a stage that integration of research results is at hand. In this situation it is important that different approaches are used and that researchers from different disciplines are acquainted with appreciating and discussing each other's results. This is a prequisite to combine the results and develop on the knowledge of the farmer and his behaviour. We hope that the seminar contributed to create a platform in which we can match our results to each other. We are all working on a part of the same puzzle and none of us will be able to solve this puzzle on his own.

George Beers
Ruud Huirne
Carlien Pruis

# OPENING BY THE SECRETARY GENERAL
# OF THE EAAE

Prof.dr. Vinus Zachariasse, Secretary General EAAE
Woudschoten, October 16, 1995

Ladies en gentlemen, dear colleagues,

Thank you for the opportunity to open this seminar. The reasons of my presence here are twofold.

First of all it is an honour to me as Secretary General of the European Association of Agricultural Economists to welcome you. That is on behalf of the Executive Committee of the Association, that has given its official endorsement to this European seminar.

One of the objectives of the Association is to further the development of science and knowledge in our profession. Besides the triennial congress, the European seminars do provide an excellent opportunity for exchanging results of and insights on basis of research with colleagues. The seminars have the advantage that the scope usually is much more precise than is possible at the congress. A seminar does amtrack the specialists in a certain area, so the papers and discussions can go more in depth and, because of the smaller number of participants, one can meet the most relevant colleagues during breaks and in the evening.

In the running period 1993-1996 in total 13 European seminars are organised. By overviewing the topics of the European seminars one sees on the one hand new subjects as for instance on 'The role of agricultural externalities' in Vienna last year and on the other hand on-going, repeating subjects. One of those subjects is 'Farmer's decision making' in combination with the 'opportunities of information technology' or other issues. In this period two proposals on Farmer's decision making were presented: one from our Danish colleagues and this one in the Netherlands. Usually the Executive Committee does not endorse more than one seminar on the same subject. In this case however, since the Danish proposal was submitted very early and in the case of the Netherlands anyhow an international seminar was part of rather big national project, the Executive Committee has tried to orient both seminars as different as possible and to start the announcement of this seminar rather late. The Executive Committee warned the organizers of this seminar, that the risk of too few participants had to be considered as realistic.

I think, looking at the number and quality of participants and papers of this seminar, the Executive Committee was a little bit too reluctant and that it did underestimate the progress of research and the enthusiasm of researchers of this specific field. I do congratulate the organizers with their success so far.

We do expect that in the next period 1996-1999 again one or two seminars on this topic will be proposed. Therefore I like to encourage everybody to take also such an initiative and to prepare proposals for the period after the next congress in Edinburgh in September 1996. Some five proposals on different topics are already submitted. So far, not yet one on this topic. It may seem a little bit early yet, but the preparation of a good proposal usually takes quite some time. The Executive Committee will be very grateful to receive proposals in time in order to discuss them for endorsement and to assist you among others by publishing several announcements in our Newsletter.

The second reason for my presence here is my involvement in the preparation and guidance of a Dutch project on objectives, decision-making and information requirements of farmers in relation to the development and implementation of information technology in the agricultural sector.

On basis of a study of Wageningen Agricultural University for the Dutch National Council for Agricultural Research in 1991 four fields of socio-economic research on development and implementation of Information Technology in Agriculture were identified. To do research on all four fields with the limited budget was assessed as too ambitious and it was decided to concentrate the research activities on the issue 'Objectives, decision-making and information requirements of farmers'. The background was that both the development and the implementation of information technology applications was at a much slower rate than expected. What to our opinion at that time hampered most, was a good fit between farm information systems and the real requirements of the farmer. The most successful applications of information technology were developed by farmers themselves or in close cooperation with them. The main target of our project was how to bridge the gap between the opportunities of information technology on one hand and the information needed by the farmers on the other hand.

The project was executed by several departments of Wageningen Agricultural University and The Agricultural Economics Research Institute, with George Beers as coordinating person and a steering committee with me as chairman. The project is built up from 6 subprojects with quite different approaches to the main topic 'Objectives, decision-making and information requirements'. Several of these subprojects will be presented during this seminar (Huirne, Van der Ploeg, Beers, Alleblas, Van der Ploeg and Leeuwis).

In a summarizing seventh report a synthesis will be given of the different approaches as such, the possible better prospects by combining some of the approaches and what white spots of missing information on this topic will be left after the projects. Furthermore the main financer of the project, the Ministry of Agriculture, Nature Conservation and Fisheries expects that the results of this research will provide a basis for its policy on information technology for the next future. Knowing that this topic was and is being studied in several countries, it was decided that at the end of the project an international symposium or seminar should be organised to exchange results and ideas with colleagues how to proceed in future.

Information technology is really a basic technology with a tremendous impact. I regard the implementation of information technology and its applica-

tions therefore as one of the essential successfactors for farmers and agricultural sectors in future. Information technology has a direct link with the dissemination of knowledge. In a recent proposal in our institute to study knowledge as a factor in the future competitive development of farms and agricultural sectors, it was written that, and I quote 'knowledge means competitive power; that it therefore is the basis for realisation of added value and - looking at the decreasing part of the primary firms in the total added value in the agricultural product columns - that this basically is caused by a relatively worsening position on information by farmers compared to the other economic actors in the product chain'. If true, I do think that information technology is an important vehicle to provide general information on a wider scale and at low costs and to provide specified information for the specific conditions of a farm and for the specific objectives and requirements of the farmer. To us, scientists working in this field of decision-making by farmers, it provides an important mission to work on the provision of relevant management information for farmers in order to maintain or improve their competitive position.

There is a second development which will urge more specified information per farm. In our country, as in some other countries with an intensive agriculture, the government on national or regional basis provides more and more quantitative activities and especially restrictions on the decision making opportunities of farmers. The more quantitative the rule by law will require a kind of management that meets such a need for quantitative information by the farmer. The farmer will be forced therefore to think not only in quantitative data but also in the relevant relationships, say in the underlying models. It is therefore to be expected that the gap between scientists and farmers will be bridged partly in this way; the most important however is to realise a good fit between software and the farmer's decision making.

This seminar was very well prepared by George Beers and in particular Carlien Pruis. Looking at the proceedings I think I can also speak on behalf of you all and thank them for their efforts. I wish you an interesting and challenging European seminar. Not only because of the paper presentations and discussions, but also because of the contacts with colleagues from 14 countries.

# CONSISTENCY IN GOALS, INFORMATION NEEDS AND RISK MANAGEMENT OF DUTCH DAIRY FARMERS

Ruud B.M. Huirne 1), Mirjam A.M. Spreeuwenberg 1), Saskia C. Scheer 1), Aalt A. Dijkhuizen 1) & Stephen B. Harsh 2)

## Abstract

*One of the major problems for farm-level information system users and developers is to determine the farmer's information needs. These are generally based on his or her goals and management strategies with respect to important decisions. Once information needs have been identified, the question has to be addressed as to what extent these needs are consistent over time. In this paper we describe workshops focused on assessing dairy farmer's goals, information needs and risk management strategies. The workshops were conducted in 1993 and repeated in 1995. Total number of participants in the workshops were 49 in 1993 and 40 in 1995. 26 dairy farmers participated both in 1993 and in 1995. The results of this study indicate that goals and information needs of the dairy farmers are consistent if the farmers are analyzed as a group. However, significant differences were found between the responses in 1993 and 1995 if the farmers are analyzed individually. This low level of consistency has implications for farm-level information supply, whether through an information system or through extension.*

## 1. Introduction

The process of introduction and adoption of farm-level information systems is proceeding slower than expected (Eleveld et al., 1992). An important reason for this is the lack of knowledge on system criteria that have to be satisfied for successful application. The last decades, the process of system development was mainly determined by extension workers, researchers and policy makers. The farmer, as the proposed user of the system, was hardly involved in this process. Therefore, user-oriented research was initiated a few years ago to focus much more on the information needs and decisionmaking processes of of individual farmers (Huirne et al., 1993; Huirne et al., 1994).

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A workshop for farmers was developed by Wageningen Agricultural University and Michigan State University focused on assessing goals, information needs and risk management of dairy farms. In 1993, the workshop was conducted successfully three times, with in total 49 dairy farmers as participants. In order to be able to study the consistency in responses, the workshops were repeated 2 years later, in 1995. In 1995, 40 dairy farmers participated, of which 26 also participated in 1993. The workshop consisted of two main parts: a more general part focused on general aspects of farmer's management, and a more specific part focused on the farmer's sire selection. Sire selection was selected as a typical case for determining information needs: it is an important activity on a dairy farm, and it influences both production and income. The risk attitude of the farmer usually has a significant effect on sire selection. The farmer has to find the optimal trade-off between profit and risk involved in breeding. The process of the farmer's sire selection is however not well understood.

In this paper, the outline of the workshop is presented and discussed. The paper then continues with the results of the workshops, in which the findings in 1993 are compared with those found in 1995. Special attention is given to differences in farmer's business goals, breeding goals, sire selection information needs, and risk attitude with respect to sire selection.

## 2.    Materials and methods

### 2.1    Workshop format and materials

The workshops are designed to determine goals, information needs and risk management strategies of dairy farmers. They are held in the evening: from 7:00 till 11:00 pm. The workshop program and supporting materials center around exercises that encourage active participation. In developing our workshop, we made fruitful use of the materials of a more general workshop described by King et al. (1992). In the workshop, there are from 12 to 15 participating farmers. Computer ownership is not necessary. In fact, the workshops are most effective when information system characteristics vary widely.

Prior to each workshop, participants completed a worksheet that provides summary information about their farm operation and their information system. After the introduction, in which the objectives and the time schedule are explained, the workshop began with participants introducing themselves and sharing some of their responses to questions on the farm information worksheet. The workshop had two major sections. The first section focused on more general aspects of their management, which are the basis of the decision-making processes of the farmer. This section included five exercises that help the participating dairy farmers define their business goals and management habits. In the first and most important exercise of the first section, each individual identifies four business goals that he or she judges to be most important from an extensive list of business goals. Then 100 points were divided over these four most important goals in such a way that more important goals should get more points.

In the second section of the workshop, focus was on sire selection, being one of the critical success factors of dairy farming (Huirne et al., 1993). Three exercises were included in this part of the workshop. The first one was about breeding goals, in which farmers rank traits in their breeding goal by dividing 100 points in such a way that the most important traits get the most points. The second exercise related to information needs for sire selection: available and missing information on sire selection were selected from an extensive list of (potential) information sources. The final exercise was focused on sire selection risk attitude. In this exercise the farmer's risk attitude with respect to sire selection was assessed, based on several sire selection problems that were solved by each farmer. In each problem, the farmer had to balance the different attributes of possible sires: price, reliability and expected production (type-production index or TPI).

The workshop ended with a round table discussion. Discussion was centered around two topics: (1) are computers essential in future farming?, and (2) how should future management systems look like? Participants share expectations and experiences on these questions.

At the end of the workshop, all the completed worksheets were collected. They were used for preparing follow-up reports that were mailed back to the participants (along with the worksheets) within a few weeks after the workshop. The worksheets served as a source of data for this research on information needs. As mentioned before, the workshops were conducted in February 1993 and repeated in February 1995. Using exactly the same worksheets in both years enables the analysis of consistency in responses of the (26) farmers that participated both times.

## 2.2    Participants

Participants for the 1993 workshop were selected as follows. From the data bank of the Dutch Dairy Herd Improvement Association (DHIA) about 150 addresses of farmers, spread over three regions in The Netherlands, were randomly selected. The only criterium was that the farmers had at least 25 black-and-white dairy cows. In total, 49 farmers responded positively to the invitation to participate in the workshops.

For the repeated workshops in 1995, first the 49 farmers who participated in 1993 were approached and invited. 26 farmers were able to come to the workshop for the second time. Furthermore, 14 'new' farmers (also randomly selected) were willing to participate. So, the 1995 workshops had 40 participants.

As we were not able to conduct a non-response analysis, it may be possible that farmers participated who were particularly interested in topics such as 'decision making', 'information use', and 'sire selection'. This self-selection bias must be kept in mind in interpreting the results of this study.

## 2.3 Data analysis

Two major methods were used to analyze the data collected in the workshops: group comparison and factor analysis. In group comparison, data are divided in a number of groups according to a certain key-variable. Then averages per group are calculated, and used to compare the groups. Using group comparison, data from the 1993 and 1995 workshops were split into a number of groups, and the group averages were calculated and presented. Statistical testing of differences between groups was done with the following SAS-procedures: PROC TTEST (t-test), PROC FREQ/CHISQ (Chi$^2$-test), PROC NPAR1WAY (Kruskal-Wallis-test). This was only done for groups that involved the 26 farmers who participated in both workshops.

The second technique applied was factor analysis. Factor analysis represents the covariance within a $\kappa*1$ vector $x_t$ of observables in terms of their mutual dependence on a smaller $\lambda*1$ vector $f_t$ of 'hidden factors', where $\lambda<<\kappa$ (Sargent, 1993). The second-moment matrix (correlation matrix; $V=Ex_t x_t$) is restricted to be the sum of a matrix of rank $\lambda$ and a diagonal matrix: $V = LL\cdot + D$, where L is a $(\kappa*\lambda)$ matrix and D is a $(\kappa*\kappa)$ diagonal matrix. The model can also be represented as $x_t = Lf_t + \epsilon_t$, where $Ef_t f_t = I_\lambda$, the $(\lambda*\lambda)$ identity matrix, $E\epsilon_t \epsilon_t = D$, and $Ef_t \epsilon_t = 0$. The $(\lambda*1)$ vector $f_t$ is composed of "hidden factors", while the $(\kappa*1)$ vector $\epsilon_t$ contains idiosyncratic noises.

The factor analysis model asserts that all of the covariance within the $x_t$ vector is intermediated via the action of a much smaller number of hidden factors. The use of the model in this research is interpreting farmers' answers (i.e. scores) given in several tests of the workshop. Here $x_t$ is a vector of farmer t's scores on $\kappa$ tests on various subjects, such as goals, and information needs. So, factor analysis is mostly used for building linear models designed to summarize the most important source of variance within a data set $x_t$.

## 3.    Results

### 3.1    Description of the participants

As described before, 49 dairy farmers participated in 1993 and 40 in 1995, and 26 of them participated in both workshops (further denoted as '26-farmer core group'). The age of the farmers varied between 22 and 60 (1993) and between 25 and 60 (1995) years. The average age was 40.6 years (1993) and 42.6 years (1995). The average size of the farms was 66 cows, 65 replacements, 30 ha of pasture, and 7 ha with crops (1993) respectively 70 cows, 66 replacements, 33 ha of pasture, and 8 ha with crops (1995). The farms had 1.7 (both in 1993 and 1995) operators, while 50% (1993) respectively 68% (1995) was involved in a partnership. More than half of all farmers used a PC and a feeding computer, both in 1993 and 1995 (table 1).

As can be read in table 1, the 26 farmers that participated in both workshops (core group) differed significantly between 1993 and 1995 with respect to hectare of cropland, milk production per cow, and percent with partnership.

The results of the core group are slightly higher than the whole group. However, farm characteristics of all participants are much above the national averages. This means that the workshop participants had relative large, well automated farms with above-average results.

Table 1  Average farm information of the participating dairy farmers

| Variable | Whole group farmers | | 26-farmer core group | |
|---|---|---|---|---|
| | 1993 | 1995 | 1993 | 1995 |
| Number of participants | 49 | 40 | 26 | 26 |
| Number of dairy cows | 66 | 70 | 73 | 75 |
| Number of replacements | 65 | 66 | 70 | 71 |
| Pasture (ha) | 30 | 33 | 34 | 34 |
| Cropland (ha) | 7 | 8 | 6 a) | 8 a) |
| Milk production/cow (kg) | 7,769 | 8,176 | 7,905 a) | 8,286 a) |
| Number of operators | 1.7 | 1.7 | 1.9 | 1.8 |
| Percent with partnership | 50 | 68 | 50 a) | 73 a) |
| Percent with PC | 63 | 58 | 42 | 50 |
| Percent with feeding comp. | 42 | 73 | 65 | 73 |

a) Significant difference (p < 0.1).

On average the farmers used 10 sires to breed their herds in 1993, and 11 sires in 1995. The most popular sire in 1993 turned out to be Sunny Boy. He was selected 35 times in the farmer's top-3, followed by Ideal, Nordkap and F16. In total the 49 farmers mentioned 50 different sires in their top-3. In 1995, Jabot was the most popular, followed by Sunny Boy and Celcius.

In table 2, some breeding practices of the farmers are outlined. Notice some remarkable (but non-significant) differences between 1993 and 1995. 42% of the farmers used the advice from other people (classifier, technician or semen salesman) in their sire selection (1995: 51%). Beef bulls were more popular in 1993 than in 1995. As much as 60% of the farmers was a member of a local group that exchanges breeding information and ideas in 1993. That

Table 2  Breeding practices of the dairy farmers

| Topic | Whole group farmers | | 26-farmer core group | |
|---|---|---|---|---|
| | 1993 | 1995 | 1993 | 1995 |
| Do-your-own AI | 19% | 20% | 23% | 19% |
| Advice of classifier, etcetera | 42% | 51% | 42% | 44% |
| Local group info exchange | 60% | 43% | 54% | 46% |
| Embryo transfer | 21% | 23% | 23% | 31% |
| Using beef bulls | 38% | 20% | 31% | 15% |

number decreased to 43% in 1995. The 26-farmer core group was not much different from the whole group (see table 2).

## 3.2 Business goals

The average number of points attached to the four most important business goals is presented in table 3. In 1993 the most important business goal was finding the best balance between costs and returns (16.3 points). Give attention and care to the livestock (14.5 points) and make the best possible or highest technical results (12.4 points) ranked second and third, followed by maximizing the annual profit (11.6 points). These four business goals also ranked 1 through 4 in 1993 for the 26-farmer core group, even in the same order. In 1995, the same 4 goals received most points. However, the order was different. Maximize the annual profit ranked highest (15.6 points), followed by finding the best balance between costs and returns (15.4 points). A remarkable shift was observed for the business goal to increase the size of the farm (6.1 points in 1993 versus 10.1 points in 1995). However, in the core group this shift was much smaller (table 3). The most important goals of the core group were in 1995 similar as in 1993.

*Table 3    The most important business goals of the dairy farmers*

| Business goal | Whole group | | Core group | |
|---|---|---|---|---|
| | 1993 | 1995 | 1993 | 1995 |
| Finding best balance between costs/returns | 16.3 | 15.4 | 18.1 | 17.0 |
| Give attention and care to the livestock | 14.5 | 13.1 | 16.3 | 15.1 |
| Make best possible/highest techn. results | 12.4 | 10.2 | 12.4 | 11.1 |
| Maximize the annual profit | 11.6 | 15.6 | 12.4 | 14.1 |
| Keep costs of farm as low as possible | 8.7 | 6.4 | 5.5 | 4.8 |
| Gain the highest possible farm returns | 7.8 | 4.9 | 9.3 | 3.6 |
| Increase the size of the farm | 6.1 | 10.1 | 4.9 | 6.6 |
| Transfer business ownership to children | 4.9 | 5.8 | 7.0 | 8.4 |
| Have time for leisure and family activity | 4.2 | 6.4 | 2.6 | 6.4 |
| Make highest prod. with lowest effort | 3.4 | 3.8 | 3.1 | 4.1 |
| Maximize the efficiency of labor resources | 3.3 | 2.9 | 3.5 | 3.6 |
| Quickly adapt to new developments | 2.7 | 0.8 | 1.4 | 0.0 |
| Use environmentally sound practices | 2.6 | 1.7 | 2.5 | 1.8 |
| Produce with low purchased inputs | 1.5 | 2.9 | 1.0 a) | 3.4 a) |

a) Significant difference (p < 0.1).

Goals that were commonly considered as being relatively unimportant in 1993 and 1995 included quickly adaptation to new developments, making the highest production with the lowest amount of effort, maximizing labor efficiency, using environmentally sound practices, and producing with low pur-

chased inputs (table 3). The latter, however, showed a significant increase in the core group (from 1.0 to 3.4 points).

If the focus, however, is shifted to changes in individual responses on the business goals worksheet, some significant changes over time can be observed. The consistency in selected business goals of individual farmers (core group) between 1993 and 1995 was 53.4%. This means that (on average) farmers gave 53.4 points to the same goals in 1993 and in 1995. So, 46.6% of the points were given to other goals in 1995 (i.e. the inconsistency in responses is 46.6%). Major changes in responses were observed for the goals of finding the best balance between costs and returns, and the goal of maximizing annual profit.

More detailed analyses have been carried out with factor analysis. The objective was to gain more insight into relationships between risk attitude and other personal characteristics of the farmer, characteristics of the farm business and breeding traits. Eleven so-called hidden factors explained 71% of the variance in the data set, which included 39 selected variables. Each factor was described and explained by way of a group comparison. Classification with respect to the management styles 'risk-taking' versus 'risk-avers' showed that farmers who faced themselves as risk-taker, had more economic oriented goals, produced more milk per cow, were not very risk-avers in their sire selection (see next sections), and see themselves more as a 'fanatic farmer'. Classification with respect to farming styles made clear that 'practical farmers' had the least economically oriented goals and usually faced themselves as risk-avers. The 'cow farmers' realized the highest milk production level per cow.

## 3.3    Breeding goals

In determining the most important traits in their breeding goals, the farmers had to divide 100 points over 14 possible traits: points assigned to one trait could vary between 0 and 100. Table 4 summarizes the average scores of the 1993 and 1995 workshops. Kg milk was the most important trait for the whole group both in 1993 and 1995. This trait was followed by feet and legs (12.5 points) in 1993 and by type-production index (15.7 points) in 1995. As could be expected, because of the current milk and fat quota system, percentage fat and kilogram fat were the least preferred traits in the farmers' breeding goals.

When looking to the differences for the 26-farmer core group between 1993 and 1995, a significant difference can be observed for the importance of feet and legs: this trait dropped from 15.0 to 12.8 points (table 4). Another change, but not statistically significant, was the increase in importance of the type-production index (from 11.7 to 16.8 points) and the decrease in importance of protein traits (i.e. percentage protein and kilogram protein). In general however, the ranking of traits we almost the same in both years.

If the changes in responses of the (core group) farmers on an individual basis is studied, the following conclusions can be drawn. There is a 65.8% consistency between the responses in 1993 and 1995. This means that farmers gave 34.2 points to other breeding goals in 1995 compared to 1993. Major changes were observed for the TPI breeding goal.

*Table 4    Relative importance of traits in the breeding goal of the farmers*

| Trait in breeding goal | Whole group | | Core group | |
|---|---|---|---|---|
| | 1993 | 1995 | 1993 | 1995 |
| Kilogram milk | 15.4 | 16.8 | 13.3 | 13.8 |
| Feet and legs | 12.5 | 12.5 | 15.0 a) | 12.8 a) |
| Udder | 12.3 | 12.3 | 14.0 | 12.4 |
| Kilogram protein | 11.8 | 8.1 | 11.2 | 10.1 |
| Type-Production Index (TPI) | 10.4 | 15.7 | 11.7 | 16.8 |
| Percent protein | 9.0 | 10.4 | 10.0 | 9.2 |
| Total type | 8.3 | 9.7 | 8.1 | 9.4 |
| Body capacity | 4.6 | 2.4 | 3.9 | 2.7 |
| Fertility | 4.0 | 3.4 | 3.0 | 2.8 |
| Milkability | 3.6 | 3.0 | 3.1 | 3.3 |
| Calving ease | 3.6 | 2.1 | 3.3 | 2.2 |
| Rump angle | 1.8 | 1.2 | 1.6 | 1.3 |
| Percent fat | 1.4 | 1.6 | 1.0 | 2.2 |
| Kilogram fat | 1.3 | 0.8 | 0.8 | 1.0 |

a) Significant difference (p < 0.1).

## 3.4    Information needs for sire selection

In 1993 and 1995, most farmers (96%) subscribed to a national Magazine for Cattle Breeders. 80% of the farmers used information of the bull charts and the catalogue of their AI-organizations in their sire selection process. About half of the Dutch farmers used advertisements in magazines, while about 25% of the farmers mentioned their classifier, technician, semen salesman, or neighbors/friends as an information source. There were no (significant) changes between 1993 and 1995 in this respect.

Table 5 gives an overview of the information that is actually available (and used) by the farmers. The bottom part of the table indicates the information that the farmers would like to use, but that was not (yet) available to them. Notice the difference in use of information on the predicted transmitted ability (PTA) Type (1993: 90% versus 1995: 79%), price per unit (1993: 81% versus 1995: 62%) and sire and maternal grandsire (1993: 71% versus 1995: 49%). Most farmers (81% in 1993 and 79% in 1995) would like to have available information on longevity.

Looking to the responses of the core group, a similar picture arises. Within this group, however, the price per unit dropped significantly, while information on milking speed showed a significant increase.

*Table 5    Ranking of available and missing information for sire selection*

| Type of information | Whole group | | Core group | |
|---|---|---|---|---|
| | 1993 | 1995 | 1993 | 1995 |
| **Available information** | | | | |
| PTA Milk, Fat and Protein | 98% | 95% | 96% | 92% |
| PTA Type | 90% | 79% | 92% | 81% |
| Reliability value | 88% | 77% | 77% | 77% |
| Price per unit | 81% | 62% | 85% a) | 62% a) |
| TPI | 79% | 87% | 73% | 88% |
| Sire and maternal grandsire | 71% | 49% | 69% | 58% |
| Calving ease | 67% | 72% | 65% | 69% |
| Milking speed | 63% | 72% | 54% a) | 81% a) |
| Culling percentage | 54% | 38% | 46% | 35% |
| Pictures | 29% | 31% | 31% | 38% |
| **Missing information** | | | | |
| Longevity | 81% | 79% | 73% | 73% |
| Daughter fertility | 62% | 72% | 65% | 73% |
| Disposition | 60% | 54% | 62% | 58% |
| Disease resistance | 52% | 46% | 46% | 42% |
| Muscularity | 19% | 10% | 12% | 12% |

a) Significant difference (p < 0.1).


## 3.5    Risk attitude with respect to sire selection

Risk attitude of the farmers with respect to breeding values (TPI) was subdivided into four classes: risk seeking, risk neutral, slightly risk avers, and strongly risk avers. The risk attitude was determined in an exercise, in which the farmers had to find a 'point of indifference' between a risky option (50% probability that a certain sire will have a low TPI, and a 50% probability that he will have a high TPI) and a certain option (TPI is known with certainty): the so-called ELCE-method (Anderson et al., 1977).

Risk attitude with respect to breeding values was significantly different between 1993 and 1995. In 1993 most farmers turned out to be slightly risk averse (53%) or strongly risk avers (12%). This means that these farmers would accept a lower TPI to reduce risk in sire selection. In other words, these farmers would be willing to pay a certain amount of money (or TPI) to avoid a risky choice. In 1993, 25% of the farmers was risk seeking. In 1995, however, only 8% of the farmers was risk avers, while 46% was risk neutral and 46% was risk seeking.

If the price of semen with TPI of 1,250 would increase from $25 to $100, farmers reacted in the same way in 1993 and 1995. Most farmers would buy the expensive high-TPI-semen for only a part of their herd. If the semen gets more expensive with a higher reliability, farmers were willing to pay the higher price for their best cows both in 1993 and 1995. They would buy cheaper semen with a lower reliability for minor cows.

Comparing the individual responses of the core group farmers, a consistency of only 23.1% was observed. This means that the risk attitude of 76.9% of the farmers (i.e. 20 from the 26) changed between 1993 and 1995. All these changes went in the direction towards more risk seeking.

As explained before, with factor analysis the data set was analyzed further. The hidden factors determined by the factor analysis did not provide a clear conclusion with respect to risk attitude. The farmers' own view on their risk attitude with respect to sire selection partially matched the risk attitude measured in the exercises.

## 4. Final remarks

There are several methods to derive information needs. One of these, i.e. workshops with dairy farmers as participants, is described in this paper. The findings are based on six workshops. More workshops are desired in order to be able to do sound statistical analysis. Therefore, the workshop results are described in broad terms, and have to be interpreted with care. Results obtained with the workshops are in line with results of earlier workshops conducted in the USA and The Netherlands in the field of information management of dairy and swine farms (Huirne et al., 1993; Huirne et al., 1994). However, it is recommended to explore other methods to derive information system needs as well. Direct questioning received, with respect to this problem, positive criticism in The Netherlands (Verstegen et al., 1995) and the USA (Harsh et al., 1992). Further research is needed to evaluate and compare the results obtained from different methods.

Comparing the average results from the farmers who participated in both workshops (core group) as a group, there are not so many significant differences between 1993 and 1995. In other words, there is a high consistency in average results. However, if focus is shifted to the responses of individual farmers, then the conclusion is that there are significant changes between 1993 and 1995, i.e. on an individual basis there is only a low consistency in goals (both business and breeding goals), information needs and risk attitude.

What is striking about deriving information needs and risk management strategies is the central importance of people rather than technology. This emphasized a fact that must be realized and remembered by both users and developers of farm information systems. The computer is a tool with enormous potential. Like any tool, however, its usefulness depends largely on its suitability for the task at hand and on the skills of its users. Similar finding were reported by King et al. (1992). More research is needed in this unexplored field of user-oriented research.

With the new insights gained into farmer's information system needs, several management systems may have to be re-implemented. The most common strategy for this is the so-called 'life-cycle' approach (Davis and Olson, 1985). It consists of three major stages: (1) definition, defining information requirements, (2) development, translation of the requirements into a physical management system, and (3) installation and operation, testing and putting

the management system into operation. The first (definition) stage of the life cycle should be based on farmer's information needs research, like the current project. This will lead to a new product for the second and third stage, and eventually to more suitable and successful, user-oriented management systems. Research is under way to determine such new directions for system development.

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# MANAGEMENT SUPPORT IN AVIARIES FOR LAYING HENS: GOALS, CRITICAL SUCCESS FACTORS, INFORMATION NEEDS, A MANAGEMENT CONCEPT AND MANAGEMENT TOOLS

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## Abstract

*Aviary housing systems have been developed to improve the welfare of laying hens, but they require an other management than cage systems. To reduce the difference in cost-price between eggs produced in aviary systems and cage systems and to control the variation in the production circumstances, adequate tools to support daily management are needed. This paper describes the aviary farmer's goals, critical success factors, information needs, and the selection of an appropriate management concept. The aviary farmer's goals are 1) the efficient production of high quality eggs, 2) a welfare friendly treatment of the hens , and 3) a long-term profitability of the farm. The control of feed consumption, ambient temperature and the early detection of diseases are the three main critical success factors. Timely and reliable information is needed on feed consumption, egg-production and diseases per group of hens or per compartment in an aviary system. The Poultry Information Model was adopted as a suitable management concept. An analysis of the daily management functions 'operational planning', 'implementation' and 'operational control' for three critical success factors resulted in the recommendation of management tools for the function of 'operational-control'.*

**Key-words** : management support, aviary system, information needs

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## 1. Introduction

Modern poultry production is characterised by large flocks and high investments in buildings and equipment (Renkema, 1992). The number of egg-producing farms in the Netherlands decreased with 48% since 1980 to 3241 farms in 1993. In the same period the total number of hens increased 12% to 29.8 million hens in 1993 (CBS,1993). More than 70% of the hens are housed on 15% of the farms and these farms have more than 20.000 hens (NN,1993).

The welfare of poultry has become an important issue in the last 30 years (Elson, 1989; Appleby et al., 1992; Blokhuis & Metz, 1992; Blokhuis & de Wit, 1992; Wit de, 1992). Social and political pressure were the main reasons for developing alternative housing systems for the cage system (Appleby et al., 1992). In the Netherlands aviary housing systems for flocks of 15.000-25.000 hens are built as a welfare friendly alternative for the still widespread cage system (Blokhuis & Metz,1992). An aviary system is basically a traditional floor housing system with extra tiers of slats or wire to increase the use of the vertical space in the house (Appleby et al., 1992). A stocking density of 20-25 birds per m² floor area can be attained, which is comparable with the stocking density of a three-tiered cage system. Traditional floor systems usually have less than 7 birds per m² floor area.

Income margins on poultry farms are small and thus income is extremely susceptible to a drop in the price of eggs and to deficient technical input/output ratios (Renkema, 1992). Consequently, poultry farmers are trying to decrease risk and to find ways of increasing the ratio between production value and production costs. The cost price of eggs produced in aviary systems is 8-15% higher than that of eggs produced in cage systems (Elson, 1989,1992; Meierhans et al., 1992). Van Horne (1991) found a 7-12% higher cost price for the Tiered Wired Floor (TWF) aviary system (20 hens/m² floor area). A greater feed consumption, higher housing costs and an increased risk of more variation in the production results were important factors responsible for the higher cost price in aviary systems.

Management, which is the decision-making process in which limited resources are allocated to several production alternatives so that goals and objectives are attained, is a complex and difficult task because it takes place in a risky and uncertain environment (Kay, 1986; Huirne, 1990). Management in aviary systems differs and sometimes is found to be more complex than management in cage systems because hens are housed in large groups, so they have more freedom to move (Elson, 1992; Meierhans, 1992). Furthermore, hens in aviary systems have more contact with their droppings (litter), which increases the risk of a fast spread of infectious diseases, bumble foot, worm infections and red mites (Appleby et al., 1994; Bosch & Niekerk, 1995). Eggs laid on the floor or on the tiers cause much extra labour and there is an increased risk of second grade eggs. Flock dynamics also can cause severe problems. If too many hens accumulate, they die from suffocation. In an aviary system the poultry farmer has to walk through the hens during the obligatory daily inspection, so there is a different interaction between the poultry farmer and the hens, which can result in other information from the flock than in cage systems.

According to Ziggers and Bots (1989) there is a correlation between negative financial results and complex decision situations; they concluded that financial results could be improved by the use of management tools that improve the quality of the decisions and Sainsbury (1992) found that successful farms are those that react quickly to any risk or appearance of diseases. Based on the findings of Ziggers and Bots (1989) and Sainsbury (1992) one can conclude that effective management tools are necessary for controlling the decision situations in aviary systems for laying hens.

Recent technological progress in computer hardware and software and a rapid decline in the costs of computers have increased the opportunities for effective computer-based support of farm management (Day, 1991; King et al., 1990; Lanna & Streeter, 1994). Belyavin (1988) concludes that the poultry sector is ideally suited to use computer technology, because of the intensification of poultry farms.

The main goal of our study is to develop computer-based management tools for the aviary farmer, to enable him to plan and control the complex production process based on an optimal use of daily data. This paper describes the aviary farmer's goals, critical success factors and information needs and the selection of an appropriate management concept. It also analyses the daily management functions operational planning, implementation and operational control for three critical success factors and an advice is given to develop management tools to support daily management in aviary farms for laying hens.

## 2.    Goals, critical success factors and information needs

Before tools that support daily management can be developed, the goals, critical success factors and information needs to support these critical success factors are determined. Comparable results of Huirne et al. (1993), which were obtained by using workshop and interview techniques, from pig and dairy farms were used together with a literature research and discussions with poultry experts, to determine the goals, critical success factors and information needs for aviary poultry farms (table 1).

### 2.1    Goals

The most important goals on pig and dairy farms are 1) the efficient production of meat c.q. milk, 2) the realization of optimal technical results and 3) to ensure the long-term profitability of the farm (Huirne et al., 1993). For pig farms the fourth goal was the production of high quality products, but for dairy farms the fourth goal was the optimal treatment of the animals (Huirne et al., 1993). Important goals for aviary farms of laying hens are 1) the efficient production of high quality eggs, 2) an optimal treatment of the hens (for their welfare), and 3) a long-term profitability of the farm. Efficient production in this case means the realization of optimal technical production results against low costs. High quality eggs in aviary farms mean a low percentage of floor eggs and a low percentage of second grade eggs.

## 2.2 Critical success factors

The critical success factors for production management on pig and dairy farms were disease control, heat detection and feed cost control. Control of the feed consumption, control of the ambient temperature and disease control are important critical success factors on aviary farms. Feed costs amount to 60-70% of the total production costs and they are partly responsible for the difference between the cost price of eggs from aviary systems and cage systems (Horne, 1991; Luiting, 1991; Renkema, 1992).

The control of the ambient temperature in the aviary house is of interest, because egg production and feed- and water consumption are related to the ambient temperature (Belyavin,1991; Kampen van, 1984; Marsden & Morris, 1987). With an increasing ambient temperature between 10°C and 30°C, the feed consumption decreases more as the egg production (Kampen van, 1981; Marsden et al., 1987). Marsden and Morris (1987) calculated that energy available for egg production was maximum at 23°C for brown hens and maximum at 24°C for white hens.

Table 1    Goals, critical success factors and information needs for aviary housing systems for laying hens

| **Goals** |
|---|
| 1    efficient production of high quality eggs |
| 2    optimal (welfare friendly) treatment of hens |
| 3    long-term profitability |
| **Critical Success Factors** |
| 1    control of feed consumption |
| 2    control of ambient temperature |
| 3    early detection of diseases |
| **Information needs** |
| 1    fast and up-to-date data on feed consumption, diseases and production results |
| 2    detailed daily information per group of hens or per compartment |

Early detection of diseases and disease control is also a critical success factor (Keirs et al., 1991; Blokhuis & Metz, 1992; Sainsbury, 1992; Rives, 1993). The spread of diseases in an aviary system can differ from a cage system. In a cage system the only contact between hens is limited to hens in adjacent cages. Bosch and Niekerk (1995) recorded disease data from 17 flocks in aviary systems. Treatments were needed in 16 flocks, which suggest that it is important to be aware of possible disease. However, only in five of the 16 treated flocks a decrease in the production results was found, which indicates that the poultry farmers use more information besides the production results. No data on treatment and disease were available for cage systems, so a good comparison was

impossible. Appleby et al. (1994) stressed that, compared to cage systems, there is a higher risk in floor-housed flocks of infectious diseases, endo- and ecto-parasitism, pathological conditions of the feet and problems caused by atmospheric contamination, both dust and noxious gases. In cage systems, however, there is a higher risk of fatty livers and osteoporosis.

## 2.3    Information needs

Information is needed to reach the farmer's goals and to control the critical success factors. The effectiveness and the efficiency of management can be improved by using reliable and timely information (Bots et al., 1990; Dean & Wellman, 1991; Devir et al., 1993). Information is based on data that are transferred and interpreted in the context of a specific problem (Harsh, 1978). If data are transformed into the right information, they can be used to support different decisions, but the value of information changes with time (Harsh, 1978; Beetley & Gifford, 1988). In general, the older the information, the less it is worth.

Information needs concerning production management on pig and dairy farms were 1) fast and up to date information on actual and possible diseases, 2) detailed production and reproduction information on individual animals and 3) information on feed costs and rationing balancing. In the same way for aviary systems it is important to have fast and up to date information on actual feed consumption, possible diseases and production results.

The production unit under the farmer's control in aviary systems, will be a flock that is housed in the whole house or a sub-flock that is housed in a compartment. A compartment then is a physically separated part of the house. Within a compartment hens of the same age and strain are housed and have the freedom to move around freely. The size of the production unit may differ from farm to farm. In smaller production units aberrations in the production process could cause more statistical variation in the production data. Consequently, these aberrations may be detected easier and there will be probably more time to take the right measures. The size of the production unit also depends on the feasibility of collecting data. All relevant data, such as egg numbers, egg weight, feed consumption, water consumption and body weight must be determined per production unit.

In new problem areas or husbandry systems, such as aviary systems are, it must be determined first which information can be gathered and what this information conveys about the state of the production process, because the method of data collection influences the quality of information (Lanna & Streeter, 1994). Therefore, it is necessary to know the characteristics, such as averages and variation of specific variables and relations between variables in different production circumstances and in different production units.

At present, most poultry farmers send their weekly production data to their feed suppliers, who transform the data into standardised management reports. Only a small number of poultry farmers use a Personal Computer with a Management Information System (MIS) on their farm (ATC, 1994). The MIS on the farm performs the same tasks as the central data processing. Its main task

is to register flock data and to produce weekly or four-weekly reports and graphs of the production results. Flock data are gathered daily, but are aggregated to weekly or monthly indices. This inevitably means a loss of information. When data are processed on the farm using a MIS, it becomes possible to produce daily reports, and short time aberrations in the production process can then be detected more easily. A period of one full day will be an appropriate time horizon for managing the poultry production process in aviary systems.

## 3.    Management concept

A management concept is a model that describes all relevant decision-making processes of a farm and their mutual relations and it is used to understand better the management of a farm. The choice of a management concept depends on the type of organisation and the type of problems/decisions it must be used for (Bots et al., 1990). To adopt a suitable management concept, one can look at 1) the internal consistency, 2) the level of detail, 3) the validity and 4) the transferability (Bots et al., 1990).

The management concepts of strategic, tactical and operational management (Blumenthal, 1974; Boehlje & Eidman, 1984), the Wageningen Operations Approach (Kampfraath & Marcelis, 1981), the paradigm of de Leeuw (1982), the Poultry-Information-Model (PIM) (COVP, 1986) and the model of In 't Veld (1992) are compared on the four points mentioned by Bots et al. (1990). They are all internally consistent and valid. However, they differ in the degree of detail and the transferability. The PIM has been adopted as the management concept for aviary systems, because this model has already been introduced and accepted into the poultry sector (it is transferable) and because it describes different levels (strategic, tactical, operational management) in detail.

The PIM is a complete description of a poultry farm and it gives a representation of the decision moments (process model), the information flows and the data structure of a farm (data model). Within the PIM functions and processes are distinguished. A function is defined as a part of a farm that is coherent in the same information needs (COVP, 1986). A process is a part of the function that can be executed separately. The PIM distinguishes three main functions, namely 1) strategic and tactical planning, 2) operational management and 3) evaluation, which is shown schematically in figure 1.

The daily control of the production process is modelled in the main function 'operational management' of the PIM. Operational management is subdivided into operational planning, implementation and operational control (COVP, 1986). Operational planning concerns the short-term decisions, in compliance with the actual daily results, that are focused on the implementation of the tactical plan. The tactical plan is a result from the tactical planning. Operational planning, therefore, concerns the day-to-day decisions. Implementation is the realisation of the operational planning. Operational planning and implementation are applied to processes within functions (figure 1, husbandry function, egg production function, etcetera). Each function contains an operational control process that is concerned with the comparison of the operational
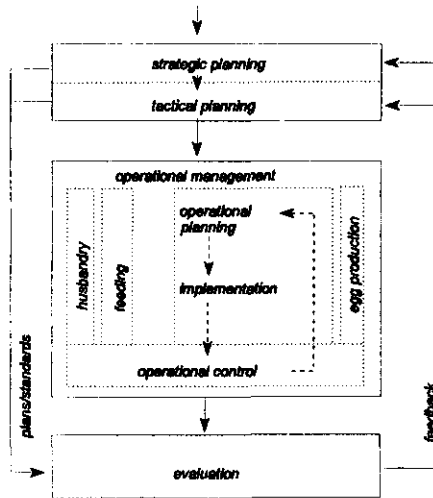
*Figure 1    The management concept used in the Poultry Information Model (according to COVP, 1986)*

plan and results achieved and with the harmonisation with other functions. Results of the short-term operational control are the input for the next cycle of operational planning, implementation and operational control (COVP, 1986).

## 4.    Management tools

The daily cycle of operational planning, implementation and operational control is analyzed for the three critical success factors, control of feed consumption, ambient temperature and the early detection of diseases. Recommendations are given to develop adequate management tools.

### 4.1    Control of feed consumption

Two operational planning techniques for the determination of the daily feed consumption for a flock of hens can be distinguished. The first is based on calculating the planned feed consumption, and the second is based on *ad lib* feeding.

Feed consumption depends on the body weight, daily growth, egg production, ambient temperature, plumage condition, air velocity, genotype, activity, available area per hen, feed trough length and the shape, structure and concentration of the feed (IKC, 1994). Only a limited number of these variables

are used for the actual planning of the feed consumption. The Dutch Extension Service (IKC,1994) gives formula's to calculate the daily feed consumption, which are based on the egg production (kg/day), growth per day, the body weight and ambient temperature. It is also possible to use standards that are delivered by the feed- or breeding company. Instead of calculating the planned feed it is read from the standard.

The second planning technique, which is most used in practice, is feeding the hens *ad libitum* till an age of 35 weeks and from then on restrict the hens in feed. The farmer looks for the optimum feeding strategy by reducing the amount of feed step by step. This is allowed as long as the egg production (egg number and egg mass), and the body weight remain at the same level or improve. This method is appropriate for hens older than 35 weeks, when there can be a certain amount of luxury consumption (Luiting, 1991). Finding the optimum feeding strategy for laying hens with this planning technique is more or less trial and error.

Implementation of the planned feed consumption in modern poultry houses is done by feed-computers. A feed-computer is a process computer that performs the daily distribution of the feed in the house (ATC,1994).

Operational control consists of the comparison of the planned feed with the actual feed consumption. This can be done when the feed consumption is really planned, so based on the planning method one, the formula's and the standards. If the planning method is 'trial and error' it is necessary to compare the actual egg production and body weight with their expected values. Differences between the expected and actual performances and changes in other functions, such as the number of hens in that flock, will be used to determine the corrective actions (more, the same or less food) for the next cycle of operational planning, implementation and operational control.

## 4.2 Control of the ambient temperature

The operational planning of the ambient temperature is kept very simple. The farmer sets the desired temperature somewhere between 20 and 25°C and changes this only when outdoor climatic circumstances are extreme (very cold or warm). Sometimes he uses two set points, one for the light period and one for the dark period. The implementation is performed by very sophisticated computer based climate computers and the poultry farmer completely relies on the existing control technology that is incorporated in these climate computers (ATC, 1994). Controlling the ambient temperature is typically a process that takes place within a 24 hours period. Nevertheless, the poultry farmer checks at least once a day the realised ambient temperatures and compares them with the set points.

## 4.3 Detection of diseases

Operational planning for the critical success factor disease control is difficult. It cannot be planned to detect possible diseases. What could be planned is the implementation of a vaccination scheme. To prevent diseases a strict vac-

cination scheme should be followed, but this is a results of the tactical planning. Implementation consists of the actual vaccination and the collection of data for the disease control. Vaccination (preventive) or medication (curative) could be done by spraying, addition in food and water or by individual injections. Detection of diseases is based on data that are collected in the hen house. The farmer uses his senses (ears, nose and eyes) to observe the hens, the droppings and the litter in the house. These data are classified qualitatively, for instance: good or bad, and brown or red. Beside these qualitative data, the farmer uses quantitative information on the egg weight, egg numbers, egg quality, feed consumption, water consumption, ambient temperature, body weight, uniformity and mortality (IKC, 1994) to detect diseases. An advantage of this type of data is that the data collection could be automated by using process computers and sensors (Belyavin, 1988; ATC, 1994; Lokhorst & Vos, 1994). Combinations of these quantitative and qualitative variables and the severity of deviations can be coupled to known diseases and aberrations in the production process, in order to detect these aberrations in time.

## 4.4 Recommendations

From the above analysis it could be concluded that at the moment the poultry farmer hardly pays attention to the operational planning of the three critical success factors. For the implementation the poultry farmer relies on sophisticated process computers. Operational control, however, asks a lot of attention of the poultry farmer. Management tools, therefore, in the first place should be aimed at supporting the operational control of the three critical success factors, control of feed consumption, ambient temperature and the early detection of diseases. Important daily quantitative variables for the operational control are egg production (egg numbers, egg weight, number of second grade eggs, number of floor eggs), feed consumption, water consumption, mortality, ambient temperature, body weight and flock-uniformity per group of hens or per compartment. Furthermore it is important to control qualitative data such as the colour of the faeces and the noise of the hens. The management tools must be able to deliver planned values (reference values) for these variables and to compare and combine them with the actual results of the group of hens. The poultry farmer gets in this way insight in the current state of the production process and he will be warned for possible aberrations in the production process concerning the three critical success factors feed consumption control, control of the ambient temperature and the early detection of diseases.

The development of such management tools and the research that is aimed at the determination of the quality of the information that is gathered in new housing systems, like the aviary system, is subject of research and will be worked out in other related articles.

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# NEGOTIATING MILK PRICES OF SMALL RUMINANTS BETWEEN FARMERS AND DAIRIES IN CORSICA: PROVISION OF A NEGOTIATION DECISION SUPPORT SYSTEM (NDSS)

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**Abstract**

*Milk pricing in Corsica is particularly affected by the secular traditions inherent in sheep farming. The situation is currently being exacerbated by the new constraints imposed by international commercialization conditions as well as by the large number of parties involved in the production and processing chain. Establishing milk prices in terms of quality presupposes: a) the definition of standards, b) the convergence of different interests. Experiments using a decision support process were recently undertaken using a NDSS made available to farmers and industrial dairies by INRA researchers. The potential of this system appears encouraging, both through the multiplication and storage of data and by the calmness of the discussions that take place around a screen-relayed dialogue owing to INRA researchers. It appears both desirable and possible for the experiment to be extended to cover other farms.*

**Key-words** : Negotiation, Negotiation support system, Quality of milk, Dairing sheep

## 1. Introduction

Like many Mediterranean regions with major social, technical and climatic constraints, Corsica, marked by its insular character, has been submitted to rather than instigated the development of commercial exchanges. These have rapidly changed from a barter system based on confidence to industrial transactions where quantity and quality of the production are paramount. Within this

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new context, our research aims to help the different concerned parties to create a positive future for themselves by integrating technical innovations, new constraints and the attitude of the other parties involved in the production and processing chain.

Having defined what is covered by the quality concept, we then trace the consequences of its inclusion in the recent developments that have taken place in a production chain that has been marked by decisions and the reevaluation of these unilateral decisions, we felt it necessary to create the conditions needed for dialogue between the two types of parties involved in the chain: the producers and the transformers. We felt that setting up a NDSS was channel worth exploring and this paper presents the processes involved, their uses and the reactions of interested parties. Given the wide range of reactions to the NDSS, we shall try to indicate the main typological lines that we observed during these negotiations.

## 2.    The role of Quality in the development of agreements

### 2.1    The production chain and its agreements

In Corsica, milk from small ruminants remains the main animal-based enterprise with a total of 100,000 animals and 10,5 million litres processed for ewes, and 40,000 animals and 6,4 million litres processed for goats (Choisis et al., 1993). In a typically Mediterranean climate (alternating drought and plethora), milk production seasons traditionally take place between the autumn and the beginning of following summer within the framework of apparently stable compromise between animal husbandry cycles, environmental resources and the demands of the milk processing industry. For nearly a century, ewe milk has mainly been collected by industrial Roquefort cheese producers. Over the last few years, in reaction to a relative overproduction in this enterprise, we have seen the development of small local industrial producers and the farm production of Corsican cheeses. Although assisted by a summertime tourist market that fairly successfully absorbs a widespread production, the chain seems somewhat handicapped in its attempts to position itself on export markets. We are currently seeing intense competition between dairies (a large number of processing units according to collected volume) alongside a lack of balance between the production period and the high consumption period (lack of quantity and quality); all of this within the framework of an essential need to retain a traditional image (symbol of quality).

### 2.1.1    Parties involved in the production and processing chain

This lack of *an overall objective* has been modelled by the authors (Bouche, 1994) by proposing that the chain be represented by articulating it around the three components of the « *Operative System* »: *Production, Administration (Control)* and *Institutional Development (Reliance)*. Using this, they demonstrate the essential need to create a « *collective decision-making centre* »

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(*comprehension, objective, design*) in accordance with the model proposed by LeMoigne (1990). This representation also makes it possible to demonstrate the essential role that could be played by information systems in the development of an organized decision-making level. The absence of a collectively organized decision-making level is made even more important by the fact that the region, like other Mediterranean countries, has undergone a number of upsets linked to the internationalization of exchanges and the standardization processes imposed by the EU. By retaining an independent approach (Choisis et al.,1994) no concerned party can truly contribute to running and building a collective future (distribution of investment aids, etcetera). Under these circumstances, a system that is incapable of introducing its own standards (or adapting them to work within a standardized framework) suffers from the introduction of external rules.

### 2.1.2   Modification of agreements

Within the *production* framework, the milk commerce (between a dairy and those that supply it) is controlled by «*domestic agreements* » (Thévenot, 1989) based on understanding and knowledge, despite a system of rules intended to place the exchanges within the framework of « *industrial or trade agreements* » (Vallerand et al., 1994). Consequently, dairies are controlled by domestic agreements in their relations with local or export markets. Generally speaking, the insular economy is still under the strong influence of domestic agreements between economic parties.

### 2.1.3   The many forms taken by Quality

The quality of the different milks and, consequently, the payment system reflecting the quality of product, is a major problem that has preoccupied those concerned by these production and processing chains for a number of years, especially those involved in north European cattle production. The *reinforcement of constraints* (Cruchant, 1993) introduced in France since 1969 was not taken into account by insular parties until the introduction of European Directive 92/46 in 1992. Currently, although milk quality is considered as being important by the administrative departments responsible for applying these directives, industrial dairies see quality as a means to reduce charges on the raw material. The real need to modify the quality of a rich milk(no content deterioration by selection) and, in terms of hygiene, that can be controlled by technology (cold, pasteurization) is poorly expressed by the dairies. This diversity of quality representations has been analyzed through meetings with a large number of concerned parties and translated into a typology (figure 1).

This typology demonstrates the central position held by the « Commercial » sector (milk payment in accordance with contents and cleanness), giving it a strategic position between the non-negotiable area of sanitary factors and faults of lesser importance linked to reversible malpractices (adulteration, etcetera). This « Commercial » sector is to be found at the interface between regulatory and voluntary issues, and simple mechanical and more

complex biological interventions. Despite the importance that it can hold for the region as a whole, it is to be found on a level that concerns the relations between the dairies and the farmers. There are also certain other characteristics that cannot be shown on this chart:

Complexity of Quality impact

(Society)
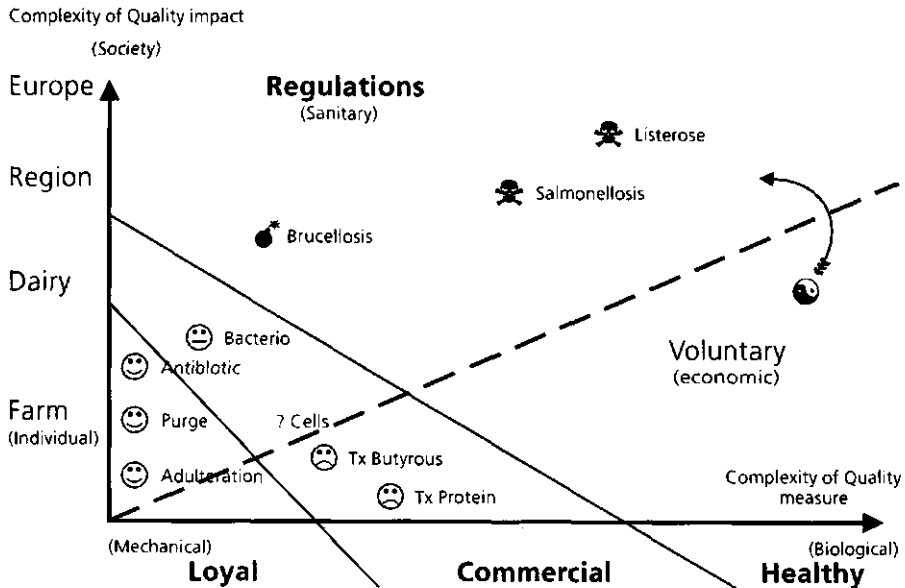


Figure 1   Milk quality typology (Bouche, 1993)

-       continuousness, between urgency (waiver up to 1998) and nonchalance (Decree since 1969);
-       immateriality, governed by an non-existent inter-professional entity;
-       constant presence in the discussions between concerned parties;
making this zone of friction a knot in the organization of the chain. This has led researchers to introduce organizational levers to try and create « a negoti-ated order » (Strauss, 1992).

2.1.4     Payment based on quality: a recently introduced system

In 1986 (Bouche et al.,1987) and in 1990, a local cooperative asked the INRA for assistance in setting up a milk payment system that takes account of the richness of the milk and its hygienic quality. The cooperative was looking for a system able to adapt a calculation methodology and carry out simulations. Despite its best intentions, the INRA found itself acting as guarantor in the choice of formula, but did not succeed in generating a negotiation between the dairy manager and the suppliers. Milk analyses have been carried out by this cooperative since 1990. The results are given to farmers but the quality-

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based payment has only been operative since the last season (1994-95). The payment system was forcefully imposed by the cooperative which, during the season, found itself obliged to modify the calculation parameters as the initial parameters were found to be overly penalizing for a proportion of the producers. As from 1992, three other private dairies introduced the same analysis protocol without, however, setting up a quality-based payment system. This approach only covers a few of the twenty existing dairies but should see itself being increasingly used over the next few years.

## 3.    The NDSS, a tool to establish dialogue

Due to the absence of exchanges and negotiations on the quality based milk payment between dairies and farmers, we felt that the construction of a NDSS (Negotiation Decision Support System) was particularly appropriate to allow the different parties to cooperate with one another in view of reaching a negotiated agreement. We felt there was a need to initiate relations, as they clearly did not exist, demonstrate the constraints of the different protagonists and ensure that these were understood by the other concerned parties.

### 3.1    Reaching an understanding

The design and setting up of systems to back *cognitive collective negotiation or cooperation processes* appears to remain relatively underdeveloped. These processes, together with problem formulation or resolution phases, should be developed in the near future (Espinasse et al., 1995). The Interactive Decision Aid Systems (IDAS) have developed alongside the growing use of computers (Lévine et al., 1990). These systems, initially differentiated around the problems concerning cooperation within production groups (Benchimol et al., 1992) and within the field of negotiation, now seem to be heading in the same direction insofar as research is concerned (Espinasse et al., 1995). The construction of a NDSS will be based on the works carried out by Fisher et al. in 1982 which established five main factors for *successful negotiations*:
a)    separate the people from the problem;
b)    provide communication between negotiators;
c)    help negotiators identify their real interests;
d)    generate options for mutual gain;
e)    use objective criteria.
Jelassi (1989) details the advantages of computerization in negotiations for each of these headings. Communications between negotiators appears to be influenced by four factors (Jarke, 1986) which need to be integrated in setting up computerized negotiations (distance between partners, time synchronization, sharing of aims and controls). Using the same approach to classify a GDSS (Group Decision Support System), DeSantis and Gallup in 1985 proposed four systems based on the separation of negotiators and the length of the session. However, although it may be said that the separation between individuals has an important impact on the transaction (cooperative work is made easier

in a closed environment and, conversely, it is preferable in a competitive situation to retain a distance, including a physical distance, between the protagonists), the systems that we shall be using are too limited to be taken into account in this typology. In 1995, Espinasse stated that the NDSS serve as mediators in terms of bringing together the respective points of view and positions of the parties, reconciling differences and suggesting compromise solutions. As a communication assistance tool for the protagonists, their aim it to reduce the emotional impact which often characterizes the exchanges and break down the barriers linked to influences and/or timidity of the parties. As systems that assist the progression of the process, they help the parties identify their interests, within the context of the confrontation, with over interests and allow the parties to evaluate the importance that they give to their particular expectations. As a third and neutral party, these systems allow the development of scenarios that take into account of the different positions being held. They should lead the protagonists to discuss their aims, worries, constraints and real objectives. Only then is it possible to develop measures which might be able to satisfy the opponent points of view (Pomerol, 1994).

## 3.2    Between Cooperation and Negotiation: Future planning

### 3.2.1    Between cooperation and conflict

Negotiation shall not be used to resolve an existing « conflict » but rather to develop a « future planning » that is common to the parties that are, by definition, competitive (or that have a protagonistic relation). Discussions between the farmer and the dairy are connected, within the same relation, to two fields that are often in opposition, competition and collaboration:
-       the paradigm of cooperation (integrative negotiation) as partners within the same chain, that common sense encourages to cooperate for a jointly developed future (product image, price policy, etcetera);
-       the phenomena of negotiated competition, where each party attempts to hold the upper hand (games theory).
Within an insular context where pastoral history has a strong influence, one should remember, to analyze this ambivalence of interests, the sociological maxim: « all against the foreigner,... , myself against my brother ». The frontier between this conjunction of interests, to ensure that everyone travels in the same direction and derives the best possible profit, remains very hazy in many interprofessional negotiations. However, the addition of formalizing third party (Bouche et al., 1995-b), the computer, to relationship can serve a useful purpose. The use of a tool that demands the formalization of exchanges and is capable of storing data is not intended to resolve antagonistic situations and can even reinforce them, thus causing blockage and conflict situations. At this point it is important to direct discussions towards future planning, an innovation which will be based on the use, within the model, of information produced from preceding seasons, thus leaving the concerned parties with the fun creative task of developing strategies for the future. The real challenge will be to successfully bring together individual long-term plans to create a collectively

imagined future based on rules that are obeyed by all concerned parties. The hypothesis developed by the authors is to use a collective formulation, in compliance with the psychological concepts of form (Guillaume, 1979) within which reformulation assists resolution (Watzlawick et al., 1975), to throw light on the *strange loop* where the application of external standards and the collective construction of specific standard overlap one another.

### 3.2.2 Outside and inside: the importance of the act

A negotiation, fundamentally an act of communication, initially requires that questions are asked concerning the overlap between the basis and the form. If one assumes that the object of the negotiation depends above all on a need that the negotiator must meet, it seems almost trivial to affirm, as stated by Bellenger (1992), that the « *interactive mode experienced* » by a negotiator has as much importance as the result obtained through the negotiation. This investment of form becomes increasingly important in rural and Mediterranean societies. The fondness that concerned parties in these societies have for the form taken by the negotiations may be said to be intrinsically dependent on the multiple resolution of needs (to be considered, to be attained, etcetera).

### 3.2.3 Respecting standards: the law

Another previously mentioned aspect must first be taken into account in the construction of the NDSS. The object of the negotiation, the « quality-based payments for milk », is introduced into a domestic universe that, apart from parties not directly involved in the system (Administration, imported standards), has no real need for this imposed requirement. It is often easier and almost normal for local parties to systematically envisage an avoidance situation each time a new decree is introduced. And even if it doesn't happen, they almost proudly try and find the best possible way to get around the new law. It is easier for a concerned party to place himself in a « reactive » frame of mind faced with a new environment than to see himself working towards its successful introduction.

To respect these consideration, the NDSS must reconcile:
- the dialogue and digital information;
- the game and interactivity;

Its translation in the field should lead the concerned parties to involve themselves in an information system that they can judge as being « intimate », inasmuch as it allows their income to be published.

### 3.3 Equipment used in the study

The study system is built around a relationship between two personal computers interlinked by cable. Each of the machines is assigned to a specific party, either dairy or farmer. Each party thus has its own specific man-machine interface (figures 2 & 3). The exchanges are set up according to two formats:

- digital, which transmits prices and productions modifications strategies;
- textual, permitting the transmission of written information.
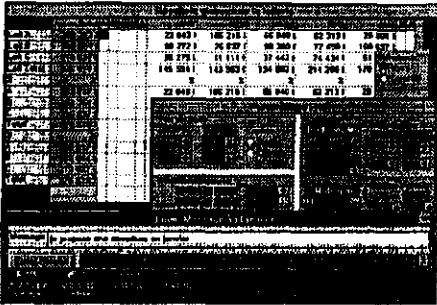


Figure 2   Dairy screen                                    Figure 3   Farmer screen
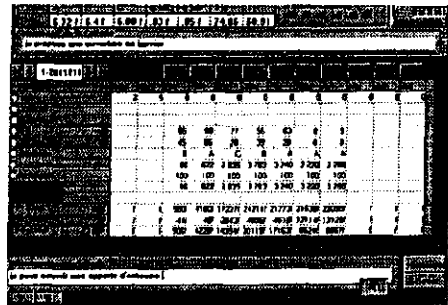
### 3.3.1    The dairy: establishing prices

The dairy can display the monthly individual results of each producer or provide consolidated general results for the dairy. The display makes it possible to successively display the number of litres, the contents, the cleanness and the financial results. The main functions are based around the interactive establishing of the price in accordance with certain parameters: bacteriology, fat content, protein content. Secondary screens make it possible to establish parameters for:
- the period that the dairy is open or closed;
- the maximum financial amount put aside for the payment of the raw material;
- the optimal monthly processing quantities.

Two specific windows allow the transmission and reception of information with the partner. Apart from the control keys, each of these windows includes:
- the text of the transmitted or received information;
- a display of the modified parameters;
- a list of messages.

Other utilities are used to make the tool ergonomic and user friendly.

### 3.3.2    The farmer: impact on revenue and compensatory strategies

Designed along the same principle as multi-windows, the farmer's terminal has the same exchange functions (transmission, reception) and the same

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ergonomy (secondary information, calculator). the main window gives him results (quantity, quality and revenue). A set of keys allows him to modify the different parameters. These are immediately expressed in terms of financial impact.

The farmer is first provided with proposed price, the collection period, the dairy's average production and a text indicating the dairy's strategy. He can measure the impact on his contributions and, consequently, simulate modifications to his production system. These modifications are retransmitted in gross and relative values.

### 3.3.3    Memorizing all events: a key to understanding strategies

In addition to the information visualized during the experiment, the NDSS also provides for storing two types of information on each of the hard disks:
-      Modifications generated by users in the intelligence phase (phase 1 of the Simon (1977) decision-making process). It is then possible to study reactions and hesitations in trying to find a satisfactory solution. It can also be used to evaluate the first criteria modified by the decision-maker.
-      All transmitted information following each transmission to other computer.

The time and chronology of each storage permits an analysis of exchanges according to a time vector (see figure 4) (period between two decision steps, speed and increasing detail of intelligence phases).

### 3.4    How the experiments were carried out

The experiments were carried out using two dairies. The games were played out in July, just after the end of milking year. The data used was the real results of deliveries and analyses carried out during this year. The proximity of climatic (drought, etcetera) and animal husbandry (lambing) events make it possible for farmers to easily gather the data.

The choice of a « field » system using two cable-linked portable computers (despite a proximity handicap) was preferred to the use of a more complicated system installed in appropriate premises. This solution meant that negotiations were carried out directly in an environment known by the concerned parties (dairy or farm).

## 4.    Results and discussion

### 4.1    Negotiation and the concerned parties

Without wishing to detail the negotiations between the authors and the concerned parties prior to the acceptance of the experiment, it is nevertheless worth noting the reluctance of the concerned parties to enter into such a close relationship or use an information system that displays the revenues of each party. Once this hurdle was overcome, the main difficulty for the participants

was « enter into the game ». There were three main reasons for this hesitation phase: apprenticeship, intelligence (as expressed by Simon) and the difficulty of approaching the issue of pricing and constructing a representation.

### 4.1.1    Collaboration as opposed to negotiation

The first experiment, deliberately carried out using a dairy manager and farmer who were friends, was only partially successful. Despite the clear interest that the two parties expressed on being shown the screens and the display of results, the negotiation went to the end after the first five exchanges as the dairy manager almost immediately proposed a satisfactory price to a farmer who was fairly well positioned in terms of quality.

This negotiation, carried out with both parties in the same room, soon showed us the limits to the advantages of proximity. The two parties rapidly found themselves using the same screen to discuss the technical improvements that could be made to farming systems rather than really carry out price negotiations.

### 4.1.2    The best shall be the first... to negotiate

We were confronted with a phenomenon that, although trivial, had a level of importance that created a bias in the pseudo-democratic process represented by this negotiation. The dairies preferred that the game be played with farmers showing the best quality results. In the eyes of the dairy, these farmers should represent the « model » to be followed by the others. We noted that these farmers were also the best equipped and the most apt to integrate and *negotiate* a quality approach and that, consequently the educational impact of the tool was therefore reduced.

### 4.1.3    Bacteriological quality: a negotiation that could work

If the richness of the milk remains, for all concerned parties, an obscure issue that is difficult to control, representations concerning the cleanness of the milk seem easier to integrate. Figure 4 traces negotiations with a farmer having relatively « clean » milk. A first phase without major modifications ❶ is followed by an excessive increase of milk A (farmer's wish) ❷. Not accepted by the dairy, a heavy penalty is then applied to class C ❸ at the same time as a reduction in the price paid for class A. Consensus is obtained whilst maintaining this penalty for class C (encountered just once in the year by this farm) and with an increase in the amount of milk paid as class A, being around 6.60 Francs ❹.

price in Francs / litre

6.8
6.7
6.6
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7

14:09    14:16    14:24    14:31    14:38    14:45    14:52

① ② ③ ④

— — — Class A        Class B    · · · · · ·  Class C
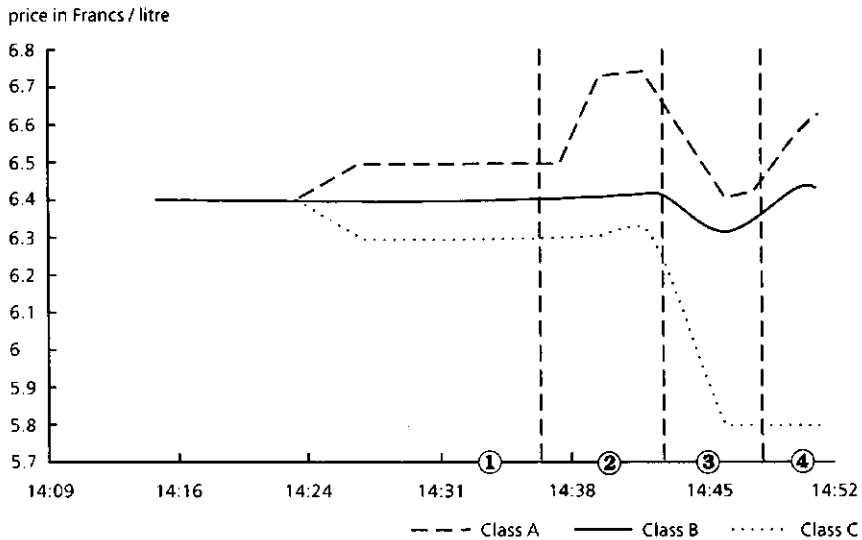
*Figure 4    Example of the development in seeking an acceptable price for bacteriological qual-*
*ity*

### 4.1.4    Absence of negotiation

During another experiment, at a time that we were much in demand by an industrial dairy to treat this question, we were confronted by a nearly complete refusal by individual farmers to negotiate. As soon as the tool was first tried out, the company manager rapidly determined a set of values that he found satisfactory and parameters for calculating the price, without seeking to make other simulations. This was despite a clear interest shown with regards to the tool and the desire expressed to use it to satisfy the needs of the dairy. According to Pomerol (1994), a problem can be defined as the difference between an actual situation and a desired situation. Making a decision to resolve a problem therefore means reducing a difference. A decision which does not modify anything can therefore be interpreted as meaning that the current situation is the one that is most desirable. The lack of will to negotiate reveals the difficulty of anticipating the reactions of farmers faced with new payment constraints. As the « good » farmers benefit from the new system, the dairy manager finds it self-evident that the « bad » farmers should simply follow the example of the « good ».

### 4.1.5    Virtual situations preferred to reality

Contact was therefore made with farmers supplying this dairy. They showed the same level of interest in the tool but it was not possible to confront

them through a « connected game ». This real-time, *irreversible* connection clearly worried them. However, as soon as the two parties no longer found themselves in the presence of one another, they accepted to enter into dialogue through the computer. The researcher became a neutral third party guaranteeing that the virtual situation could be reversed, avoided or cancelled. In this deferred negotiation, where the researcher simulated the behaviour of the other party, the moves made in the game were far more aggressive and has limits that were far less acceptable than when the parties were directly connected.

### 4.1.6    Reduced future planning for prudent parties

Despite the possibilities made available to the users by the software, they remained, in all cases, very reticent in their modifications (« Decision-making calls for imagination » Pomerol, 1994). The proposed adjustments were confined to simple modifications concerning increased milk yields or changes in the bacteriological classification. Very few players were tempted by more radical modifications, such as changes in the milking periods or partial deliveries, although they had requested that these scenarios be programmed. There is no doubt that this behaviour must be seen in terms of the « procedural rationality » of the concerned parties. They cease looking, much like in a real decision-making situation, as soon as the first satisfactory solution is found. This was despite the fact that the software was designed to encourage game-playing and offer a great deal of freedom to the players.

### 4.1.7    Negotiation taxonomy
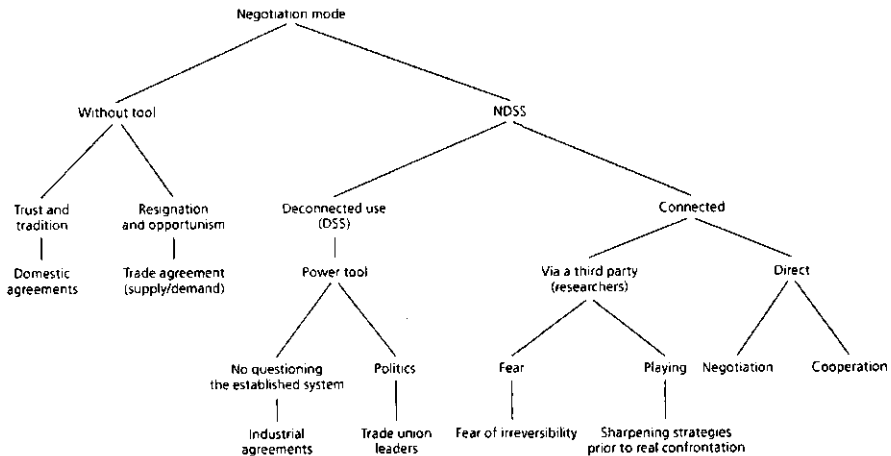


Each of the experiments we carried out revealed itself particularly fruitful, to the point that the information we offer in this paper only covers a very small area. Although we are aware that there remain a great many questions to ex-

amine in greater depth, we felt it important to classify the different behavioural patterns of the concerned parties in the form of a tree. Amongst the parties that did not see any real advantage to using the proposed tool, it was easy to pick out those with a great confidence in tradition, whose relations with their partners are dictated by *domestic agreements,* as well as those who react on a « case by case » basis to serve their direct interests and who do not wish to involve themselves in anticipatory scenarios that would prevent them from reacting to immediate situations (*trade agreements* covering supply and demand). The people using the tool can be separated into two categories: firstly, the users of the NDSS as such and, secondly, those interested in using the tool on an individual basis either to help them *justify* a standardized system imposed by *industrial agreements,* or to stand out (holder of *a technical capacity* or a *privileged relationship* with a technical world) from the others in the eyes of the partners (*opinion agreements*). The NDSS as such is itself differentiated by those who accept using it when directly connected between partners for cooperation or negotiation (*civil agreements*) and those who have accepted to play but via a third party (the researcher) to avoid being fully committed for their partner or who wish to use game-playing to refine their strategies prior to moving onto direct confrontation. It goes without saying that this simplified classification is far from complete and, above all, it's reducing for often complex phenomena, such as the different rationales of the concerned parties which lead them to change from one procedure to another.

## 4.2    Negotiation and the researcher

### 4.2.1    Opening the information system

Although the advantages of the NDSS are undeniable in formalizing the problems involved in milk payment and the role of quality in relations between the farmers and the dairy, we felt it important in this constructivist representational approach, to underline the role that such a tool can take in modifying the representations of the researcher. Although we understand the reticence of the parties to reveal their « secrets » concerning their respective revenues, once the initial investment in confidence is made between the two parties, this particular aspect was never found to be a constraint. There were very few apparent difficulties for the negotiators to have an open dialogue concerning their respective gains and losses. Conversely, once involved, we found ourselves being almost criticized for the precautions we had taken to ensure the anonymity of the results of other farmers absent on the day the negotiation took place.

### 4.2.2    Learning to use the tool

Secondly, we feared that the concerned parties would have a certain difficulty in learning to use the tool as we presupposed that they were not particularly familiar with the use of this type of data. We were also worried that the tool was not sufficiently user-friendly. To our astonishment, the farmers had no

difficulty in interpreting the screen and the data, nor in understanding the possibilities offered by the tool.

### 4.2.3    Harmonizing criteria and representations

Finally, these experiments also made it possible to consider the pertinence of criteria used in negotiation. It was strange to note that certain criteria initially proposed by the designers to display economic results (Margins, Profits) were little used by the parties. They preferred working with simplified criteria that was more appropriate to their representation of the problem (price per litre of sold milk, etcetera).

### 4.3    Contribution of the NDSS in formalizing the Quality issue

This negotiation phase between dairies and farmers led to a clear understanding of the misunderstandings and risks which could potentially reveal themselves during the setting up of an innovative measure that has not called on the participation of all parties.

### 4.3.1    Demystifying Quality

« *All that natural is good* ». This image, often used by advertisers of the industrial processors themselves, is naturally of vital importance in the positions taken by the producers who find it difficult to envisage that a « natural » milk could contain « polluted elements » imagined by foreign technocrats. Objectification by figures compared between farms or, within a farm, between periods, has a major effect in making producers more aware. This awareness is that much greater as the figures are expressed as monetary values that directly represent the farmer's revenue. For examples, the figures fairly easily recognize the increase in the bacterial load due to increased temperature during the summer period. The farmers can therefore clearly imagine structural modifications able to increase the bacteriological quality of their milk (Bouche et al., 1995-a) and therefore their revenue (refrigerating the milk, efficient washing of milking machines, etcetera). The approach that farmers and dairies can have concerning the chemical quality of milk also very interesting. We were told countless times in the field that « *our milk is the richest* », without the farmers being able to objectively prove this affirmation. Demonstrating the quality, if only through divergences from a wide ranging standard, would seem to be a very positive element. However, over and above this factor, the most positive element remains that both parties become aware of the complexity of measures to be taken concerning the richness of the different milks when they come from extended farming areas. It is therefore insufficient to simply copy standard payment formulas derived from more intensive models as these are presupposed to have developed their own specific references which, by definition, are not automatically transferable.

### 4.3.2    Paradox of payment for quality and Distribution of riches

During these meeting with different professionals, it became clear that « *no one wanted to produce non-quality* » but, in practice, effective improvement of quality interested very few people. Although it is true that all dairies are clearly interested in processing clean (« unpasteurised milk » qualification, simplified work, etcetera) and rich (MU yield) milk, it is also true to say that technologies tend to event out this quality (pasteurization, thermal treatment, etcetera) and that, on a local level, there are no means to carry out any measures of the chemical quality of the milk. It is undeniable that this measure is seen as a new constraint imposed by Europe and that, consequently, the responsibility of their application lies in the hands of the State and is dependent on a positive approach by the industrial processors. By definition, these latter distribute the « non-quality » when this is translated by a lack of earnings by all suppliers. The suppliers are well aware that although the chemical quality is purely a matter of luck, the bacteriological quality demands constant efforts that can be easily thwarted by damaging risks (pathological episodes, increased temperatures, etcetera) that should undoubtedly be confronted on unified basis.

## 5.    Conclusions and prospects

In its current form, this work should be seen as a first trial using the tool. There is no intention to arrive at an effective negotiation between farmers and dairies nor, through this NDSS, to establish a general forecasting model for all reactions that may occur during these development phases. The aim is essentially educational, to induce and participate in the construction of a collective conscience by better formalizing the development phenomena. It was quite clear, in the different meetings, that there was a major lack of communication on this subject between dairies and farmers. These latter experience the installation of quality-based payment for milk as a new constraint imposed by the industrial processor. Although they are supplied with analysis results on a monthly basis, no explanation allowing them to interpret the figures was provided. To enrich our understanding of the relations between the concerned parties, the number of dairy-farmer couples should be increased. For the moment, this number remains limited to the size of the available sample group. However, this number should increase fairly rapidly given the desire expressed by other industrial processors to set up the milk analysis protocol at the beginning of the next season. The effective setting up of a quality-based payment will not be seen in the near future as private dairies are aware that this decision cannot be instigated on an individual basis as there is a fear that their milk suppliers will switch over to competing dairies. An attempt to set up an interprofessional system by the different concerned parties in the chain is currently being organised. The first issue to be examined by the interprofessional system will certainly be the setting up of a quality-based payment for milk on a regional level. This NDSS could therefore represent an interesting tool in the col-

lective bargaining process. It could be made even more useful by adding other parties involved in the production and processing chain, particularly those in the technical and administrative sectors, as well as commercial and political agents who undoubtedly place their interests with regards to the chain in terms of image and the respect of natural environment and traditions. In terms of improving the tool, the authors currently envisage the consideration and analysis of negotiation files through the use of *genetic classifiers* (Golberg, 1989) to reveal apprenticeship, cooperation or conflict phases in real-time during the negotiation and lead to the development of rules that can be appropriated on a collective level. In addition, requests that the tool be adapted have been made to us by both parties: the dairies in order to have a simulation software package, the farmer representatives to have a technical backup software (development bodies are currently organizing portable computers to this end).

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# ENTREPRENEURIAL STRATEGIES, DECISION MAKING AND STYLES OF FARMING

Jan Douwe van der Ploeg

1. Building on the new neo-institutional approaches, on the so called 'commoditization debate' and on the recent international debates on technology, it is possible to reconceptualize markets and technology as composing a room for manoeuvre allowing (at least theoretically) for a range of different positions. Each of these positions is characterized by a specific set of interlinkages between the farms on the one hand, markets and technology on the other. The construction of these interlinkages is reflected in, if not governed by the balance of transaction costs, transformation costs and governing costs. That is, each position as chosen in the room for manoeuvre, entails a particular balance of transaction-, transformation- and governing costs. On their turn the definition and specification of these costs reflect the institutional arrangements in which farming is embedded as well as the entrepreneurial strategy as operated by the concerned actors.

2. Intrinsic to entrepreneurial strategies are, in the first place, questions as how to relate the farm-enterprise to the markets ('make or buy' as is stated in neo-institutional analysis). Are the main resources to be produced and reproduced mainly within the farm itself (and/or obtained through socially regulated exchange), or are the to be mobilized as well (or even mainly) through the markets. Secondly, there is an important range of questions on how to convert the available resources into end-products. What e.g. is to be the balance between quantity and quality of labour on the one hand, new technological designs on the other? A wide range of relevant experiences, collective memory, values, interests - in short: cultural repertoire - might flow together and condense into specific (and mutually contrasting) entrepreneurial strategies.

3. The discussed entrepreneurial strategies do not only regard the 'external relations'. They evidently concern the internal structuration on the farm as well (that is the specific interrelations between the many 'variables' describing the technical and micro-economic aspects of the process of production.

4. The unity of a specific entrepreneurial strategy and a farming practice constructed according to that strategy will reinforce both strategy and practice. It will make as well for a specific developmental pattern at farm-enterprise level.

5. In Dutch dairy farming their is considerable variation as far as the integration in or distantiation from the resources markets is concerned (and consequently, the relation vis a vis output markets is also highly variable). It has been shown (not only through the more traditional 'difussion-of-innovations' approach, but also through new inquiries into input/output

relations) that at the 'technological' dimension there is an equally impor-
tant variation. The malleability of the interrelations between technology,
markets and the farm enterprise is, as a matter of fact, actively used by
Dutch dairy farmers. In the indicated 'room for manoeuvre' there are
different empirical positions. each corresponding with a particular dis-
course, that is: with a particular entrepreneurial strategy.
6.	The different resource-combinations and technologies flow together in
farming practices (in internal structurations of the process of production),
which can be explored empirically (with e.g. principal component analysis
and/or cluster analysis) and also be 'matched' with the findings of agro-
sociological research into entrepreneurial strategies. Thus, enriched, em-
pirically informed and differentiated images can be obtained of farming
as (differentiated and) strategically inspired practice. These are referred
to as farming styles.
7.	Using a combination of cluster-analysis and discriminant analysis the spe-
cific (and strategically combined) ordering (or structuration of 'internal'
and 'external' relations can be explored. This has been done within the
context of the Dutch DOBI programme. The annexed diagram (that re-
gards dairy farming in the Friesland province) synthesizes the main find-
ings.
8.	Each 'position' as indicated in the diagram entails a specific farming prac-
tice (that is, different interrelations between e.g., cows, fields, labour,
fertilizer, feed and fodder, machines and therefore as well different cost
structures and different interrelations between GVP, costs and income).
Each position entails as well (and is 'created' by) a specific decision mak-
ing model, being the latter, as it were, the calculus as entailed in the
broader entrepreneurial strategy.
9.	This implies that there are hardly or no 'unambiguous' concepts and pa-
rameters in the practice of farming. 'Nett profit' (netto bedrijfsresultaat)
might be a useful notion in the style of e.g. 'large farmers', it might be
confusing or even be rejected in the style of e.g. 'economical farmers'.
Containment of monetarian costs might be a relevant concept in their
case, whilst the same notion is useless if not counterproductive in the case
of the large farmers. Etc. etc. Even more important though is the follow-
ing finding: the interrelations between different concepts is highly vari-
able (that is: style-dependent). When 'economical farmers' strive a.o. for
a containment of monetarian costs relates in a positive way to the reduc-
tion of environmental pressure (expressed a N-sur-plus/ha). In other styles
such an interrelation is missing or even diametrically opposed to the one
encountereds within the practice of economical farmers.
10.	Hence, support-systems for management will remain 'crude' instruments
(far away from the required 'fine-tuning'). A first requirement for the
development of such systems ia s differentiation as instrumental level
that reflects the real differentiation as encountered in the agricultural
sector itself.
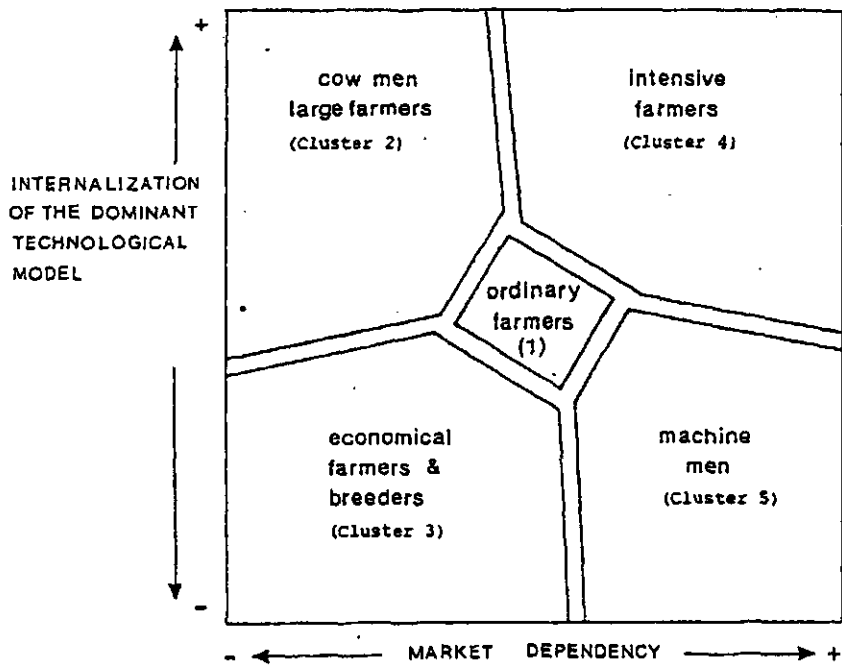
*Figure 1    Farming styles and their relation to markets and technology*

# DATA ANALYSIS TO QUANTIFY THE IMPACT OF MANAGEMENT ON DAIRY FARM PERFORMANCE

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**Abstract**

*Objective of this paper is to evaluate milk yield per cow in relation to economic farm results, taking into account the specific production situation, environmental restrictions and management capacity of the farmer. A desk study was carried out with a bookkeeping/DHIA-dataset of 680 farms to identify the important management areas. A path diagram was built with net returns per 100 kg of milk as the goal variable. Milk yield turned out to be related to the amount and price of concentrates fed, and the breeding value for kilogram of milk. Milk yield influenced number of cows per hectare, percentage of fat in the milk, dairy cow replacement rate, and some reproduction parameters. Net returns per 100 kg of milk was dependent upon milk quota per hectare, milk contents, amount and price of silage and concentrates bought, reproduction parameters and animal movements. On the basis of these results, a field study is planned for the future to measure farmer's management characteristics in more detail. Farms will be selected on the basis of milk yield per cow and net returns per 100 kg of milk. Relationships between management capacities of the farmer and the technical and economic results will be investigated. At the end all results will be integrated to quantify the relationships between management, milk yield, other technical results, economic results and environmental effects.*

**Key-words** : milk yield, management, economic results, dairy cows.

## 1.    Introduction

Farms in similar production circumstances can have quite different technical and economic results. In dairy farming, management has a significant influence on milk yield and as a consequence on farm income. Some farmers are

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able to realise a high milk yield per cow, resulting in a high farm income. Others face a situation where the additional returns from a higher production are outweighed by increased costs of disease and fertility problems, or the high milk yield is reached by a far too expensive feeding strategy. The management capacity of the farmer is believed to play an important role in this respect. In literature, there is no uniform way to define management. Williams et al. (1987), for example, defined DHIA-data as being management (i.e. concentrates fed, days in milk). On the other hand, Bigras-Poulin et al. (1984/85) focused on socio-psychological characteristics as well. Besides this, different methods are used to quantify management. Goodger et al. (1984) created an overall index on the basis of 12 categories, where as in most studies different technical parameters are used next to each other, all representing one aspect of management (Cowen et al., 1989; Kiernan & Heinrichs, 1994; Zweigbaum et al., 1989).

Different research projects are carried out that focused on the relationship between milk yield per cow and farm income. Daatselaar (1988) found an increase in net returns per cow (gross returns minus variable costs) with increasing milk yield per cow per year across farms, but the increase is smaller above 8,000 kg of milk as in between 5,500 en 6,500 kg. McGilliard et al. (1990) found that the net cash income per cow per additional kilogram of milk was $0.22 at 5,000 kg/cow per year, decreasing to $0 at 8,162 kg. Schmidt & Pritchard (1987) used a spreadsheet model to calculate the farm income for different feed and milk prices. It turned out that in many cases the marginal returns would be greater than the marginal costs of increasing the milk yield, even till a yield of 11,818 kg per cow per year. Stallings et al. (1992) compared high producing herds with average producing herds by survey. The higher producing herds have greater net cash income per cow than the average herds. Only McGilliard et al. (1990) found a decrease in net returns per cow when the milk yield exceeds a certain value. Other studies found an increase, but the increase is smaller at high milk yield. Besides this, in all studies net returns are measured on a per-cow basis. However, in a quota system the total amount of milk produced is the limiting factor. In that case, it is better to optimize the net returns per 100 kg of milk. No studies were done on that aspect, so there is no literature available covering the whole range of factors in an integrated way. Therefore an empirical research project in this field was initiated. Purpose of the project is to evaluate the milk yield per cow in relation to economic farm results (net returns per 100 kg of milk), taking into account the specific production situation, environmental restrictions and management capacity of the farmer.

This is worked out in two steps. First a desk study was carried out on an existing dataset to identify important management areas that are especially important in explaining farm performances in general and net returns (i.e. gross returns minus additional feed costs) in particular. Second, based on the outcome of the desk study, a longitudinal field study is initiated to quantify the influence of critical success factors on milk yield and economic farm results. In this paper results of step 1 and the outline of step 2 will be presented and discussed.

## 2.     Materials and methods

Data are available from an information system for dairy farming (DELAR 2000+) and the Dutch DHIA. Major purpose of the DELAR-system is to give farmers information on production of the cows, pasture and crops, use of concentrates, silage and milk products and insight into other costs as fertilization costs and costs of contract work on their farm compared to other farms. However, the data can also be used for research. Data from 885 farms over the period May 1993 till April 1994 were made available for the current study. From 680 of these 885 farms DHIA-data on milk yield, reproduction and breeding values were available as well. A selection of 478 farms was made: only farms with black and white cows from the Dutch-Friesian and/or the Holstein-Friesian breed were included in the analysis. Table 1 gives some descriptive statistics of the farms.

Path analysis was used to analyze the data using PROC GLM and PROC STEPWISE by SAS (SAS/STAT, 1988). Path analysis indicates hypothesized relationships among variables by arrows leading from the putative risk factor ('causes') to the possible 'effect'. There are several advantages of path analysis. The technique forces the investigator to specify the hypothesized interrelationships among variables, including direct and indirect causal associations. This allows the model builder to make use of available a priori information regard-

Table 1     Descriptive statistics of the dataset (N=478)

| Variable | Avg. | SD | Min | Max |
|---|---|---|---|---|
| Hectares | 30.9 | 13.3 | 7.5 | 104.9 |
| No of cows | 56.8 | 22.4 | 13.7 | 189.7 |
| Milk yield (kilogram in 305 days) | 7658 | 687 | 4892 | 10320 |
| Quota per hectare | 14036 | 3459 | 6660 | 32068 |
| Net returns/100 kg (Dfl.) *) | 76.0 | 5.7 | 57.8 | 102.6 |
| Breeding value kilogram of milk | 376 | 149 | -274 | 830 |
| Breeding value kilogram of fat | 16.5 | 5.29 | -13 | 31 |
| Breeding value kilogram protein | 15.2 | 4.2 | -6 | 26 |
| Heat detection (%) | 56.4 | 6.6 | 26 | 76 |
| Insem./pregnancy | 1.96 | 0.34 | 1.07 | 3.64 |
| Int. calv.-1st ins. | 79.1 | 11.4 | 51 | 193 |
| Non Return (%) | 61.9 | 10.4 | 30 | 96 |
| Calving interval (days) | 390.1 | 13.2 | 357 | 438 |
| Price calf sold (Dfl.) | 454 | 56 | 295 | 729 |
| Replacement rate (%) | 34.4 | 12.8 | 2 | 139 |
| Price cow sold (Dfl.) | 1570 | 202 | 934 | 2153 |
| Concentrates/cow/yr (kg) | 2512 | 590 | 972 | 5954 |
| Price of concentrates (Dfl./1000 VEM **)) | 0.38 | 0.03 | 0.31 | 0.64 |
| Fertilizer-N/ha (kg) | 309 | 83 | 79 | 642 |
| Mowing percentage | 214 | 57 | 28 | 488 |
| N-surplus per hectare (kg) | 424 | 99 | 76 | 876 |

*) Net returns = gross returns - additional feed costs; **) VEM stands for Dutch Feed Unit; 1000 VEM = 6.9 MJ $NE_L$.

ing known or plausible asymmetric relationships. This is an important advantage over conventional regression analysis (Goldsmith, 1977).

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 flows (by assumption) only along the unidirectional arrows. Exogenous variables are 'given' and there is no attempt to explain relationships among these variables. Therefore, these variables are placed in 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 'correlation' rather than 'causal association'. The other variables are the 'endogenous variables'. It is the hypothesized relationships involving the endogenous variables that path analysis attempts to formalize. For every endogenous variable in the diagram, a linear regression is worked out. On the basis of these regressions, standardized path coefficients are calculated. Coefficients are utilized in a standard unit form. 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 $(E_i)$. 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.

Bivariate correlations are estimated from the model by tracing out all possible paths between the variables, multiplying all the standardized path coefficients of a single path together, and then adding these compound path coefficients. Bivariate associations were decomposed into direct causal, indirect causal, and spurious (common cause) 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 more arrows are passed, the association is indirect through one or more other variables. Spurious associations are traced by starting backwards from one variable in the model 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 the correlation matrix.

## 3.    Results

Under the Dutch quota system the farmer has to maximize income per kilogram of milk she is allowed to produce. Hence, goal variable in the research is net returns per 100 kg of milk. A diagram was set up with all kind of relationships that were expected to be causal. Breeding values, quota per hectare, soil type, calving to first insemination, the price of concentrates and the price of calves sold were seen as 'given'; these are the exogenous variables. Endogenous variables are the concentrates per cow per year, milk yield per 305 days, protein and fat percentage, milk price of the factory, number of inseminations

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per pregnancy, percentage correct oestrus, calving interval, non-return rate, births per cow per year, replacement rate, price of cows sold, cows per hectare and young stock per hectare. These variables are (partly) explained by the model but are also explaining other parameters themselves. Net returns per 100 kg of milk, the goal variable, is given at the right hand side of the model.

On the basis of this diagram, relations are checked, and non-significant relationships (P > 0.10) were removed from the model. In total, 16 arrows of the original model were excluded because of insignificance, resulting in the model shown in figure 1. The breeding values of milk, fat and protein turned out to have no direct causal association with the net returns per 100 kg of milk. Besides this, a relationship between reproductive parameters and the dairy cow replacement rate was expected (Jansen, 1987). However, only calving interval and the percentage of correct oestrus are significantly related to the replace-ment rate. Number of inseminations per pregnancy and the non-return rate did not have a direct association with replacement. It has to be taken into account that the data used for the desk study are averages per farm. Therefore they can only be used for between-farm comparison. So the data cannot be used to show effects within herds.

Table 2    Decomposition of estimated bivariate associations into direct, indirect and common cause components

| Independent | Dependent | Causal Direct | Indirect | Spurious | Total Estimated | Measured |
|---|---|---|---|---|---|---|
| Concentrates | Milk yield | 0.45 | | 0.09 | 0.54 | 0.57 *) |
| Breeding milk | Milk yield | 0.38 | 0.08 | 0.04 | 0.50 | 0.51 |
| Breeding prot. | Milk yield | | | 0.43 | 0.43 | 0.45 |
| Breeding fat | Milk yield | | | 0.25 | 0.25 | 0.42 |
| Quota/ha | Milk yield | | 0.16 | -0.32 | -0.15 | 0.35 |
| Quota/ha | Net returns | 0.30 | -0.76 | 0.01 | -0.45 | -0.53 |
| Cows/ha | Net returns | -0.57 | -0.05 | 0.32 | -0.31 | -0.50 |
| Concentrates | Net returns | -0.41 | 0.08 | -0.20 | -0.53 | -0.45 |
| Silage | Net returns | -0.23 | | -0.35 | -0.58 | -0.38 |
| Milk yield | Net returns | | 0.22 | -0.23 | -0.01 | -0.19 |
| Efficiency | Net returns | -0.07 | | 0.04 | -0.03 | -0.12 |
| Non Return | Net returns | | 0.05 | -0.04 | 0.01 | 0.08 |
| Breeding prot. | Net returns | | 0.03 | | 0.03 | 0.07 |
| Breeding fat | Net returns | | 0.01 | -0.03 | -0.02 | 0.04 |
| Oestrus | Net returns | | | 0.03 | 0.03 | 0.04 |
| Calving int. | Net returns | -0.05 | -0.02 | | -0.07 | -0.02 |
| Breeding milk | Net returns | | -0.04 | 0.10 | 0.06 | -0.01 |

*) from original correlation matrix.

Table 2 gives the decomposition of associations into direct, indirect and spurious components for milk yield and net returns per 100 kg of milk being the dependent variables. 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 real correlation between the variables.

The model shows that milk yield is related to the amount of concentrates fed, the price of these concentrates and the breeding value for kilogram of milk of the cow. Milk yield influences number of cows per hectare, the percentage of fat in the milk, replacement rate, and some reproduction parameters. Schmidt & Pritchard (1987) also found a positive relationship between milk yield and costs of replacement.

Net returns per 100 kg of milk turns out to be dependent upon many different factors. An important factor is the milk price paid by the factory. The square of the standardized path coefficient ($R^2$) represents the statistically explained portion of the variance in the dependent variable. So, $(.50)^2$ or 25% of the differences in net returns is related to differences in milk price. The price is highly dependent upon the protein and fat contents of the milk (figure 1). However, an explanation of differences between farms in milk contents could hardly be given on the basis of these data: breeding value for kilogram of fat and kilogram of protein can only explain part of the differences in milk contents.

Another important aspect in the explanation of differences in net returns is the amount and price of silage and concentrates bought. Together they explain 23% of the variance in net returns. Quota per hectare is important in this respect. More quota per hectare implicates a higher feed requirement per hectare. However, quota per hectare also influences the net returns via other ways: cows per hectare, young stock per hectare and quota per hectare together directly explain 44% of the variance in net returns.

The variables mentioned above, have a major influence on the net returns. Besides these, there are variables with only a small, but significant effect on the net returns. These are reproduction parameters and animal movements. Figure 1 shows that reproduction parameters are associated with the 305-days milk yield per cow and have also a significant relationship with the net returns; 2% of the variance is related to these variables. This is contradictory to the findings of Jansen (1987), who stated that at the farm level there is no effect of milk yield on fertility. Olds et al. (1979), however, have found that at the farm level a higher milk yield results in more inseminations per pregnancy. Olds et al. (1979) found stronger relationships at the farm level between reproductive parameters as found in this study. The correlation between inseminations per pregnancy and calving interval was 0.35 and between calving to first insemination and calving interval even 0.81. In the current study, standardized path coefficients of respectively 0.10 and 0.36 were found (see figure 1). On the basis of these data it can not be made clear whether this is the result of difference in reproductive management between high and low yielding farms or the result of real biological differences between high and low yielding cows. Animal movements also influence the net returns. The replacement rate of the cows and the price paid for cows and calves that are sold explain 4% of the variance in net returns.

The weights of the error-term $E_i$ is calculated as $(1 - R_i^2)^{.5}$. So, the error-term of the net returns equals $(1 - (.25 + .23 + .44 + .02 + .04))^{0.5} = 0.13$, indicating

that 13% of the variance in net returns can not be explained by the current model.

From the desk study it can be concluded that net returns are related to feeding and pasture (measured by amount and price of silage and concentrates), farm intensity (measured by quota per hectare), reproduction and animal movements. These factors statistically explain quite some variance in milk yield and net returns. Milk yield plays a central role in the system. However, no direct, clear relationship with net returns is found. The variance in the endogenous variables can often not be explained; the error-terms for the endogenous variables are quite high. They vary from 0.69 to 0.99. Management aspects are thought to be the cause of these unexplained variances. However, these management aspects cannot be identified with the current dataset.

## 4.    Discussion and outlook

The desk study has given more insight in the importance of the different parameters for explaining the net returns. However, the impact of the (background) management of the farmer is not yet clear. Therefore, a longitudinal field study is planned. In this field study management aspects of the areas found in the path analysis (feeding, pasture, reproduction and animal movements) will be measured in detail. Besides this, animal health is often mentioned as an important aspect in this respect. No animal health data were available in the current dataset. For that reason, animal health will also be included in the field study. For all these areas, management and technical aspects have to be measured.

A group of farms will be intensively followed during a one-year period. Selection criteria for the farms are based on the results of the path analysis and on the goal of the study. Quota per hectare turned out to be quite important in explaining the net returns. However, this factor is not of our direct interest. To exclude this effect, only farms with an average quota per hectare will be selected. To meet the goal of the research, farms will also be selected on the basis of the milk yield per cow and the net returns per 100 kg of milk.

Different methodologies will be used to collect these data. Workshops, for instance, will be used to measure risk attitude, management skills etcetera of the farmer. Other tools that will be used are psychological tests, experimental economics etcetera. Besides this, other datasets will be used. A lot of data are automatically recorded in the Netherlands. Milk yield and reproductive data will be provided by the NRS (the Dutch DHIA). Animal movements, quality of the silage and veterinary costs are other data that are available in existing farm-level management systems. A bookkeeping system will be used to gather the economic farm results. Another important way to gather the data is by regular farm visits. The farmer will be asked to keep a diary to write down technical aspects that are not measured by existing datasets.

Double checks will be built in to compare the results from different methodologies and to check the reliability of the data and the compatibility of different methods. Data will be analyzed per research area by multivariate analy-

sis techniques. At first relationships between management capacities of the farmer for a specific area and the technical results of the same area will be discussed. Besides this the relationships between management skills (per research area) at one hand and milk yield at the other hand will be worked out. Goal of the last step is to integrate all findings to determine relationships between management, milk yield, other technical results, economic results and environmental effects.

## 5. Acknowledgement

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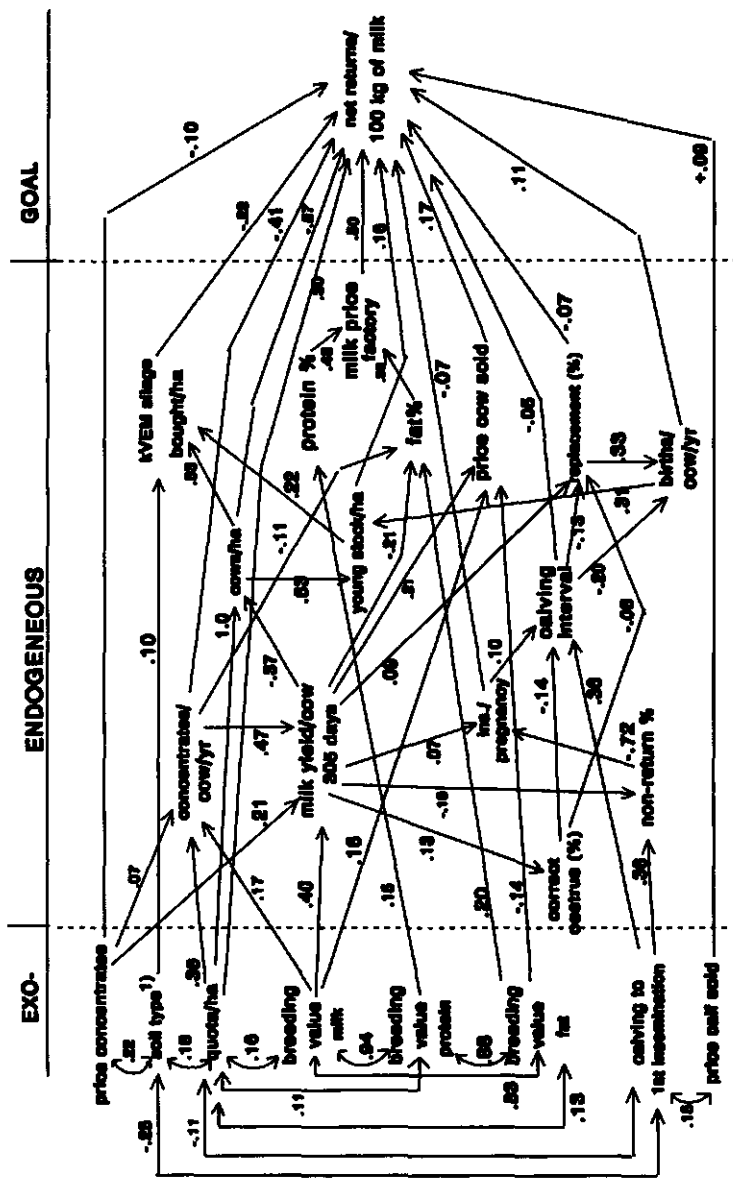
Figure 1    Path analysis model. Arrow weights = standardized partial regression coefficients

# STRATEGIC DECISION PROCESS ON THE FARM: NEW ISSUES FOR MANAGEMENT ADVICE SUPPORT

Laurent Hémidy 1)

## Abstract

*In this paper, we investigate the long term management of the farm firm and the development of new methods to support the strategic decision making process. Generally, strategic management is viewed as a sequence of separate processes: strategic diagnosis, planning and control. However, in the present context of large uncertainty, it becomes more important to ana-lyse how strategies can be defined, then expanded and reviewed. For man-agement advice services, the main goal is to help farmers manage dynami-cally the links between the strategy formulation and its implementation. Because many advisers and farmers value a positive evolution of the coun-selling relationship, this problem appeared to us to be of particular interest.*

*From interventions by researchers and advisers in several situations of farm management advice, we suggest a general framework to guide the development of new methods to help farmers structure their own strategic decision processes. Results of this research are presented and a brief descrip-tion of actual methods is provided.*

*The originality of this approach is: i) to develop the farmer's strategic vision and the evaluation of solutions in the light of conditions of imple-mentation; ii) to formalize interactions between strategy and day-to-day management, in terms of information and decision; iii) to structure the counselling relationship by the development of a function of 'strategic ac-companiment'.*

*Emergence and then, use of these methods by advisers, on a large scale, in differents farm management centers, show the relevance of find-ings reported in this research.*

**Key-words** : Farm management, Strategic decision process, Management advice support.

## 1.    Introduction

Today, many farmers lack guiding marks. They wonder about the fu-ture of their farms and what course to follow now. What is the 'good' pro-

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duction system for me tomorrow, in my situation? In relation to these questions, several changes require that they consider the potential future of the farm: new CAP from European Community, the uncertain evolution of prices, the saturation of agricultural markets and the difficulties to find new outlets. The choice of new directions becomes more crucial and delicate, because of the greater dependency to the evolution of the economic environment. And it will be more important to strongly link a vision of the future and chosen goals, the project to be adjusted and the means needed for its successful conclusion, indeed for its possible revision.

In this situation, management advice centers cannot continue to suggest easy and standard solutions. Advisers are no more able to define the 'best' solution to the farmers' problems. Some difficulties become more important: for example, the variety of situations they do take into account and the growing complexity of management problems. It also becomes impossible to assume the environmental stability. In these conditions, how can one help farmers to choose and to project their action in the long term?

According to this perspective, the limits encountered by most of these centers are twofold. First they want to help farmers to develop a more strategic new way of thinking about management, which integrates risk and uncertainty. Yet, most of currently used tools and methods are inconsistent with this counselling situation. Another limit concerns the organization of advice centers. Beyond the need of new instruments, they have also to deal with the evolution of their occupations. Finally, the problem is to know how a strategic management approach can be applied to farm management.

This paper answers these questions by testing the applicability of strategic management to farm management advice, from several concrete situations. It finds that the development of new adapted methods appears to better help farmers to think strategically and leads to a new form of counselling relationship.

Section 2 presents the general framework of this study, the research problem and the method. Section 3 reports the major results of the study. Discussion and conclusions are in sections 4 and 5.

## 2. Framework and research problem

### 2.1 Contingency and strategic planning

The dominant view of strategic management is based on the concept of contingency. This concept was first developed by organizational researchers to explain why different organizational structures or firms were more effective in certain situations. Thus, the finding of a good fit between the business's strategy and its situation leads to a significant positive impact on performance. The situation has been analysed according to the following dimensions: environment, resources, managerial characteristics and organizational structure. Several studies have explored the fit between strategy and situation (for example, Chandler, 1962; Bourgeois, 1980). They have

supported the appropriateness of a contingent approach to the strategic management.

In the same time, many researchers and practitioners have recommended to develop strategic planning in firms. They have argued that an explicit planning process was a better way to create and maintain the fit between the organization and its environment. For Armstrong (1982) and Ansoff (1991), this process produces better adaptation and financial results than does trial-and-error learning.

This position was not shared by all the community. Several empirical researches have shown that the planning process could be dysfunctional, or at best irrelevant. One of the most widely quoted criticisms is that planning produces too much rigidity. Mintzberg argues that organizations must deal with uncertainty. Thus, it is difficult and even dangerous to articulate strategies (1987, 1990). Strategies tend towards a great predetermination of the future course; they block the vision and restrict the detection of emergent opportunities.

Recently, Mintzberg has tried to find a balance in his review of strategic planning. First, he argues that analysis and intuition must be mixed in the strategic management processes. He also suggests that strategic planning may help to transform intentional strategies into achieved strategies, in order to lead to an efficient implementation (1994).

## 2.2    Strategic planning and farm business

From the perspective of this study, the limitations with the existing literature are twofold. First, because the literature focusses on large businesses, we have to determine how to develop a strategic management approach to small businesses like farms. Secondly, for the same reasons, it becomes essential to deal with a specific dimension of our problem, that is the possible role of external advice in the farm strategic planning process.

One of the major purposes of strategic planning is to promote the process of adaptative thinking or thinking about how to attain and maintain firm-environment fit (Miller & Cardinal, 1994). Because decision processes in the farm have a highly individual dimension, adaptative thinking can be valuable because it can help farmers to overcome the vulnerability of their farm. A second major purpose of strategic planning is to help managers integrate and control the firm, throught a formal and explicit process. In contrast to the first point, this kind of benefits is probably more difficult and complex to reach in farms, due to their lack of formal management. Because they are small businesses run by owner/managers, farmers rarely think in terms of managerial terminology and rarely use formal managerial procedures. In addition many farmers rely on intuition, experience and a global sense of empirical evidence to make decisions (Harling, 1992). Any new strategic method has to take into account this specific way of thinking.

Now turn to the question of management advice. It is wellknown that one of the most important pathways of innovation diffusion in farm management is nowadays the counselling supply of management centers. For

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many years and even now most of them, their service supply has delt mainly in accounting and bookkeeping. They have also developed some narrowly specialized services like investment financing, cash-flow budget, fiscal or legal regulations. In order to insert strategic management advice into their service supply, these centers must also create the conditions for this renewal, in terms of knowledge, organization and skills. Thus, they need to overcome the present form of counselling relationship with farmers.

## 2.3 Research problem

The research problem studied was to explore the required conditions for the application of strategic management in farms, taking into account the two following specific constraints: the small size of this type of firm, and the presence of relations between the farmer and his adviser. We have conducted a qualitative and inductive field study. No formal testing of hypotheses was attempted. However, we relied on an *a priori* framework defining what would be favourable factors for the development of a strategic management process in the farm.

(i) Unlike practices encountered in large businesses, the strategic management process must be simple and flexible. In particular, the time needed for the strategic reflection is probably an important constraint.

(ii) Because of uncertainties and lacks of information, it is necessary to link more strongly planning and strategic monitoring, in order to permit revisions in due time.

(iii) The strategic management process must be thought like a dynamic interaction between two incomplete frameworks: a strategic action plan more than an *ex ante* program; a strategic monitoring guide more than an *ex post* control. In regard to the considered strategy, the action plan allows to precise the desirable or possible actions and the monitoring guide then integrates the conditions of adjustment or revision. It can be emphasized that their building should be compatible with the empirical 'culture' of farmers.

(iiii) The adviser's help must deal with the two following aspects: the strategic analysis and the strategy's choice; the implementation of strategic monitoring and its real-time use.

Finally, all of these points converge on a main proposition also argued by Mintzberg (1994), the necessity to develop an operational (and not formal) definition of what are planning and monitoring in the context itself of the strategy's elaboration and implementation.

## 2.4 Method

Talking about planning and strategic monitoring in these terms implies an empirical research and an interactive work with farmers and advisers. We had to select favourable counselling situations where it was possible to develop this research. Two characteristics have been selected: an open

attitude to innovation and a real confrontation to the evolution of the needs of farmers in terms of strategic management.

Last years, these situations have especially arisen in France in the field of management advice centers. The major problem they encounter is nowadays a stronger competition, due to the decreasing number of farmers. They also fear that farmers may turn away from existing services. Thus, management advisers are willing to renew current methods and tools, in order to better answer to the farmers' needs and expectations.

During the past three years, we have worked with several teams of management advisers in different regions of France (Champagne, Bretagne, Ile-de-France...). The main goal of these 'interventions' was to develop a new strategic management advice process, inside the management center and with the effective participation of advisers. In a first step, working groups were formed. Collective discussions and numerous experimentations by advisers themselves from concrete cases have allowed to gradually define the contents of the new method. In a second step, all advisers have been trained and now apply this method. Finally, a sample of practicing advisers was selected in order to analyse impacts on farmers and the evolution of counselling relationship.

The validation of this research is twofold. The success of each innovation process in each counselling situation and positive judgments of concerned actors (farmers, advisers, executives...) are a first validation step. Then possible generalization of the new method, evaluated throughout contrasted counselling situations, leads to a more general validation.

## 3. Results

Results of this research have been obtained and validated progressively, from work progress in different management advice centers. The experimentation by advisers leads to two types of results: new methods for strategic management advice and a new type of counselling relationship. We shall present the findings in this section and summarise the emerging impacts in the next section.

### 3.1 New methods for strategic management advice

In the strategic management advice process, we can distinguish three steps: strategic analysis, strategic monitoring implementation, and real-time monitoring assistance. These steps are logically linked. Their application depends on the farmer's needs and aspirations, and in several cases, on the complexity of the chosen strategy.

*Strategic analysis*

In a first step, strategic analysis (summarized in the figure 1) consists of three points:

(i)     to analyze the present situation, stressing the farmer's motivations and management attitudes, the assets and constraints of his farm, his vision of environment and its evolution;

(ii)    to define with him a strategy, or in other words, privileged directions of transformation of the farm, and to 'translate' this strategy into an action plan;

(iii)    to organize the relationship with the adviser and to precise future meeting points between them (important tasks, intermediate diagnosis, strategy revision...).

The development of this step implies several interviews and discussions, with the farmer and the people concerned by the future of the farm (family, partners, associated farmers...). The structuration of interviews is attained through open but structured questionnaires built by the advisers' team. The commonly questionnaires focus on the analysis of the farmer's demand, on his questions, on the diagnosis of the farm's 'trajectory' and on the present situation, and especially on the environmental analysis. This last point must be tackled with attention and coherence because it conditions the quality of the choice of the strategy.

The farmer and his adviser gradually list possible or desirable actions and future events which are useful and important to consider, in terms of risk or opportunity. From these lists and in relation to the farmer's goals and objectives, it becomes possible to 'draw' one or several possible strategies for the next years. This open step of thinking and analysis is finally reviewed by the farmer.

The second part of strategic analysis deals with the choice of one strategy. Each possible strategy is evaluated on the basis of expected results, implementation constraints and conditions for success. Action plans, budgets and risk evaluations are compared. One strategy then is chosen. A detailed action plan and a working plan are listed. The adviser then is in position to suggest an follow-up schedule, or in others words, some key-dates for his relation with the farmer.

The strategic analysis is closed by the writing of a final report (15-25 pages). Its content is a summary and a synthesis of the process. Some appendixes can be added like technical aspects, market analysis and financial budget.

Globally, the use of this method requires:
-    several interviews with long intervals in time (from 3 to 6 or more);
-    intermediate reports written by the adviser;
-    a progressive validation of the analysis process by the farmer;
-    a well-suited expertise in several domains (technique, economy, business...).

This last point can be problematic in certain situations which require to integrate many domains of knowledge or expertise. These cases must be managed by calling on others experts, for instance, inside the management advice center. Otherwise, the contribution of external specialists is necessary.

*Strategic monitoring implementation*

The main result of the previous step is the definition of the farm's strategy, in operational terms like an action plan, with its assumptions about conditions for success. This definition is a sort of framework from which it becomes possible to implement the strategy. But we morever know that finally the realized strategy will be different. Opportunities and environment changes can lead to adaptations or revisions in certain situations.

For this reason, the farmer needs to be helped during the implementation of the strategy. The chosen way for this help, beyond the suggestion of a specific accompaniment, is to build with him a strategic monitoring chart.

The central problem of the implementation of strategic monitoring is the choice of indicators. In relation to the farmer's project, the chosen strategy and its specific aspects, it is essential to determine the appropriate, available and useful indicators. This choice is far to be obvious.

In order to structure this choice, the first and important step of the method is to identify and to clarify the success key factors. Downstream from the chosen strategy, success key factors can be viewed like essential points which condition the success of this strategy. Generally, there are two types of success conditions:

- relative to the expected final situation, they notify the judgment that will be realized about the strategy's outcome. We find here expected results or some characteristics of the final situation which will allow to analyse the success of the strategy's implementation;
- relative to the potential trajectory of the farm, they highlight crucial aspects of the action plan. These are implementation conditions, intermediate results to be reached or important farm's characteristics to be maintained.

Success key factors can be classified into three categories: technical and economic results to be reached; 'critical' performances or, in other words, performances whose inadequacy or deterioration would compromise aimed objectives; assets or benefits to be maintained. This classification is very useful to guide the adviser in the use of the method.

Thus, the building of the success key factors list becomes the starting point from which the adviser and the farmer can choice control indicators (cf. figure 2). After what, indicators are collected in a monitoring chart. For some of them, expected values from budget can be added.

Although the definition and the use of monitoring charts are a classical method in management, this method produces a more interesting tool for farmers. First, the monitoring chart is specific and adapted to the farm's situation. Its construction method allows to explain the choice of indicators. This is a major educational advantage, compared to standardized approaches. Secondly, its strategic dimension is real. Indicators are chosen in relation to the farmer's strategy. Logical links exist between strategy and real-time information collection, through the monitoring chart. Then adaptation or possible revision of the strategy become easier and adequate in time.

For the use of the strategic monitoring chart, the availability of necessary informations has been assumed in the previous step. However, its implementation can disclose some weaknesses or failures in the farmer's information system. Two cases are possible. If these informations are relative to the farm's environment, the adviser can suggest new information sources to which the farmer has an easy access. Otherwise, a new role of the adviser can be to bring these informations from the ressources of his management center.

If the missing informations are linked with the farm operations and organization, the information management practices of the farmer need to be improved. Generally, solutions can be found with a brief analysis of the farmer's information system (methods and tools used, internal information sources, produced results...). But in some cases, the problem is more complex and solutions also depend on a more intensive analysis between information management, decision processes on the farm and strategic monitoring.

In this way, we have suggested in a recent research a conceptual framework for the formalization of interactions between strategy and operational management in terms of information and decision (Hémidy & Soler, 1994). We have also argued the interest of this framework to support the farmer in analyzing and evaluating his own management thinking.

## 3.2 A new type of counselling relationship

Experimentation and then use of the methods presented above lead to new forms of relationship between the adviser and the farmer. This evolution was partly predictable. In fact, renewing methods and suggesting a strategic management advice were also a way to transform the adviser's work.

In France and since over twenty years, management advice centers have focussed their services on bookkeeping and farm accounting. Working with many farms, they are able to analyse their economic evolution and the general trends of their transformation. Beside accounting service, they have also developed some specialized services to cope with limited management problems. These studies are often disconnected.

Strategic management advice introduces some new aspects:
- a global analysis of the farmer's project in its multiple dimensions;
- a qualitative reflection about the future of the farm and its environment;
- an help for the implementation of this project;
- a suggested accompaniment of the farmer in the long time.

Accordingly, the counselling relationship is quite modified. In terms of quality, produced advice is more strongly linked with the farm's course and its potential trajectory. The adviser has a better knowledge of the underlying logic of the farm. He can adapt his advice and its interventions make more sense to the farmer. In terms of rythm and used time, the counselling

relationship becomes an accompaniment, or in other words, a long time structured support. Each adviser's intervention then is connected to others in regard to the farmer's project and his strategy.

## 4.    Discussion

The emergence and then the implementation on a large scale of these methods tend to prove the relevance of the research assumptions. Furthermore, work with advisers' teams in contrasted counselling situations (farm production systems, size of management advice centers, existing advice supply...) confirms this relevance. The final survey highlights the two following points: people implied in experimentations globally have a positive judgment about these new methods and their use on farms; the experimental phase is often overtaken and leads to a real transformation of the advice supply of centers.

### 4.1    Impacts on farmers and their management

In all studied cases, strategic analysis appears to be an essential step in the thinking process of farmers. Analysis of their own objectives through interviews, return of a written report with a mix of qualitative synthesis and calculations, the building of simple tools like action plans are much appreciated. Furthermore, the survey of farmers which have taken part in experimentations allows to precise the main points where benefits are most conclusive.

Along interviews and multiple reflecting steps, the farmer and its adviser work together and deal with the complexity of the farm and the control of its management. This mutual work is at the same time reflexive and creative. It leads to a 'standing back' attitude and to a reviving of critical thought. Because farmers are strongly involved in present action, this type of work is even more interesting and useful.

The definition of strategic directions and then the building of action plan for the strategy's implementation, organize and form a 'beaconing' of management for the future. Action and working plans, monitoring indicators and rules for action allow to define a strategic framework in wich the farmer will be able to position himself in the agenda of his project.

In these terms, the goal of strategic analysis and implementation of monitoring is not to plan the future of the farm. Because of uncertainty and possible environmental changes, the farmer's strategic vision cannot be complete and final. On the contrary, the strategic framework must be complemented and progressively renewed, in relation to new informations, opportunities or difficulties. This stronger attention to the environmental evolution and its possible impacts on strategic choices can imply new advice needs and a strengthening of the existing counselling relationship. The suggestion of an accompaniment plan by adviser is also a good mean to anticipate them.

## 4.2 Impacts on advisers and counselling organization

The insertion of strategic management advice in the dynamic of the counselling relationship produces effects on the advisers' profession and also on the organization of the management advice center.

### Development of an exchange on the long time

Beyond their acquisition and their usability, the practical experience of these new methods enriches and transforms the 'culture' of advisers. Thus, advisers work with farmers according to what farmers are (their values) and what they want (their objectives); they build with them solutions to their problems. This mutual work modifies the dynamic of knowledge. From a single transfer supported by expertise, it becomes a real exchange, according to different points of view and complementary know-how.

The choice of the strategy with successive validations, its implementation and then its control are several steps which will structure the future of the relationship between the two 'partners'. Consequently, decision support tools and methods (annual budget, cash-flow and investment planning...), currently used by adviser, find a better place in the counselling relationship. The different advice actions become coherent. They are developed according to a common vision of the future of the farm.

### Impacts on advisers and center's organization

During the advice work around farm strategic management, the adviser has essentially a general and global role towards the farmer. But in certain cases, some problems or questions are too specific and overcome his field of competence. He needs to call on specialists, generally working in the same center. Thus, the development of this type of advice requires a real coordination between advisers, in order to maintain coherence of advice, from the farmer's point of view. Finally, the challenge is also to improve services offered to farmers by an increased collective efficiency.

Impacts of this methodological work are significant for concerned advisers, and more widely, for 'general' advisers which have a periodic relationship with farmers. We also observe a generalization of this new vision of the counselling relationship in other professions inside centers. For example, even limited studies are not always bounded to the problem to be solved. They are put in relation of the global context of the farm and its possible evolution.

### Development of personalized advice supply and economic aspects

Management advice centers' executives ask themselves about the possible diffusion of these advice methods. At first, the specific characteristics of the strategic management advice process (several interviews, thick written report, accompaniement...) imply an important cost which is also difficult to

control. The number of interested farmers able to pay this advice now is unknown. With experience, it will be possible to adapt the process and reduce the cost. Some advisers' teams will work in this direction in the next years.

Secondly, personalizing advice supply leads to propose an adapted and explicit working process (list of questions and problems, conditions of realization, cost, estimated duration...). Thus, required time and its schedule is variable according to farmers. Consequently, the organization of an adviser's activity can become complex to manage.

Finally, the question in abeyance remains the evolution of farmers' management advice needs. Developing this type of advice is in part an anticipation on this evolution. The challenge now is to increase its diffusion and, in the same time, to adapt the management advice center's organization.

*Requirement of new advisers' skills*

The transformation of advice supply and relationship between the adviser and the farmer leads also to the emergence of a new profile of adviser. We have already seen some of its characteristics throught the description of methods and their use by advisers.

Mainly, the new profile assumes two levels of skill and knowledge. On the one hand, the adviser has to know and to master standardized approaches like budgets, simulations, financial or business analysis. On the other hand, he has to develop a skill of integration, or in others words, an ability to position their implementation and to give sense to their use, according to the global approach of strategic problems.

Morever, the final survey highlights three main factors for the development of these new skills:
-       an open attitude of thinking and a large capacity to listen;
-       an ease to establish a close relationship with farmer through a constructive dialog;
-       an analytical ability to understand farmer's questions, to feed back and to report.

The experimentation step has appeared to be an interesting and useful way for the explicitation of new required skills. From this point, it is now possible to suggest some directions for the advisers' initial training. But beyond the training course, we have observed that learning by action was also essential. That is why advisers must rely on mutual discussions and assistance to improve the learning process.

## 5.     Conclusion

This paper attempts to show that the application of strategic management to farm management is possible, in the present context of management advice. To do so, an experimentation with advisers has led to develop new adapted methods and has renewed management skills, both for advis-

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ers and farmers. By this way, we have shown the relevance of our assumptions about applicability of strategic management advice to small firms like farms.

The analysis of experimentations in several counselling situations and the final survey allow to precise the main conditions of application and the observed impacts on concerned actors. In this aspect, this study contributes to the literature by showing how strategic farm management can be developed and how advice can be produced to support strategic thinking by farm managers. These results reinforce the calls for practitioners to find themself an operational definition of what can be planning and monitoring in the strategic management process (Mintzberg, 1994).

It should be kept in mind some limits of this study. The necessity of experimental work leads to a limitation of the number of studied counselling situations. Morever, implementation and diffusion of these new methods are not achieved. Results then must be confirmed.

Today farmers facing many changes wonder about the future of their farms. They have to adapt their business to the economic and social evolution of their environment. And in the same time, the evolution of the counselling relationship has become a necessity. This experimental research work at first, and now in a larger scale, appears to be an appropriate answer to the present situation.

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**CURRENT SITUATION**

*"My farm today ?"*
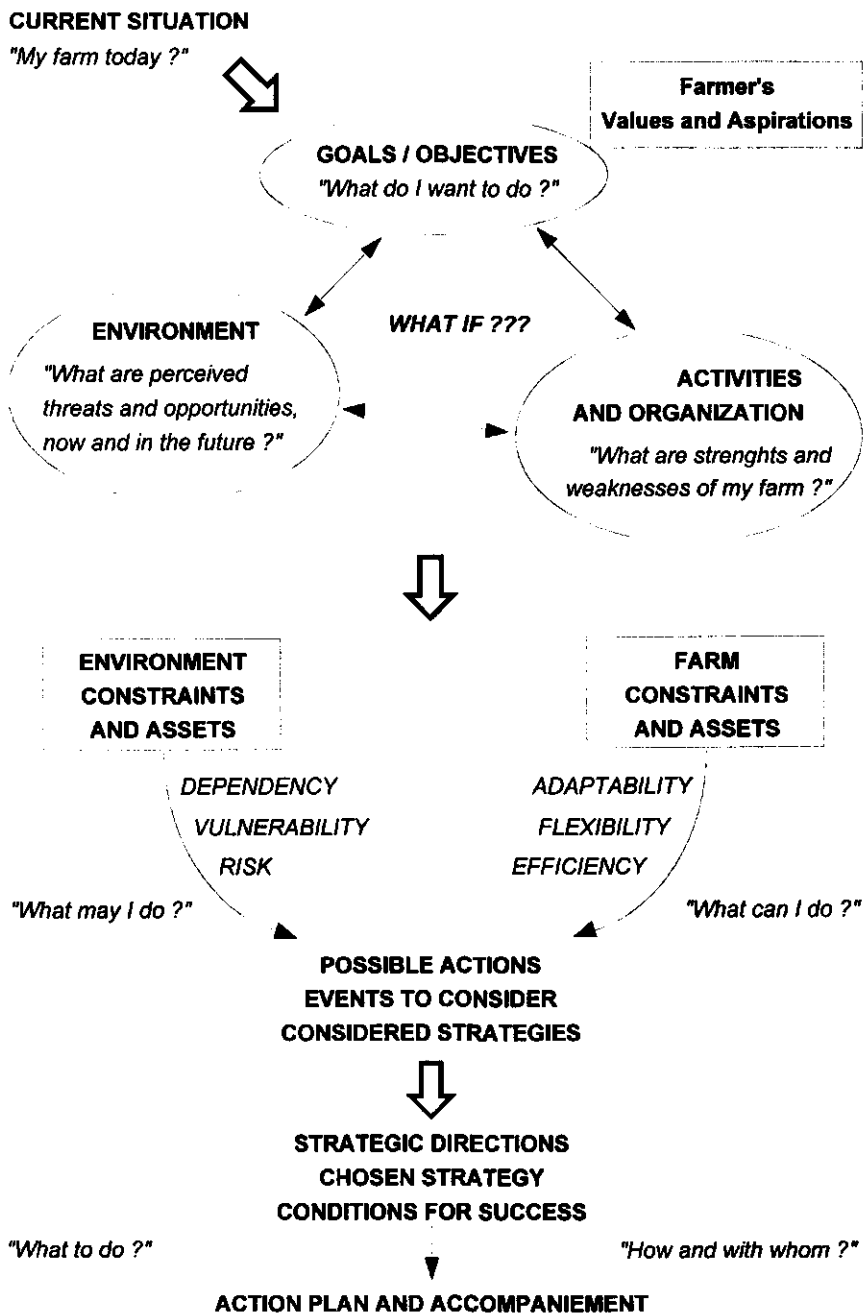


Figure 1    The strategic analysis work chart

**STRATEGIC ANALYSIS**

⇩

| CHOSEN STRATEGY STRATEGIC DIRECTIONS | CURRENT SITUATION CONDITIONS FOR SUCCESS |

► **SUCCESS KEY FACTORS** ◄

*"What results to be reached ?"*        *"What critical performances ?"*

*"What assets to be maintained ?"*        *"What constraints to be watched ?"*

↓

**LIST OF CONTROL INDICATORS**

⇩

**STRATEGIC MONITORING CHART**
**Indicators, Links with strategy, Analysis rules**
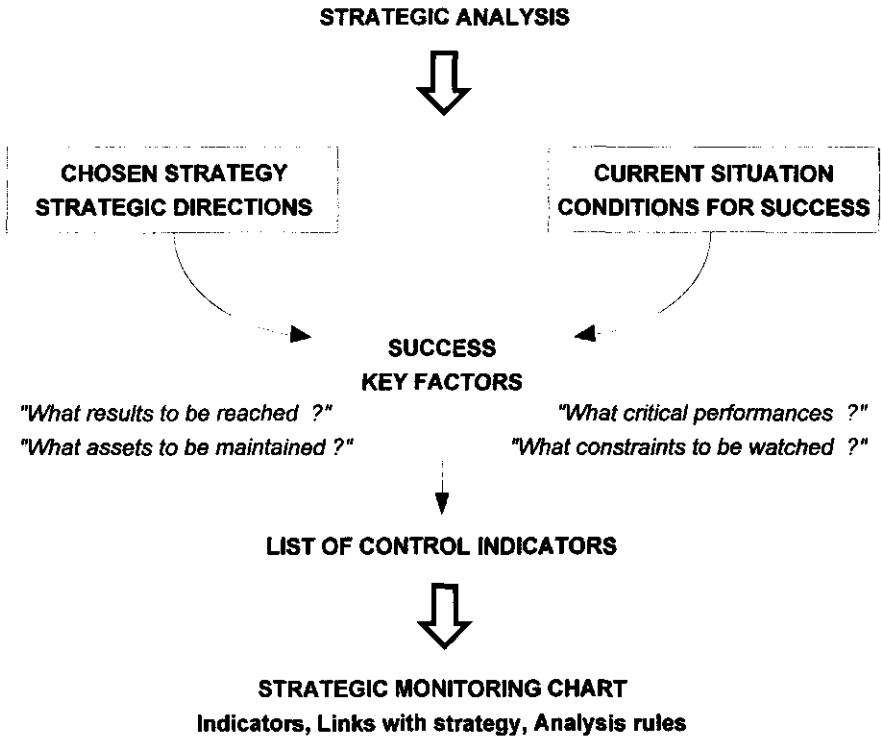
*Figure 2   The strategic monitoring implementation work chart*

# THE USE OF CLUSTER ANALYSIS TO DEVELOP A TAXONOMY OF FARMERS BASED ON THE EDINBURGH STUDY OF DECISION MAKING ON FARMS

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**Abstract**

*This paper describes the process of establishing a taxonomy of farmers based on a wide ranging database of farmer characteristics. This database, the Edinburgh Study of Decision Making on Farms (ESDMF) contains the responses of 250 farmers to a series of questionnaires on matters of farmer objectives, attitudes, behaviour, health and socio-economic profile. The problems of carrying out a cluster analysis on a data set of high dimensionality are outlined, and particularly the complexity of searching for an optimal solution when the resulting cluster groups are highly sensitive to changes in scaling, membership of data-sets, and the type of measurement algorithm used.*

*Tools to assist the user in the interpretation of the basis of clustering at each stage were developed and are outlined here. These included the development and visualisation of key indicators and the use of multi-dimensional data tools.*

*The analysis concludes that no effective clustering, and therefore no clear taxonomy, could be established on this data set. In this case, farmers can best be described by functions representing a continuum of individual characteristics rather than by discrete classifications.*

**Key-words** : Cluster analysis, Visualisation, Decision Making, Modelling.

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## 1.    Introduction

The Edinburgh Study of Decision Making on Farms (ESDMF) has assembled a comprehensive set of data from questionnaires aimed at documenting the process of decision making on farms. To date this has resulted in the development of questionnaire sets to gather information on attitudes (EFaS), objectives (EFoS), behaviour (EFiS), enterprise (EFeS), as well as psychological and health data. In all, the survey contains the responses of some 250 different farmers. Beyond establishing data gathering methods the aim of the ESDMF is to develop a greater understanding of the processes that affect decision making and it has therefore concentrated on analysis and modelling of the data.

The long-term goal is to develop models representing specific aspects of the database, for instance to predict certain data (for example stress) as a function of other variables.

Prior to this it was decided to try and establish a taxonomy of the farmers in the survey to determine if certain groups could be defined based on the characteristics of the data contained within the database components (EFaS, EFiS, EFoS, EFeS). Cluster analysis was used in an effort to establish if such groupings could be found.


## 2.    Cluster Analysis

Cluster analysis is a technique to determine whether distinct groupings can be identified within a data set. For data records with one or two (or even three) fields of information, in the simplest case determining groups may be achieved manually by plotting the data graphically. Where the boundaries of such groups are not clear, cluster analysis can be used to try and separate points into different groups. With data of dimensionality greater than three, visualisation becomes impossible. The researcher has to rely on statistical tools alone to carry out clustering. Techniques are available to map the data in ways that assist visualisation; for instance Multi dimensional scaling (MDS) (Krzanowski, 1988) is a technique to interpret the spatial relationship of the N data dimensions in a two-dimensional plane. As such it can provide an insight as to how different variables relate to each other. However, it provides information on the variables only (as does correlation or principal components analysis) and not on the records (points), so that it cannot be used directly for cluster analysis purposes.

Mathematically, cluster analysis uses the concept of distance to assess which points or clusters should be aggregated to reduce the number of groupings to the required or appropriate level (Massart & Kaufman 1983), (Jolliffe, 1986). Initially each point is considered separately, and the process successively merges the points and/or clusters that are closest to each other. The number of groups is gradually reduced until an acceptable (to the user) number remain. For hierarchical clustering, different methods vary in how distances are calcu-

lated (for instance Euclidean 1), Manhattan, ...), and equally, there is a range of methods for defining the representative point of a cluster (centroid to centroid, Ward's method 2), nearest neighbour, furthest neighbour). These different methods can produce different results, though for a data set exhibiting clear group separation, one would expect results obtained from different methods to be broadly similar, the differences being attributable indistinct groups or assignment of boundary points.

Cluster analysis is highly sensitive to any scaling of dependent variables or data transformations such as taking logarithms or exponentiation. Scalings greater than unity will increase the influence of a variable, and similarly, scaling by a factor less than one will diminish the impact of the variable. The choice of variables to include in the analysis is also critical in how it affects the outcome. There are therefore many subjective considerations to take into account when carrying out cluster analysis, and it is a process subject to experimentation in order to optimise the outcome.

## 3.    Application of Cluster analysis to ESDMF data

The program used was SPSS for Windows. This application provides considerable information concerning the mechanics of the clustering process (dendogram, dissimilarity matrix, agglomeration schedule) as well the group membership of records for different cluster numbers (SPSS, 1993). The SPSS program is, however, less rich in terms of tools to assist the user in the analysis of the results.

There are in excess of two hundred fields in the complete database, individually representing very diffuse information. Given the sensitivity of cluster analysis to the impact and scaling of different variables this would present an impossible clustering problem. The first stage of the analytical process required a reduction of the number of data fields being used. This was achieved (Willock et al., 1995) by Principal Components Analysis. The EFaS, EFoS and EFiS databases were reduced to key concepts associated with certain sets of questions. In all, the three databases were reduced to 7, 5 and 4 factors respectively. The factors formed a reduced set of variables with which to carry out the cluster analysis. These are all listed in table 1 along with the Enterprise and Psychological variables.

As a preliminary check for relationships in the data, bivariate plots of each factor against all others were generated. These did not highlight any evident patterns. The plots appeared to indicate a binormal distribution (figure 1) with no evidence of clusters in any of the two-dimensional cross sections.

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1)    Euclidean: $D = (d_x^2 + d_y^2 + ....)^{1/2}$. Manhattan: $D = |d_x| + |d_y| + ...$
2)    Ward's method sums over each point in a cluster, the sum of the distances from each point to each point in the other cluster.

| Attitude factors | EFaS 1: Attitude towards achievement, motivation |
| | EFaS 2: Attitude towards legislation |
| | EFaS 3: Pessimistic attitude |
| | EFaS 4: Openness / innovative attitude |
| | EFaS 5: Financial risk attitude |
| | EFaS 6: Chemical use attitude |
| Objective factors | EFoS 1: Business objectives |
| | EFoS 3: Quality of life objectives |
| | EFoS 4: Status Objectives |
| | EFoS 5: Objectives outside farming |
| Implementation factors | EFiS 1: Business orientated behaviour |
| | EFiS 2: Environmental orientated behaviour |
| | EFiS 3: Stressed behaviour |
| | EFiS 4: Off-farm /new entry into farming behaviour |
| Enterprise data | Age, Education, Farm_type, Ownership, Inheritance, diversity |
| Psychological variables | Task, Emotion, Avoidance, Neuroticism, Extraversion, Openness, Agreeableness, Conscientiousness |

*Table 1    Variables used in the cluster analysis*

Initial cluster analysis was produced for different cluster analysis methods using the complete set of EFaS, EFoS, and EFiS factors. With no preliminary idea as to how many groups could be expected, cluster analysis was carried out for a range of group numbers, from 2 to 12 groups.

These did not produce consistent results, generating groups with significantly different membership, and no indication of natural cluster size.

Given the acceptance of Ward's method of cluster analysis for social science data (Lorr 1983), it was decided to use only this method, in order to reduce the number of experimental factors. A number of subsets of the variables presented in table 1 were chosen. These were:
- set 1    all EFaS, and all EFoS reduced variables
- set 2    'set 1' + 'Age' and 'Education'
- set 3    'set 2' + 'Farm_type', 'Ownership', 'Inheritance' and 'Diversity'
- set 4    'set 1' + Psychological variables
- set 5    'set 3' + Psychological variables

A feature of cluster analysis is that it will always succeed in grouping data into any required number of groups, irrespective of validity of the outcome. Since the SPSS program does not provide an indication as to whether any of the cluster schemes are valid, or what confidence can be attached to them, a method to analyse the underlying aggregation process was investigated.

In particular, given that we were anticipating developing a taxonomy on the basis of fine tuning and optimising the settings used in the cluster analysis, the following information was not provided:
1.    The confidence associated with different cluster schemes.
2.    The effectiveness of different measurement metrics used.
3.    The optimal number of groups.
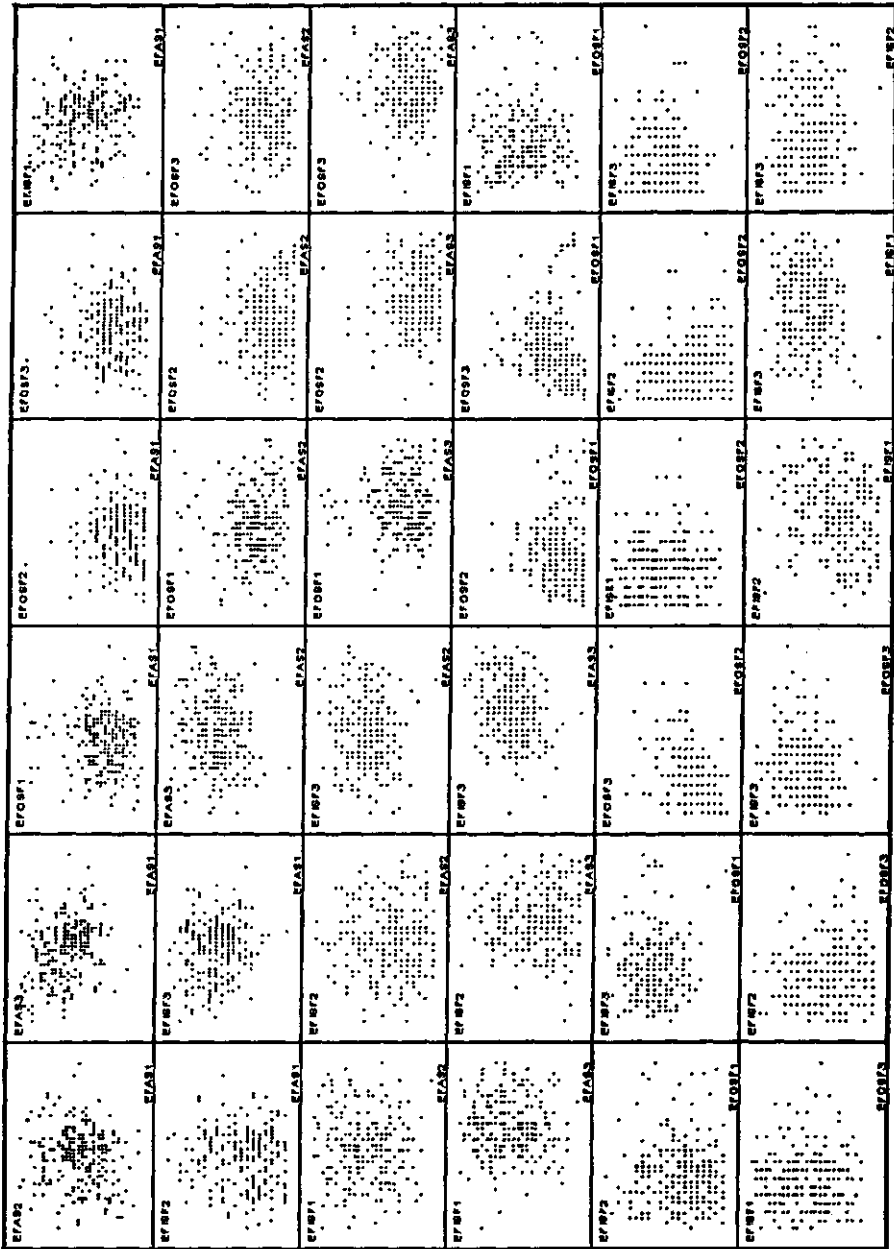
*Figure 1    Bivariate plots of EFaS, EFoS and EFiS factors*

## Cluster visualisation technique

*Analysis of variance*

In order to try to establish if the result of cluster analysis for a given number of clusters is acceptable, a method based on analysis of variance (ANOVA) was used. The ANOVA, analysing the differences between the means of groups and the variability within groups, will only work on one variable at a time, and therefore any results must be replicated for each variable and ultimately considered as a whole.

ANOVA will test a group arrangement for statistical significance. For each stage of clustering, as the number of clusters decreases, there will be a corresponding (likely) decrease in between-group variance and an increase in within-group variance. Correspondingly, the F-value 1) (ratio of between-group variance to the within-groups variance), will decrease. When plotting these values, the stages where the curve has a large gradient will indicate where the variable being analysed ceases to be well distributed across the clusters. Should the same pattern (large gradient) manifest itself for other variables, then it is reasonable to conclude that this represents a genuine cluster stage. To display this more clearly, a modified F-value was calculated as follows:

With

| | | |
|---|---|---|
| r | = | number of clusters |
| n | = | number of points in cluster |
| $X_{ij}$ | = | $j^{th}$ value, in $i^{th}$ cluster of variable X |
| df | = | degrees of freedom |

Large movements in variance are therefore highlighted by the peaks of the curves (rather than the gradients). Examples of such curves are displayed in figure 2 for clustering with the EFaS, EFoS, EFiS variables (only curves for EFaS variables are shown). These can be compared to similar curves (figure 3) for an artificially generated data set (10 dimensions, 5 clusters).

The aspect of figure 2 does not necessarily imply that no clusters are present, but the difference between the curves for the artificial data and those for the ESDMF data is very striking.

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1) Note that the number of degrees of freedom (initially 233), decreases by one at each stage. Therefore all the F values in this example have broadly equivalent numbers of d.f.
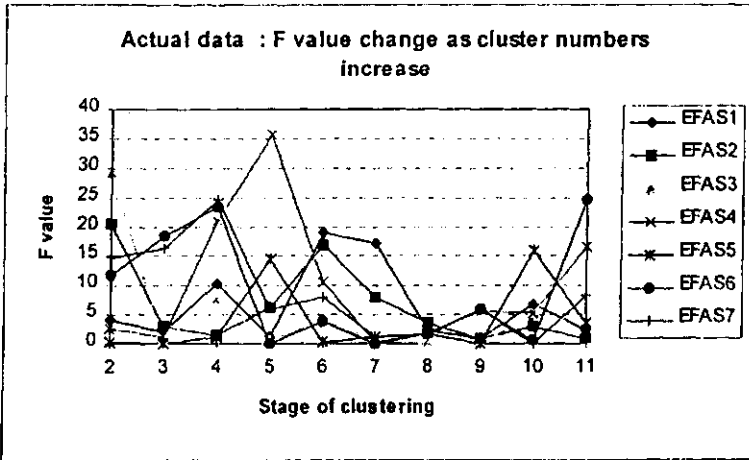
*Figure 2   ANOVA analysis for ESDMF data clustering*
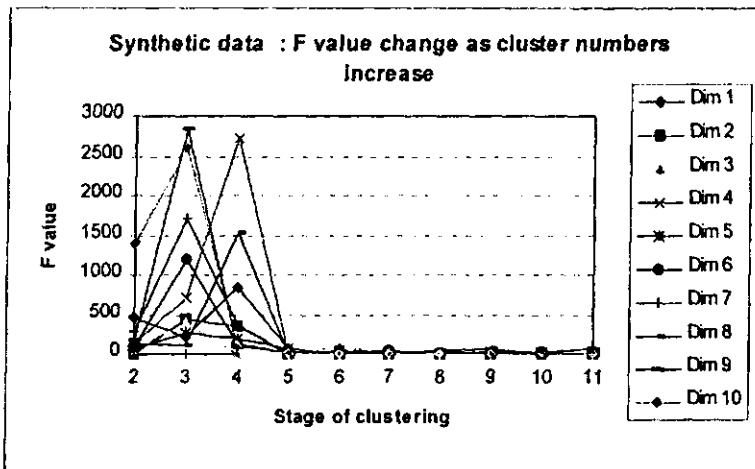


*Figure 3   ANOVA analysis for artificial data (5 clusters)*

## Mapping to the axis joining cluster centres

The analysis of variance method, whilst highlighting underlying differences during cluster analysis between the ESDMF data set and one with clear groupings, does not answer unequivocally the questions as to what confidence to associate with the clustering scheme produced by SPSS. An alternative technique was devised to provide a clearer interpretation to illustrate the clustering process.

In establishing whether a clear separation exists between groups being merged, analysis of variance can indicate if there is a distinction between the groups when considering each dimension separately. However aggregation of all the results of ANOVAs (in this case 16) is difficult. A second approach considered only the two clusters being joined, and the axis passing through their centres. By projecting the points of both clusters (and any other points) on the line joining their centres, it is possible to have an indication whether the clusters are distinct or whether they overlap. If the projected points for both clusters are clearly separated on the axis joining their centres, the clusters are certainly distinct. However, overlapping points on the projected line cannot be taken as an indication that the two clusters intersect or are adjacent (and should therefore be merged), unless it is assumed the clusters are hyper-spherical. Though not conclusive in cases of overlap, the advantage of this mapping is that it produces a visual output, and can indicate the ideal number of clusters.

In plotting this mapping, a separate plot was produced for each cluster stage (from 2 to 12 groups), eleven graphs in all. The projection appears as a number of points on a line (1 dimensional plot). For clarity, the points belonging to different clusters have been separated and staggered along the y-axis. This enables a presentation of where the projection of each cluster is separate, but can easily be overlaid on the same line.
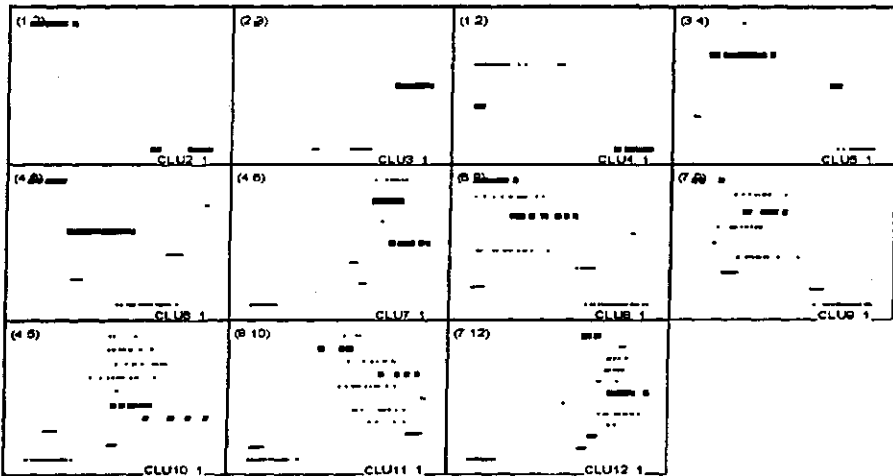


Figure 4    One-dimensional mapping for artificially generated data containing 5 clusters (12- 2 clusters)
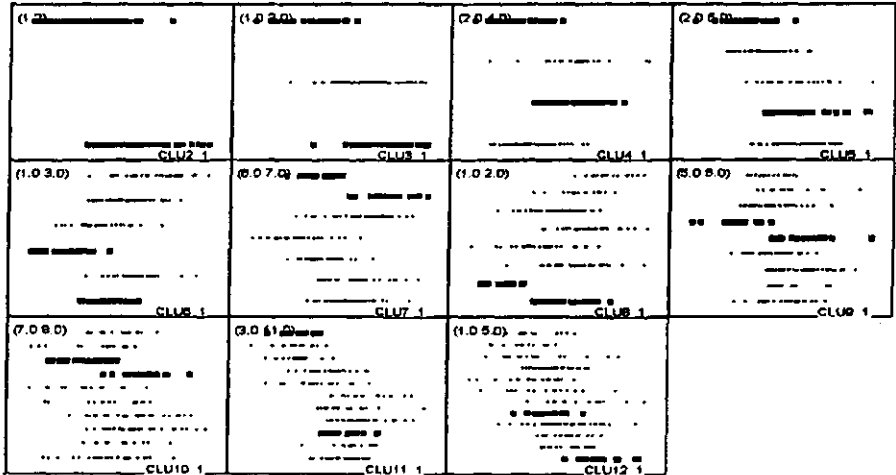
*Figure 5    One-dimensional mapping for clustering based on EFoS and EFiS factors (12- 2 clusters)*

The technique was applied to artificially created data sets with known clusters. Data sets were created for different cluster numbers (10, 5 and 2) and for different cluster standard deviations relative to the overall range of data. The visualisation of the clustering process for these groups is shown in figure 4. In the first diagram (one group splitting into two) it can be seen that the projections are clearly distinct. This is the case until the projection for '5 groups splitting into 6', where it can be seen that there is an overlap between the two separating groups. These indicate that for clearly defined (hyper-spherical groups), the technique is effective at discriminating the point at which the optimum number of clusters has been reached, though where clusters are very dispersed (high standard deviation), the method is no longer effective.

## Results

The technique was applied to the clustering of the ESDMF data set (using Ward's method and Euclidean distance). The results are presented in figure 5. In this instance, there is no particular stage where the merging groups appear to be clearly separating. In some instances there is no overlap between the separating groups though the initial splitting stages (1 to 2 groups) have a high overlap. There is therefore no evidence of natural clustering.

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## Conclusion

Though neither of the methods outlined above is capable of demonstrating the absence of clusters, they do offer strong evidence that there is no discrete grouping within the data. Both the results presented in figure 2 and figure 5 are consistent with this conclusion. Similarly, cluster analyses based on different subsets of the ESDMF database variables have produced equally poor results. This conclusion is also supported by the bivariate plots (figure 1); these offer no indication of cluster patterns within the data.

It is therefore concluded that there is a strong indication that a taxonomy based on the reduced ESDMF database variables does not exist. Rather, it would appear that the distribution of farmers within the space defined by the ESDMF database forms a continuum. This result is surprising, as it goes against the natural intuitive notion that a wide ranging group of farmers should be classifiable in distinct categories.

The tools for cluster analysis interpretation developed in this study appear to have promise though they require considerable development and validation. They have only been used on idealised data, and it remains to be seen how they would perform on data sets where known complex shaped clusters exist.

The fact that such tools needed development illustrates the difficulty of interpreting cluster analysis results with the facilities provided by statistics packages such as SPSS (and others), where research on interpretation of cluster analysis (Sarle 1983) is not integrated within the environment.

The experience of this project is that cluster analysis interpretation tools need to be well integrated within the statistics package. A major bottleneck arose from having to work across three different software environments (SPSS, Excel, Smalltalk). An appropriate framework would be a Decision Support System, from which a range of tools and tests would be available, to provide assistance to the user, and where background optimising routines could search for combinations of variables and scalings that appear promising.

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# STRATEGIC PLANNING AND ITS INFLUENCE ON THE DECISION MAKING PROCESS OF THE FARM BUSINESS

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## Abstract

*The Agriculture Management Advancement Project (AMAP) from Michigan State University, USA, applies strategic planning principles to farming businesses. Strategic planning has been used successfully in other types of business, and AMAP has adapted it to farming operations, using a curriculum based learning process.*

*The curriculum described in this paper focuses on the AMAP pyramid, where the base is the business's mission statement, the development of long- and short-term goals to support the mission, and tactics to achieve the goals. Producers involved in this process also learn how their personality types affect their information processing and management decisions.*

*Also described is the outcome of the project so far, including modifications, observations on effectiveness, and personality types of the participants. The supplemental management modules dealing with issues such as human resource management, information systems and financial management, are used to help producers implement their strategic plan.*

## 1.    Introduction

The importance of agricultural producers having better management skills has increased significantly in recent years. One of the motivating factors for acquiring better management skills is the rapid changes occurring in agriculture. According to a recent study by Purdue University, agriculture will see an increase in government regulations, a continued demand for more environmentally friendly production, greater coordination of markets and factors of production through contract marketing, products that meet specific consumer demands, globalized markets, a greater emphasis on data and data manage-

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ment, and increased price variability. Other motivating factors include new advances in the structures and size of agricultural firms and a rapid growth in the availability of new technologies.

Leaders of the Michigan livestock industry, aware of these trends, approached Michigan State University and asked for a more management-intensive educational program for livestock farmers. Requests like these are common in the United States, as the land grant universities are charged with conducting major research and outreach educational (extension) programs for agricultural producers, in addition to student academic programs on campus. Universities and agriculture traditionally have close ties which has helped define the research and outreach agenda, ensuring these programs better meet the needs of the industry.

From this request, a new management curriculum was proposed and reviewed with the industry leaders. After the review the proposed curriculum was modified and the development of educational materials began for AMAP. This paper describes the management curriculum, some of the experiences learned in the teaching of this curriculum to agricultural producers, and the major factors that affect the decision-making process.

## 2. Curriculum

Curriculum development was a team effort involving campus faculty and the off-campus extension personnel. Major departments involved were Agricultural Economics and Animal Science in cooperation with Agricultural Engineering and Crop and Soil Sciences. After reviewing several management education programs, it was decided to use the concepts of strategic planning as the foundation of the program's curriculum. Strategic planning has been used by larger corporations for years. As Aaker notes, strategic planning, conceptualized in the 1960s, is concerned with strategic thrusts and capabilities. Its basic assumption is that past extrapolations are inadequate, that there will be discontinuities from the past projection, but more importantly, new trends will be emerging. Businesses should focus attention on the future marketing environment. Strategic planning involves an external analysis, which identifies the opportunities and the threats facing the business, and an internal analysis, which addresses the strengths and weaknesses of the business.

Few agricultural producers have used strategic planning. Many are unaware of the process, and it needed to be adapted to farm businesses. New York has had some experience in using strategic planning with dairy producers as part of its PRO-DAIRY project. The coordinators of this project were very encouraged with the success achieved and encouraged the MSU coordinators to use its components with their more broadly identified audience.

Strategic planning is covered in the introductory workshop. This workshop teaches producers the concepts of planning and how to utilize these concepts to make more sound business decisions. Once the producer has taken the introductory workshop, he or she can proceed to the second level of the curriculum, the supplemental workshops. These stress functional management areas

of the business such as human resources management, financial management, production management, marketing, and information management. The supplemental workshops stress the application of knowledge gained in the introductory workshop.

*Introductory Workshops - Workshop on Strategic Planning*

As the primary curriculum of AMAP, the workshop's objective is to have producers develop a unique strategic plan for their own farming operation. The scope of the curriculum is illustrated in figure 1. It involves doing an internal and external analysis of the business and developing a mission statement, long-term goals, short-term goals, and tactics for achieving these goals.

The first phase of the curriculum introduces the concept of strategic planning and how it has been effectively used by other businesses. This phase also emphasizes what producers will achieve from their participation.

The focus then shifts to what management is and what managers do. This involves a group discussion of the participants regarding the role of managers. In this section, each of the participants completes a management inventory exercise. This is an internal analysis tool that was developed by the PRO-DAIRY project. The management inventory ranks each of the participants on their skills in the five functions of management -- planning, organizing, staffing, directing, and controlling. Based upon the ranking in the five functions, management's strengths and weaknesses can be identified so adjustments can be made to make it more effective.

The next phase focuses on the external analysis which helps producers better understand the opportunities and threats facing their industry. This phase is built around Porter's competitiveness concepts. It stresses that the agricultural producer is part of a much larger consumer-driven system. Agricultural producers must competitively bid for inputs of production such as labor, land, and capital in order to produce a product that will be desired by consumers. The producer's industry is also influenced by the operating environment, level and type of endowment resources, quality and availability of supporting services, and the type and form of government programs. The effect of these factors needs to be evaluated in relationship to other competitors. To encourage discussion the participants are divided into small groups and asked to identify the major opportunities and threats of their industry. Producers have found these discussions enlightening, and they begin to think about their business and industry in a broader and more global perspective.

The external analysis is critical to the next phase of the curriculum -- developing the mission statement. The mission statement conceptualizes the vision of the business. For the producer it defines 1) who they are, 2) what they do, and 3) where they are headed. In defining the vision, it is important to know the opportunity and threats facing the industry.

The mission statement is the foundation of the AMAP pyramid. It defines the basic principles that will guide the business. These principles must be in place before meaningful business goals can be defined. It is at the mission statement phase that one of the major differences between using strategic

planning for corporate businesses and family operated farms becomes obvious. A mission statement for a farm blends the values and circumstances of individuals that make up the management team of the business. This blending process become even more complex when there are multiple families involved in the business -- a condition that is becoming more common.
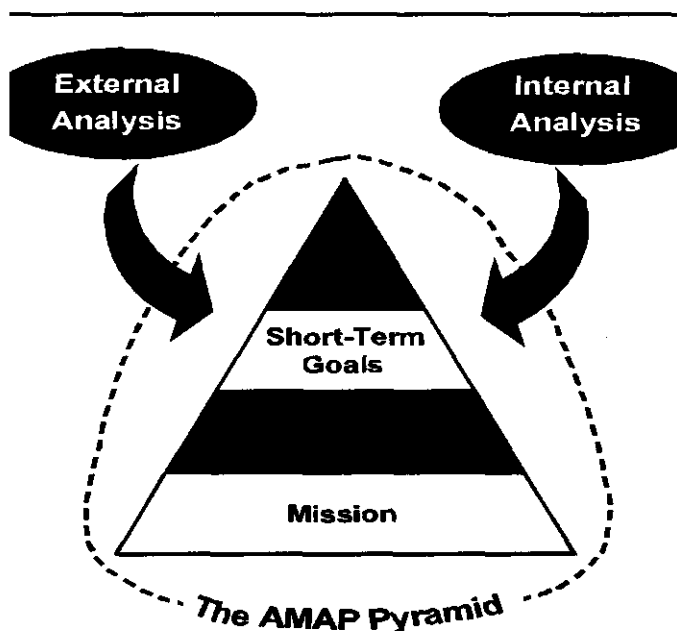


Figure 1  Strategic Planning

To help make the development of the mission statement more manageable, exercises are used to identify basic individual and family values. This exercise draws upon a technique developed and used by the University of Wageningen.

Values are those ideas or beliefs that a person rates very highly or hold dear. They greatly influence how the person will evaluate the current situation and define future directions for the business. Thus, the correct and complete definition of values is critical. Examples of different managers' statements are given and participants are asked to determine what values these managers hold. From this exercise, they can more easily define their own values.

The other main determinant of the mission statement are circumstances. Circumstances create unique opportunities and obstacles. Worksheets help participants identify circumstances that both positively and negatively influence their personal life, family, and business. After defining the basic values they hold dear and the influencing circumstances, the participants write a draft of their mission statement. They are encouraged to write a personal mission state-

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ment first. From this, a business mission statement can be more easily developed. This is particularly true in multi-family operations.

Once the foundation of the AMAP pyramid (the mission statement) is in place, additional internal analysis tools are employed to help participants better identify appropriate long-term goals that are consistent with the mission statement. One of the tools utilized is Rochart's critical success factors. Critical success factors worksheets are used by producers to determine the most important factors related to financial management, livestock and crop production, marketing, information systems, human resource management, and farm in their business. The participants are asked to identify three to five critical success factors in each of these areas for their own operation. They then evaluate how well they are performing for each of the identified factors.

The other internal analysis tool used is the Myers-Briggs personality inventory. Personality influences how people relate to others, view new ideas and concepts, and evaluate and react to problems. Personalities are defined fairly early in life and change gradually. The Myers-Briggs personality inventory describes four personality classifications types that were developed by the Swiss psychiatrist Carl Jung. They include introvert versus extrovert, sensor versus intuitive, thinker versus feeler, and judger versus perceiver.

Management style is influenced by personality type. In some cases it can have a great influence, depending on the strengths of certain personality traits. For example, if a person is strongly introverted, that person will usually have a smaller pool of people to look to for new ideas. This may limit the range of options examined when solving problems. If that individual is concerned with details and facts (sensor) that person may be less visionary and thus miss some good opportunities. Conversely, an intuitive person tends to let details slide and good decisions may not be properly acted upon. Many people in management capacities like to think they make decisions based on facts and sound logic (a thinker). Others tend to base decisions on 'what seems to be right' (a feeler). Employees who are 'feelers' working with an employer who is a 'thinker' may have difficulty communicating unless these differences are addressed.

Others may tend to agonize over decisions (a preceptor) while others make decisions quickly (a judger). Making decisions slowly and deliberately in order to avoid making mistakes can be a time-waster and a good opportunity may be lost. On the other hand, a hasty decision made by a judger can have equally disastrous results. Knowing personality traits makes it easier to adjust management styles and define the business goals and tactical plans of action.

With the knowledge gained from the internal analysis tools, critical success factors, and Myers-Briggs personality inventory, the participants then develop long-term goals -- the second building block of the AMAP pyramid. Long-term goals help the business achieve its mission. Long-term goals define the non-specific, general direction of the business. The acronym DRIVE (directional, reasonable, inspiring, visible, eventual) helps to develop long-term goals that reinforce this concept. An example of a long-term goal might be to 'increase the average milk production per cow'.

Conflict resolution is also a part of the long-term goal setting process. Conflicts can exist between personal goals, family goals, and business goals, or the goals might be in opposition to each other, such as desiring rapid expansion, but also having a stable and smooth flow of income. Conflicts in goals are more often seen on multi-family operations.

Short-term goals -- the third building block of the AMAP pyramid -- are much more specific and detailed than long-term goals, with a precise time dimension. They help the business achieve its long-term goals. Each long-term goal should have at least one or more short-term goals. The acronym SMART (specific, measurable, attainable, rewarding, timed) is used in developing short-term goals. For example, to support the long-term goal of 'increase the average production per cow', an appropriate short-term goal might be 'achieve 10,000 kilograms production per cow by March 1, 1996'. If the herd average is currently at a level that makes this goal possible as well as rewarding and challenging, this would be an appropriate short-term goal.

The last building block of the AMAP pyramid is tactics. Tactics examines the process of how to achieve short-term goals. It draws upon the problem solving process of: 1) identifying the problem, 2) diagnosing the problem, 3) generating several possible solutions, 4) deciding on a solution, 5) devising a tactical plan, and 6) evaluating the problem solving steps. It forces the participants to consider factors that might hinder a business from achieving a short-term goal, identify alternatives for overcoming these factors, decide which alternatives are best suited for the situation, and finally put a plan of action into effect.

The case study approach refined by the Harvard Business School is the basis for the tactical planning process. Decision making grid worksheets are utilized to help producers evaluate and rank alternatives. Tactical planning methods stress what needs to be accomplished, who is responsible, and when and where it will be accomplished. For example, to achieve the short-term goal of '10,000 kilograms of milk production per cow by March 1, 1996' the participants might use the decision making grid to choose the option to improve the nutrition program of the milking herd. There might be several tasks needed to accomplish this, including having a professional nutritionist balance the ration, doing forage testing, calibrating the feeding equipment. The tactical plan specifies when and how each task will be accomplished. The last part of the tactics addresses time management. Methods are introduced and the producers are encouraged to use a daily planner notebook to help them prioritize daily tasks.

The original introductory AMAP curriculum was developed for dairy and swine producers and cattle feeders. It has since been expanded to include field crops, potato producers and cow/calf operations.

*Curriculum Delivery*

AMAP is delivered in a workshop setting. The local Extension agent helps identify and encourage producers to attend. The commodity groups (e.g., Soybean Promotion Committee) are very supportive of AMAP, both encouraging producers to attend and providing funds to help support the development

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of educational materials. Similar support has been provided by the agribusiness community such as the lending agencies and veterinarians.

Each workshop session is day-long, once a week for three weeks. Teaching of the workshop is a team effort involving both the campus extension staff and local extension agents. Homework is assigned after each session. The homework consists of exercises (e.g., Myers-Briggs Personality Inventory) and writing the mission statement and goals. The first day concludes with a draft of the mission statement being developed and the second day with a draft of the long- and short-term goals.

## Workshop Observations

In the past two years, 18 AMAP Introductory workshops have been held. There have been 417 participants representing 234 farm businesses. The majority of these have been from livestock farms with dairy being the most common.

A number of observations can be drawn from these workshops. Keep in mind when looking at these observations that the main objective of the workshop is to teach management principles to improve decision making. This is not a research focused effort. Thus, the amount of data that can be collected from the producers is somewhat constrained.

Based on notes taken when the producers describe their farming operations to other participants, AMAP is attracting operations that are substantially larger than the average, achieve higher levels of production (e.g., higher production per cow), hire more labor, farm more acres, are fairly progressive technology-wise, tend to utilize more management information tools (e.g., dairy production records or crop records systems), and more likely to be multi-family operations.

A vast majority of the operations had not prepared a strategic plan for their operation. So these workshops were meeting an unfilled need. Although 52% of the farms had more than one member of the management team in attendance, many expressed the sentiment that all members of the management team be in attendance. On a Likert Scale with 5 being strongly agree and 1 being strongly disagree, the score was 4.6.

There are no tabulated results on the management style inventory. Based on the shared discussion of the participants, they tend to be weaker in the areas of planning, staffing and directing relative to controlling and organizing.

The critical success factors exercise indicates there are some common factors across most farming operations (e.g., generating adequate cash flow and high yields). There was also a fair amount of diversity among farms in the factors selected, indicating they view different factors as priorities in their operation.

Each of the farming operations provided the coordinators a copy of their mission statement for printing and framing. Thus, it is possible to analyze the nature of the mission statements developed by the participants. There was a great deal of effort and thought put into developing the statements. Below illustrates one such statement.

*Our mission is to build a prosperous, top quality, family operated dairy farm. We are a team of partners and co-workers producing high quality milk, forage, and feed grains.*

*We strive to maintain high quality production in our dairy and crop units, using our natural resources, proven and new technology, common sense, and using the best of what we have to assure an ongoing business.*

*As partners, families and co-workers, we strive to maintain the following values and benefits:*

*- A comfortable, relaxed and gratifying atmosphere.*

*- A comfortable standard of living, now and in the future.*

*- A balance of time spent between work and personal needs.*

*- Safety at work, home and away.*

*- Physical, mental, and spiritual health.*

                  *Farms*

From this example, certain values can be observed (table 1). Each of the mission statements were analyzed for types of values contained in the mission statements. The values displayed in the mission statement are fairly diverse. It is clear when reading the mission statements that no one single value dominates the vision for the business. The most common were family values. These often stress the need to have adequate and quality time for family activities, particularly relative to business activities. The next most common value was to produce a high quality, safe product. This was much more important than achieving the highest yield possible. Another often stated value was to have good employee relationships, found in 39% of the mission statements. This would be even higher if it was adjusted to reflect that some of the farms did not hire additional labor. It was also important that family members have an opportunity for growth in the business.

The concern for being a good citizen in the community is a frequently stated value, related to being involved in community activities and organizations. Also this value was directly related to this was the concern for the environment (43%). Farm families have a concern for leaving the natural resources in an improved state and producing safe food.

The financial health of the business was important as well. Over one-third of the mission statements wanted the business to earn high profits. However, as nearly high in importance was the desire to have an adequate but stable and secure level of income to support the families of the management team and employees. Growth in the business was important to over one-quarter of the businesses. Of particular concern was the desire to have the business be large enough to allow the next generation join the business if desired.

Being a progressive farming operation was a value for nearly 40% of the farms. However, only 10% placed a high value on being considered an innovator. Many stated a desire to use new technologies only after they have a proven track record.

Table 1   Values Found in Mission Statements

| Value | Percentage | Value | Percentage |
|---|---|---|---|
| Product | | Personal | |
| - High yields | 6 | - Self esteem | 10 |
| - High quality and safety | 44 | - Family values | 47 |
| - High animal values | 10 *) | - Religious values | 19 |
| | | - Good community citizen | 38 |
| | | | |
| Financial | | Technological | |
| - Profitability | 35 | - Innovator | 10 |
| - Stability/Security | 30 | - Keep abreast of times | 28 |
| - Growth | 28 | | |
| | | | |
| Human Resources | | Environmental | |
| - Family growth in business | 26 | - Implicitly stated | 13 |
| - Employee growth in business | 11 | - Explicitly stated | 30 |
| - Employee relationship | 39 | | |

*) If only considering livestock farms, the figure would be higher.

The Myers-Briggs personality test also yields some interesting results (table 2). First is the strong tendency to be sensors and thinkers as opposed to intuitive and feelers. This suggests a management style that prefers lots of facts and figures, pays attention to details and makes decisions on logic rather than instinct. Being a thinker, they are often unlike the employees they might hire. Also the low level of intuitive types suggests that they might not see the 'bigger picture'. They also tend to be judgers as opposed to perceivers. It is also interesting to note that introverts outnumber extroverts. This is particularly true of dairy operations.

An interesting aspect of the Myers-Briggs personality test is how the management team used the information to re-think the delegation of responsibilities. For example, a member of the team (e.g., the spouse) that was a feeler was often encouraged to become involved in employee matters. Also, knowing one's personality type makes it easier to compensate for the other dimensions -- a sensor interacting more with people that are intuitive.

The goals support the mission statement. For some of the values stated in the mission statement, such as family values, the goals easily follow. Many long-term goals were to spend more time with the family with a short-term goal of scheduling a vacation or reserving one evening a week as 'family night'.

It was fairly common to find production increasing goals to address financial values and production values. Another common goal toward financial stability and security values is the reduction of debt. For family growth in the business, the goal is usually to develop a plan to transfer the business from one generation to the next.

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*Table 2    Myers-Briggs Results From Workshops*

| Personality Type *) | Percentage | Personality Type *) | Percentage |
|---|---|---|---|
| ISTJ | 19 | ESTP | 2 |
| ISFJ | 12 | ESFP | 3 |
| INFJ | 4 | ENFP | 3 |
| INTJ | 4 | ENTP | 4 |
| ISTP | 8 | ESTJ | 13 |
| ISFP | 6 | ESFJ | 8 |
| INFP | 4 | ENFJ | 4 |
| INTP | 3 | ENTJ | 3 |

*) Personality type based on the four classifications (E = Extrovert or I = Introvert; S = Sensor or N = Intuitive; F = Feeder or T = Thinker; P = Perceiver or J = Judger).

To address employee relationship values, goals often relate to methods of improving the communication process and delegating more responsibilities to the employees. Environmental values often generate goals that relate to implementing environmental friendly new technologies (e.g., no till cropping systems).

At the conclusion of the workshop, the participants evaluated their satisfaction with the workshop. On a 5 point Likert scale, with 5 being strongly agree and 1 being strongly disagree, the producers average response was 4.2 when asked if they would recommend AMAP to other producers. Generally the participants are very pleased with the workshop. However, about 1 person in 25 were dissatisfied with the workshop.

Participants were also asked to indicate which supplemental workshops they would be most interested in attending. The strongest response was human resource management. This is particularly true for livestock farms that tend to hire more labor. The next desired supplemental workshop was financial management followed by production management and marketing.

We have conducted follow-up efforts with the participants. The local extension agent has played a key role in these efforts through farm visits and coordinating farm tours. The producers have indicated that the workshop has made them better, more effective managers. However, some have said as they have gotten busy with their farming activities, they sometimes lose sight of their goals and fail to follow through with their tactical plans. On the other hand, they have found that strategic planning is a useful tool for communicating with others, including employees and lending agencies.

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# SCIENTIFIC INSIGHTS INTO FARMER BEHAVIOUR AS REQUIRED BY POLICY-MAKERS

Ms Ir C.P.M. Moonen 1)

## Abstract

*Farmers are the ones who lead the way in solving problems in agriculture. Agricultural policies are no longer concentrating on just the economic aspect. The sociological angle is gaining ground as we have come to realize that farmers are actors making choices guided by more aspects than just finances. To develop policies it is more important to have information about the variation between farmers than about statistical averages.*

*Research is to reveal what farmers and growers consider less optimum situations, where there is potential for innovation and what factors are important (social, economic, technical factors, nature and environmental awareness). Co-operation between research institutions should be improved to solve issues in a multidisciplinary manner. Almost all policy fields need practical research, preferably at the farm.*

**Key-words** : Economy, sociology, farmers.

## 1.    Introduction

Agriculture is facing new challenges, especially as regards sustainability, the quality of life and competitive power. How these challenges are met is up to the sector. Farmers and growers are expected to introduce innovations at a great rate and to adjust their management methods to present and future requirements. At the same time their occupation is taking on new dimensions: farmers and growers become managers of natural resources or quality assurance scheme producers. The requirements that are made are seen as challenging, confronting or intimidating. This paper deals with:
- the theory on changes in farmer and grower attitudes; and
- the information the Ministry of Agriculture, Nature Management and Fisheries needs from research to obtain a better insight into farmer and grower activities and the choices they will make.

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## 2.    Types of changes

At the farm a distinction can be made between technical innovations and innovations in management. It is also possible to distinguish between innovations that are relatively well-known within the sector but new to individual farmers and growers and innovations that entail many uncertainties, generally related to new farm objectives, and therefore involve risks. In practice the two distinctions cannot be separated.

Whether innovations are accepted in practice depends on:
-    the degree of certainty farmers have that the innovation is beneficial to them;
-    the degree in which the innovation fits in with existing standards and values in their surroundings;
-    the intrinsic complexity of the innovation, in other words, the uncertainties it entails;
-    the possibility of trying out the innovation on a small scale;
-    the effects of the innovation compared to present management methods.

The following aspects affect the choices made by farmers and growers: their attitude to change, eagerness to learn, knowledge, experience and skills, common objectives, family situation and succession, availability of capital, and the economic outlook both for the farm and the sector. To farmers, changes are obscure, risky, wide-ranging in greatly changing socio-economic and policy frameworks. They require increased responsibility; there is also more than one management style and there are differences in problem perception.

More often than not innovations are not proceeding linearly from knowledge development to dissemination and from knowledge dissemination to application (Enzing, 1993). An interactive model of innovation was developed by Kline & Rosenberg. Characteristic of the model is the emphasis on the interaction between the different stages (and actors) in the process of innovation. Stages are for instance orientation, experimentation, and dissemination. The process can be approached at all levels and at all levels feedback can be received. Kline & Rosenberg's model can be very well applied to farmers and growers (Ministry of Agriculture, Nature Management and Fisheries, Department of Agriculture, 1995).

What is interesting about this model is that in each stage there is feedback to other actors and existing knowledge. If there are no other actors or knowledge or if actors or knowledge are insufficient, new knowledge is sought outside the model as well as in the previous and following stages. The entire process is controlled by the person trying to solve the problem.

Figure 2 shows the various influences farmers and growers are subject to. Please note that the Ministry of Agriculture, Nature Management and Fisheries oversees and influences just a small part of these influences. Awareness has grown that farmers themselves play a major role in seeking solutions to their problems, which has resulted in a new philosophy. The Ministry of Agriculture, Nature Management and Fisheries will concentrate more on processes and

create more room for promising initiatives submitted by farmers and growers, who, often at considerable risk, translate policies into sustainable management systems. Responsibility will be devolved to the appropriate level.
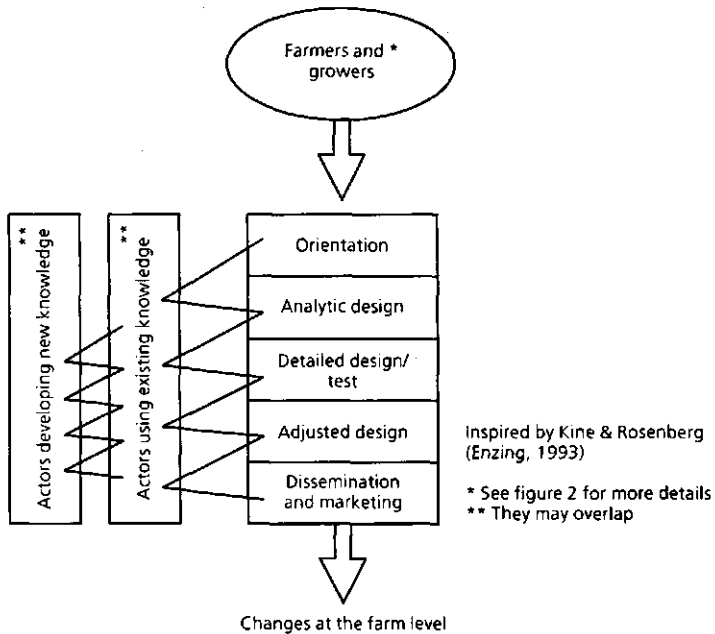


*Figure 1   The process of innovation*

## 2.1   What information does the Ministry require of research?

The central issue is: what information is required of research to obtain a better insight into farmer and grower activities and the choices they will make? The Ministry's policy aims to offer more scope for measures tailored to specific needs. As policy support is a prerequisite for making policies succeed, it is of vital importance that the Ministry is familiar with the different motives of farmers and growers. Together with the responsible policy-makers it was examined for three policy areas what the Ministry wants to know about farmer behaviour. The areas are sustainable agriculture, animal health and promotion policy.

## 2.2   Sustainable agriculture

Agricultural policies used to focus on expansion of scale, reasonable incomes and continuity. Together with autonomous development this resulted in more specialized farms. Research subjects also centred on technical-economic matters  and specialization. In nearly all researches farmers were considered to
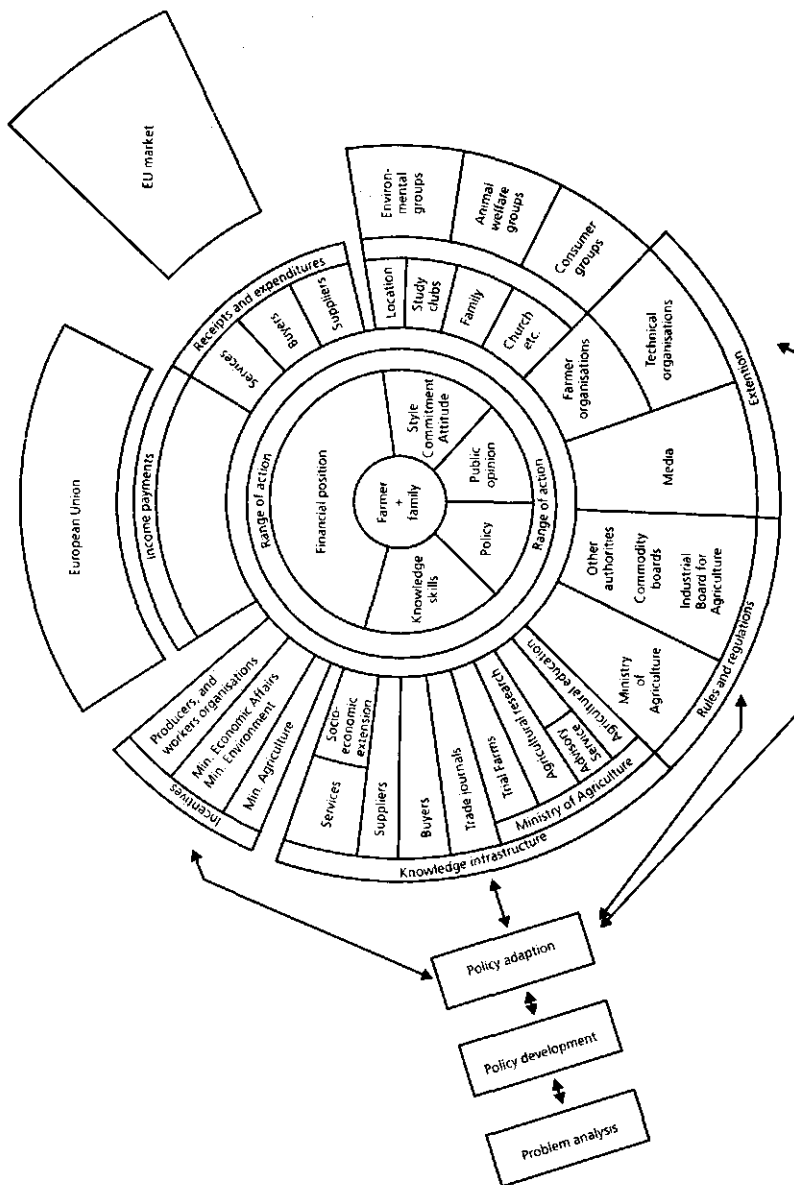
*Figure 2    Influences on farmers and growers*

Environ-
mental
groups

Animal
welfare
groups

Consumer
groups

Technical
organisations

Extension

Media

Other
authorities

Commodity
boards

Industrial
Board for
Agriculture

Rules and regulations

Ministry
of
Agriculture

Agricultural education

Advisory
Service

Agricultural research

Trial Farms

Trade journals

Buyers

Suppliers

Services

Ministry of Agriculture

Knowledge infrastructure

Socio-
economic
extension

Min. Agriculture

Min. Economic Affairs
Min. Environment

Producers, and
workers, organisations

Incentives

European Union

Income payments

EU market

Receipts and expenditures

Services

Buyers

Suppliers

Location

Study
clubs

Family

Church
etc.

Farmer
organisations

Range of action

Financial position

Style
Commitment
Attitude

Public
opinion

Farmer
+
family

Policy

Range of action

Knowledge
skills

Policy adaption

Policy development

Problem analysis

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act for 100% on economic and rational grounds. Pluriformity received little attention.

Today the subjects researched on behalf of agricultural policies have changed:

- Specialization is no longer taken for granted; on the contrary, the possibilities (existing and future) for new types of mixed farming are examined.
- Other and more dimensions in optimization are looked at than just the financial and entries are sought for policy response.
- Farming is supplemented with other sources of income (recreation, part-time farming, sale of farmhouse products etcetera).

It is important to inventory the possibilities of widening the range of farmer actions. Management indicators must be developed in such a way that they help make farmers aware of the necessity to widen their range of action. We need more information about the characteristics of farms and farmers that have been successful or not in order to give the business more prospects. What will this mean to policy? More insight is required into the pluriformity of farmer objectives and their results at the macro level, e.g. concerning increased diversity, rural incomes, employment, environmental pressure and quality of life in the countryside. We need knowledge of how sustainable agriculture can blend in with local ecosystems. Of how farmers see the relationship between economy and ecology at the farm and what this means for the choice of farm type and management methods, crop selection, minerals input, etcetera. More model studies showing the interaction between and integration with such matters as fertilization, animal diets, groundwater levels, soil type and yields are needed to acquire such knowledge.

It is known that social barriers may, for instance, hinder the conversion to organic production. Research should provide a better insight into the various factors involved in behavioural changes in farmers and growers. So far research has paid too little attention to the influence of farmers' wives on the specification of targets at the farm level and on the management decisions that are taken.

More than ever the success of the agricultural sector will depend on its ability to innovate. Innovation affords an opportunity for a farmer to distinguish himself from his competitors. What creativity is required for product and farm innovation? What, besides knowledge, is needed to make new products? What makes a farmer willing to change (from the inside)? How many and what barriers should be removed before changes are actually brought about (from the outside)?

In environmental research the central question is how farm economics are influenced by the environmental actions (investments included) undertaken by farmers. Agricultural research will be able to provide a satisfying answer. Another question is what attitude and perception farmers have of the impact of environmental actions on management. The answer to this question is important to direct future agricultural research and to facilitate communication between policy and farmers on environmental objectives and the possibilities at the farm level.

How environmentally aware are farmers and growers, and is this awareness growing or not? What are impeding factors between thinking about nature and the environment and taking action? How can policies respond? The take-up of some systems (environmental care) is hesitant, whereas others are embraced (minerals accounting). How is acceptance proceeding and why is it proceeding in this manner? Why are entrepreneurs in some sectors more prone to introduce innovations than others? Why are there such marked differences between the regions?

As regards the reduction of the burden they place on the environment, farmers and growers will have more freedom in the years ahead to choose for specific housing systems, manure application methods, etcetera. But what choices will be made and what will be lost in terms of economic activity at a given and accepted level of emission?

Research into nature production by farms has started only recently. We need much more insight into nature production translated into farm economic parameters. The question of whether this could or should lead to compensation for the production of nature is also very relevant now. In this respect it is essential to know the attitude and perception of farmers as regards the possibilities of nature production.

Overall numbers of farm heads in primary agriculture are declining each year. The group winding up their businesses is not so important from the policy view. What is important are the consequences for the remaining farms. Farmers that used to be in the middle bracket of profitability more and more often have years with very low profits or even losses. What consequences will this have for the possibilities of innovation? What are the determining factors (environment, physical planning, ability to cope with uncertainties, to adequately respond to demand)? What type of farmers and farms make up this middle bracket, what type of farmers is forced to wind up their businesses and why? What are the effects of government measures?

## 2.3   Animal health

Prevention is of paramount importance in animal health care. The attention of livestock farmers for prevention can be caught by showing what it does for common illnesses (udder and fertility problems). If they realize they can solve these problems and improve their financial results, more complicated diseases such as IBR (infectious bovine rhinotracheitis, a cattle infection) and co-operation with others will have their interest too.

The Ministry of Agriculture, Nature Management and Fisheries asks research to:
- increase knowledge by means of research results;
- increase options at the operational, tactical and strategic level by increasing knowledge;
- provide options that can be weighed;
- provide options that can fit in with management methods (different for each farm);

-       inventory the consequences for and interactions with other aspects of management.

The motive for change is that the present situation is less than optimum. Research is to be aware of what situations farmers consider less than optimum and of the determining factors (social, economic, and technical). Research is to develop knowledge and to offer it in a manner enabling farmers to weigh the pros and cons of these options. This means that, after conducting basic research if required, in almost all cases research should be carried out at experimental stations or at trial farms. Management supporting instruments are best developed at the farm.

Harmonization between basic and practical research should be improved and interaction between policy and practice should increase. Researchers may act as intermediaries by being well-informed about what farmers are up against. In strategic research the early involvement of various organizations, such as consumer groups, is a must. Co-operation between research institutions and research areas can be improved further (multidisciplinary approach); the co-operation in pig health care is a case in point.

Statistical information on animal health is very scarce; it just covers the amounts farmers spend on animal health care. We need much more data on the leaders in animal health care to get the middle group going.

2.4    Promotion policy

Promotion policy is understood as encouraging changes in behaviour in the direction desired by the government by financial incentives (levies, subsidies, tax advantages). It is for instance being considered to introduce levies on contaminating components such as energy and nitrogen to influence farmer behaviour. Further research is needed into the rational and economic reaction of farmers to levies. Subsidies are often not applied effectively: they go to followers instead of innovators. Besides, the regulations for individual or regional situations are not flexible. Many innovations do not fit in with existing regulations and therefore do not qualify for co-financing. In integrated farming the introduction of innovations is represented as a four-stage operation, the number of farms involved increasing each time by a factor of 10.

Stage 1 = 3 trial farms
Stage 2 = 38 innovation farms
Stage 3 = 350 early converters
Stage 4 = 3000 later converters

Later converters receive much of the subsidies now. The government is developing a new framework of promotion aimed at innovators and early converters. How can early converters be quantified per sector? How does this group influence later converters and how can this be optimized?

There are also individual farmers or (small) collectives of farmers who take the initiative in introducing innovations. These collectives are more and more often prepared to invest in research and development. Supporting these

investments is a method to advance risky, challenging changes in particular. Financial stimuli are meant to reduce the risks of innovations for farmers.

A systematic dissemination of knowledge, skills and experience connected with innovation is highly relevant to realize policy objectives, but in practice this is generally ignored. How can this be improved?

We should collect more statistical information on the following aspects:
- How much did farmers and growers invest last year in environmental protection, animal welfare, quality improvement, hygiene, improvement of working conditions etcetera?
- How do these investments break down regarding level and number of farmers?
- What is the average amount invested for each segment?
- During what crucial stages in a farm's life cycle is invested, such as take-over, and how is the relation with management styles and regions?

The promotion policy is considering to support innovative projects carried out by groups of farmers aiming to realize policy objectives. A group of farmers proposes a plan stating the group objectives it wants to realize in a certain area. They then determine which farmer will make what adjustments or investments. In this way there is more scope for tailor-made measures. The group objectives are the target that should be achieved. More research is needed into whether such a group experiment will succeed and under what conditions. Generally speaking, the effect of policies and policy instruments on farmers and growers should be tested in advance on a much larger scale, and applied research should be able to make useful statements about this effect.

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# THE MEANING OF ODI-RESEARCH - A FRAMEWORK FOR CLASSIFICATION OF RESEARCH ON THE FIELD OF OBJECTIVES, DECISION MAKING AND INFORMATION REQUIREMENTS OF FARMERS

Dr. George Beers [1]

**Abstract**

*A framework for classification of ODI research will be presented. ODI research is a broadly defined type of research around themes like objectives, goals, decision making, management, information requirements and the use of information systems on the farm. Looking at the various research projects on this domain, for outsiders it is hard to understand the applicability of the results and the way various projects and results are related to each other. The framework described in this paper is based on the idea that demand and supply of information products for the farmer should be tuned. Basic assumption behind this framework is that the explicit role of ODI research is to support this tuning process. From the framework five dimensions are inferred; policy, farm & farmer, decision processes, group/individual and stage of development of the information product. On each dimension a scale is developed on which individual ODI-research projects can score. By gathering and comparing the scores of a group of ODI-research projects an impression is given of the relation between the projects. When the focus is on effective tuning of demand and supply of information products, gathering scores will also identify gaps in the knowledge required for this process.*

## 1.    ODI research

In a report by the Dutch Councel of Agricultural Research (NRLO, 1991) is was concluded that the penetration of Information and Communication Technology (ICT) on the farm was not as high as expected in the middle 80-ies. The report also observed that the further introduction of ICT on the farm stagnated. The main conclusion from this study was that further dissemination of ICT on farms could not be left over to the 'technology push' because it was expected that development would not be parallel to the ICT needs and require-

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ments of the farmers. The report diagnosed a disbalance between supply and demand of information products and it was indicated that the Dutch Ministry of Agriculture defined it as her task to initiated the process of tuning this balance; as figure 1 describes.
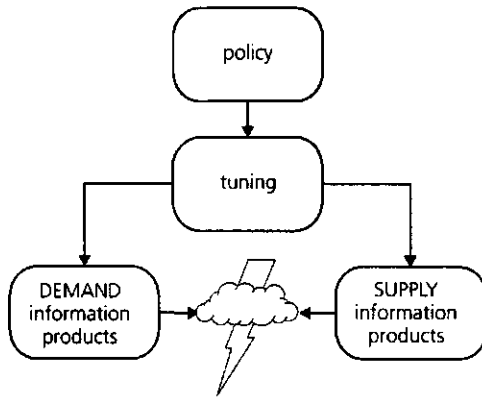


*Figure 1    The problem definition of ODI research*


The need for social-economic research was stated very clearly. Further development of ICT on the farm should be based on profound knowledge of processes and relevant characteristics of the farm and the farmer as an individual. The NRLO report of 1991 can be seen as the starting point of a new type of research that can be clustered under the name 'ODI research'. In this type of research the objective is to generate more knowledge about Objectives, Decision making processes and Information requirements of farmers. ODI research is rather broadly defined and it is performed by a lot of research groups in different scientific disciplines. It is also presented under topics like farmers goals, styles of farming, critical success factors, farm managements, information strategy planning, assessment of information systems and so on. How it is presented depends largely on the scientific discipline and funding backgrounds of the research groups involved. The common line in ODI research is that it is aimed to describe the farmer and his behavior and tries to explain this on an empirical basis. In the field of information system development this perspective can be considered to be a reaction to the normative approach in which is describe how a farmer should behave. Instead of normative behavior, the actual behavior of farmers becomes more and more the starting point of system design activities.


## 2.    The need for a framework of ODI research

From 1991 the Ministry of Agriculture in the netherlands stimulated ODI research by funding various projects. The research was carried out by various

research groups with different scientific backgrounds and disciplines and very different approaches of (in the end) the same problem. Sometimes projects looked very much alike according to the name of the project and at a further glance they prooved to be very different. On the other hand other projects with obvious different names turned out to be very much the same. For those involved in research and especially policy makers funding the research and potentially using theresuts, after a few years the situation became quite chaotic. Suspicion that the same research was done at several place and other research that was needed was not done at all. The need for an overall picture became obvious.

Within the ODI field this overview should give insight in questions like:
- are actual projects related to other research projects;
- how are actual projects contributing to the objective of tuning supply/demand of ICT;
- can results of different actual projects be combined;
- what are the gaps in ODI knowledge required for the tuning.

To give an overview of the actual research on these issues, a framework is developed to describe and classify actual research projects and results. The conceptual framework describes and relates concepts in which concepts. In this context a 'concept' can be interpreted as a potential or actual subject of research.

In the next sections the demand side, the supply side and the complete conceptual framework of the objective of ODI research will be discussed. In the framework five dimensions to describe ODI research projects will identified. These five dimensions will be operationalized in scoring tables in the subsequent sections.


## 3.    The demand of information products

The concepts determining the demand of information products for the farm are represented in figure 2. This part of the framework is usually considered to be the main field of ODI research.

The starting point in defining the demand of information products is the individual level of the farm. Information requirements are (of course) defined by the type of decision making process for which information is required. For a specific decision process the information requirement is also determined by the context that consists of the person of the farmer, characteristics of the farm and its farming system, the environment of the farm, the social environment of the farmer and the dynamics in the context. One way or another these factors are resulting in the information requirements of an individual farmer.

Another important aspect in defining the demand of information products for 'the' farm is that in the agricultural context there is a clustering element. Because of the scale of the farms, ICT is (usually) not developed for an individual farm. Therefor the demand of ICT consists of groups of farms with the same information requirements. The clustering of individual information
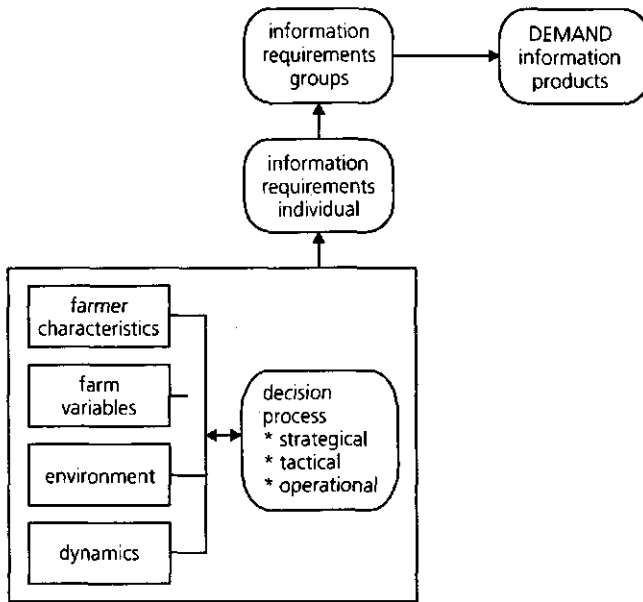
*Figure 2   Concepts determening the demand of information products*

requirements is a specific process that can be done in several ways and that requires knowledge of differences and similarities between farmers.

## 4.    The supply of information products

The supply of information products as represented in figure 3 can be considered as the total of information products that are available for farmers. The supply is realized by suppliers; with their own characteristics that will have effect on the supply. Relevant suppliers characteristics might be their level of knowledge, their objectives and the situation of their organisation. It might be expected that the suppliers that have developed these products do have a perception of the information requirements of farmers as well as groups of farmer. Other concepts that will have effect on the supply are the technology available and the stage of development of information products. The stage of development can be considered as the dynamic aspect in the development of supply.

The global framework for classifying ODI research.

When representing supply and demand in one picture, the result is the total framework as represented in figure 4.

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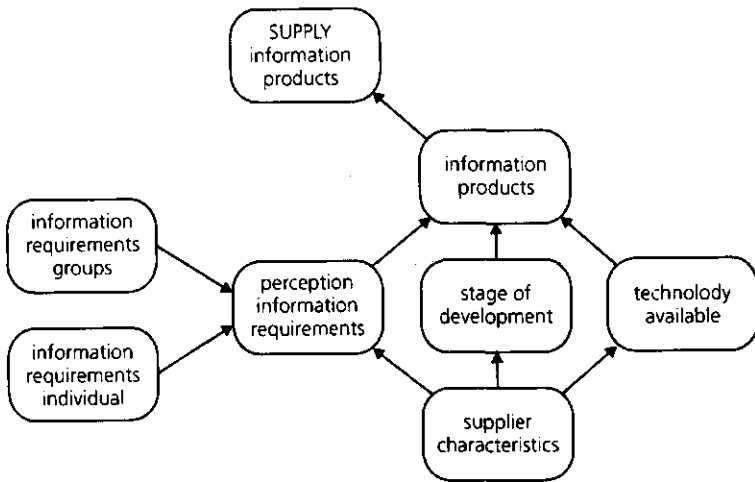
*Figure 3   Concepts determining the supply of information products*
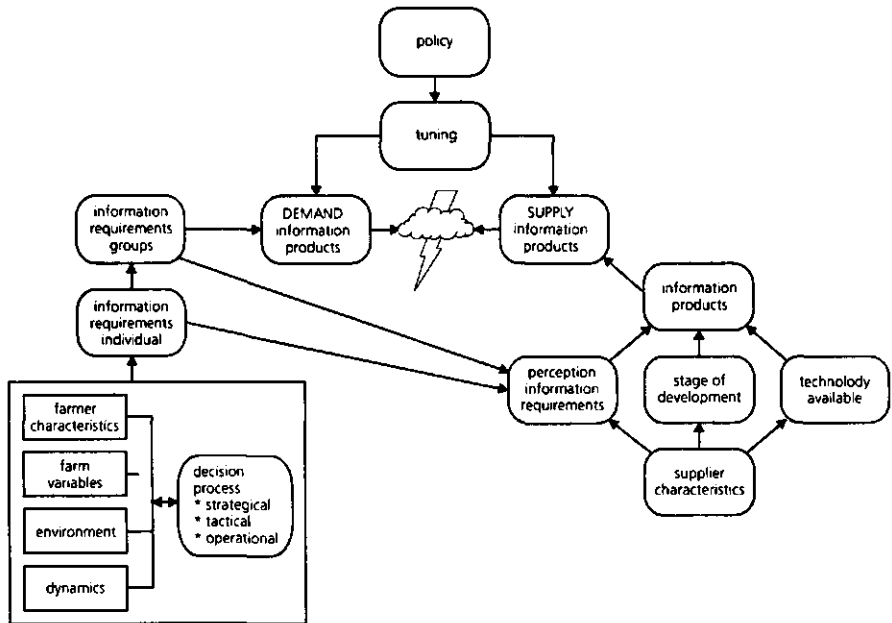


*Figure 4   The framework for supply and demand of information products; (the objective of ODI research)*

Basically all concepts represented in this framework are potential subjects of research in the sense that knowledge is required about this aspect in order to establish a balance between supply and demand of information products. This framework will be used to describe and classify research that in the ODI domain. To make the framework operational five dimensions can be derived from the framework. For each of these five dimensions a scoring table is made on which each research project (or its result) can be scored. In this way each research is classified by these five 'scores'. The five dimensions are:
- contribution for policy;
- farm & farmer characteristics;
- decision making process;
- grouping of farms;
- stage of development.


## 5. Contribution for policy

The basic assumption behind this dimension is that the primary users of ODI research are people in the field of agricultural policy making. In an early draft of the ODI framework the contribution of the research in policy making processes and related policy objectives was the only dimension used. In the development and testing of the resulting scoring table, this approach for classifying ODI research turned out to be too complex. The complexity originated from the large amount of 'types' of policy objectives. The general objectives of the Ministry; from which each directorate derives a more specific general directorate objective. These general directorate objectives are worked out in more specific policy objectives and related actions. Putting all these fields for 'potential contribution by research' together in one framework turned out to be too complex and in the end would not result in a manageble overview.

Because the contribution for policy is certainly a dimension that is relevant fro ODI research a simple version with a lot of restrictions is part of the classification. To illustrate the complexity, the position of this simplified dimension will scetched. Within the Ministry of Agriculture, Nature and Fisheries in the Netherlands there is a directorate Science and Technology. Within the policy plan of this directorate (DWK, 91) three main fields of objectives are identified; one of them is the so-called 'spear point policy' in which three 'spear points' are given; information technology, biotechnology and environmental technology. The spear point information technology is decribed in three objectives:
- stimulation of the use of available IT applications;
- intensifying of the use of knowledge by IT;
- promotion of IT infrastructure.

For these three policy objectives working plans are available. These objectives are described on a level that is operational enough for a classification of research. For each ODI research it should be possible to give points to the extend in which the research contributes to the policy objective:

| Policy objective | Score |
|---|---|
| stimulation of the use of available IT | |
| intensifying the use of knowledge by IT | |
| promotion of IT infrastructure | |

*Scoring table 1    The contribution of the research to the policy objectives*


Until 1994 there existed an explicit agricultural IT-policy. In the new policy plan of the directorate Science and Technology the IT-objectives have been integrated in the thematical policy objectives. To develop an actual policy objective scheme would be much more complex.


## 6.    Farm and farmer characteristics

For effective development of ICT for farmers it is crucial that thisis based on profound knowledge about the person that is the potential user of the tools. Personal characteristics of the farmer like level of education, social skills, learning capabilities, risc aversiveness and so on, are important factors that will effect the use of tools. For development of ICT for the farm it is also essential to know about the situation in which these tools will be used. The characteristics of the farm; products, structure, moderness, availble information systems and type of personell and management are determining the need for information porducts. Not only the farm itseld but also the environment of the farm largely influences the possibilities and requirements of the use of information products on the farm. Factors in the environment of the farm are e.g. suppliers, clients, auction, extension sevices, governement, collegues and so on. To be aware of the farm, the farmer and its environment is not enough, because these factors and their influence change quite often. Knowledge about the dynamics of this complex is also needed to develop information products not only for todays use but also for tomorrows. Dynamics are about aspect like the family cycle of the farmer, the life cycle of the farm, expectations and so on.


| Farm variable | Score |
|---|---|
| personal characteristics of the farmer | |
| farm characteristics | |
| environment of the farm | |
| dynamics | |

*Scoring table 2    The contribution of research to the knowledge of the farmer and farm in relation to the use of information products*

The extend to which a specific research project contributes to the knowledge of the farmer and farm in relation to the use of information products can be specified in scoring table 2.

## 7.    Decision making process

Information products are used in decison making processes. in the early days of information systems development the normative approach of the decision making process was dominant. Informationproducts were developed based on the vision how decisions should be made. Nowadays the awareness that decisions can be made in several ways sometimes using different type of information gains ground. A lot of ODI research aims to find out how decsion making processes are actually performed by the farmer. This research often studies a specific type of decsion making process. From decison making theories a lot of different typologies of decsion making processes can be deducted. The typification based on the horizon of the decision made is used in scoring table 3.

| Horizon decision making process | Score |
|---|---|
| strategical | |
| tactical | |
| operational | |

*Scoring table 3     The contribution of the research to the knowledge of farm decision making process in relation to the use of information products*

## 8.    Grouping of farms

Agricultural information products are usually not tailor made for individual farms. Due to the fact that the farmer is a small scale information users, standard packages of software or information are common practise. The way in which groups of farms for marketing purposes are constructed is usually based on the product that is produced at the farm. It is felt that sometimes information requirements are more determined by personal characteristics of the user (risc aversiveness, education level) than by the type of farm. To find a way of adequate clustering of farmers in order to develop information products for these groups of farms, knowledge is required about the differences and similarities between users of these products. To define whether research takes this clustering (the referential problem) explicitly into account, scoring table 4 is used.

| Level of subject of study | Score |
|---|---|
| individual farmer(s) | |
| groups of farmers | |

*Scoring table 4*     *The contribution of the research to the knowledge about indvidual or groups of farmers*

## 9.    Stage of development of information products

ODI research can be done for various stages in de life cyle of information products. Each stage in the life cycle requires a specific type of knowledge to be generated. Scoring table 5 gives the four main stages in information system development in which the research might generate knowledge to contribut to the next step in the life cycle.

| Stage in life cycle information product | Score |
|---|---|
| orientation | |
| development | |
| implementation | |
| use | |

*Scoring table 5*     *The various stages in the life cycle of information products in which research can be performed*

## 10.   Concluding

Though a lot of theory in the field of supply and demand of information products is availble, the framework has been developed in a rather tentative way. The overall problem of making synthesis in which all relations between all concepts used in ODI research might be too complex and too broad to use a deductive way of working in developing the framework. It also might be that the theoretical body of knowledge just is not sufficient for a making a framework that covers all relevant concepts. The framework as described in this paper is developed by a inductive way of working. Taking same projects in the field of ODI research and trying to find out how they are related, resulted in the framework and the scoring tables derived from it. For further development of the framework it will be tested on more research projects and results. Another point for further research is to expand the scope of usability; to other types of technologies that will have impact on the ODI complex; in a more general sense measures of governement can be in this category to. Furhter devel-

opment of the framework should result in a common framework to describe the ODI research in an accesible way in which research projects can be interpreted, compared and related to practical problem fields. A transparent way of classifying research will improce development of new research and giving direction to furhter research in the ODI complex.

# A SYSTEMS APPROACH TO REGIONAL KNOWLEDGE NETWORKS

ir. J.W.G. Geerligs, ir. M.E. Ensing-Wijn & drs. J.H. Lith 1)

**Abstract**

*Regional Knowledge Networks (RKN's) are small, temporal, problem directed coalitions of problem owners. It is claimed that the continued effort to enhance the sustainability of agriculture requires a visionary policy setting approach and must bring together a wide range of actors from economic, socio/cultural and ecological orientations. RKN's have the potential to mobilise the existing creative and innovative capacities in order to promote a more holistic interdisciplinary, shared decision making at a regional level.*
*The outcomes of RKN's are summarised as follows.*
1. *Improved social processes of developing options and contributions, to GNP and general well being.*
2. *Furthering of knowledge exchange, and linkage of knowledge generation with knowledge utilisation.*
3. *Catalysing problem perception by initiators and brokers which start and facilitate the process.*
*Problems that arise within RKN's are:*
1. *answers to regional questions are not always available in the region, especially not in closed shops;*
2. *problems that accompany new conditions (more market, more environment, more ethics) are often not recognised (in time) by the problem owner;*
3. *the farmer is expected to master a certain level of problem solving.*
*In all the cases a central question remains: 'How would the problem owner be able to build and maintain a motivated and dynamic network, responding efficiently and effectively to his question/problem?'*

**Key-words** : knowledge, networking, innovation.

## 1. Introduction

The enhancement of the sustainable development of agriculture is not only based on technical and economic principles but also on environmental matters, health and well-being principles, and on legislative and social security.

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This makes innovation a multi-disciplinary issue. The mix of principles necessary for adaptation to new markets and new environmental values is unique for case, place and time. Problem owners feel that recipes fall short; diversification and a problem-solving approach might be a good alternative to enhance a more holistic, interdisciplinary development of agriculture.

Farmers and others search for means to address their increasingly diversifying questions. The Dutch agricultural knowledge network (AKN) is complex; it comprises private enterprises and also the public funded knowledge institutions. The need for knowledge includes non-agricultural knowledge. As a result, many organisations move to knowledge dissemination: education, banks, suppliers, services, etcetera. Farmers dream of the possibility to pose all questions to one single counter, preferably a counter in the near vicinity. They know of course that this dream will not come true, but nevertheless ... . In the Dutch AKN however, knowledge institutions merge because of economies of scale. This is a movement away from the dream situation.

Producers have reached a high level of education, and they are capable of selecting appropriate sources of information. They bear the characteristics of *knowledge managers*. Information technology speeds up the process: much more management data are becoming available to users, and access to all kinds of sources of information is improving rapidly. Interactive media are opening up new perspectives for information exchange and knowledge development in networks, even on a global scale. Relationships within knowledge networks have changed. These developments are expected to have an increasing impact in the near future.

In the Netherlands and in many other countries, the State is expected to provide conditions in which AKN accommodates knowledge questions in a proper way: both recipes when required and support in problem solving when needed. Questions about the functioning of the Dutch AKN at regional levels and also an invitation from the OECD to report on the case, have been the reasons to ask a project group to investigate the questions and to describe the core of the problem.

To what extent do farmers organise support from regional networks? How does a regional network add to innovation? What is the infrastructure desired for networking? What are important mechanisms that should be understood for good governmental policy?

## 2. Approach

The approach to the problem by the project group may be characterised as a hop, step and jump. In the first phase two types of orientations on the problem were organised; these were interviews to explore the subject with representatives of three networking agricultural schools and also with representatives from several knowledge networks outside agriculture. In the second phase questions about regional networking were answered in three hearings (with representatives of respectively knowledge institutions, officials at policy levels and farmers), followed by a workshop with decision makers about

chances and problems of knowledge networks. In the third phase all the partic-
ipants to hearings and workshops were invited to share the conclusions and
formulate recommendations. A steering group did control the (re-formulating
of the) research question by the project group.

In the triple step exploration, decription and checking of the subject, also
signalling, sharing and implementing of the instrument, occurred as parallel
processes.

The first section of this paper is about the fieldwork of the project group.
In this section the farmers' expected benefits from regional networks will get
most of the attention. The second section explores possible working mecha-
nisms of regional networking.

In the course of the project the research question has been adjusted a
few times. The initial question was to find out the extent to which regional
knowledge networks are able to answer the questions from farmers in a region
about the large field of rural development.

It is worthwhile to follow the project groups' thinking in order to get a
view of the nature of the problem. This is probably also the best way to pick up
the aspects of value for application elsewhere.


## 3.    Observations from the fieldwork

Knowledge questions include both recipes and support in problem solv-
ing. Farmers, by the way, have been problem solvers for many of their prob-
lems, also when the knowledge institutions and policy makers worked with
their representatives on the preparation of recipes. To farmers the situation is
not entirely new; the interest and the expectation of growing importance of
the phenomenon is new.

### 3.1    Perceptions of 'regional' and 'networks'

The project group identified different perceptions of the word 'regional'
in regional knowledge networks (RKN's). It may be perceived as:
- smaller than national, or specific for a case, or
- assigned to a particular geographic area, or
- assigned to a social group, or
- policy implementation rather than policy making.

The word region in RKN's refers in the first place to the phenomenon that
problem owners find a way to meet each other and share a (regional) problem;
in this context the word region is not necessarily connected with one particular
perception of the four posibilities mentioned above.

Outcomes of networks differ. Sometimes networks have a mixture of functions. In this paper it is important to distinguish knowledge, interest and information networks.

- Knowledge has to do with someone's capacities, for example the generation, the exchange and the utilisation of knowledge. A knowledge network organises the sharing of capacities in a situation where problem owners, problem solvers and knowledge brokers meet. Knowledge networks are problem-directed and the problems may be well defined or vague problems. Knowledge networks rise and fall with the number of people that work on a problem. They vanish when the problem is forgotten, or when solved, the goal is reached. The partners in knowledge networks find each other for their expertise. The stability of knowledge networks differs, take for example a symposium, a work shop, a study club or a council.
- Information has to do with the supply of relevant data. An information network is a facility for the organisation of data supply. An information network is an instrument and has to provide true information. The listeners to a radio bulletin, the subscribers to a specialist journal, demand for instant advice from extension services or the addressees of statements from a dairy factory differ in their relationship to the network.
- Interest is geared to positions, influence and strategies; interests are directed to lobby and pressure. An interest network is stable and linked to interest groups. Interest networks are target-group directed and organised by representatives. The representatives are often not the problem owners, although they have identified themselves (sometimes very intensively) with the problem owner. Organisations of professionals (trade unions), of environmental groups (Green Peace), of business (farmers unions) or of public power (political parties) are examples of interest networks.

Interesting mixtures of these types of networks are women's networks, Lions' clubs or jubilee celebrations. Information and interest networks may act as knowledge networks, especially for conventional questions; they appear to be ineffective however to contribute to new questions. Within interest networks the knowledge may not be available, but also conflicting interests may hinder the solution of a problem owners' question. It appears to be very difficult for example, to deal with phosphate norms in interest or information networks.

## 3.2    More about knowledge networks

In knowledge networks people themselves are responsible for the utilisation of the network. This is different from projects and established organisations where participants are contracted in advance to realise the objectives of the project or organisation.

Knowledge networks transform. They change in due time when the perception of the problem develops. A group of related knowledge networks may have a constant nucleus. The working groups in a large network may be different all the time.

In AKN it has been observed that representatives of the knowledge institutions are inclined to organise their networks within the framework of AKN disciplines, whereas farmers have much broader networks.

The project group observed that representatives of knowledge institutions tend to belief strong in the innovative power of knowledge institutions, they support the knowledge push model. Different is the approach of regional policy makers from the Ministry, these observe demand and supply in the region and explore ways to match the two. Farmers desire recognisable counters to address their questions to and explicitly demand integrated knowledge from different scopes.

In Dutch papers and lectures the knowledge network is an issue. From all the approaches the following definition is derived: 'In a (regional) knowledge network, people meet for some time in changing compositions, to share a particular problem and to exchange ideas to solve a case'.

RKN's are small, temporal, problem directed coalitions of problem owners which act within and also outside the familiar AKN. Many problems are specific for a region, e.g. landscape, soils, outdoor recreation, water management, markets and infrastructure. Other problems are specific for a sector; these are often easy to address at national levels.

3.3   The farmers' position

For almost a century, the Dutch agro-knowledge network has been largely supply-side financed. Efficiencies of scale at the supply-side are the cause of enlarged institutions with specialists. During the last ten years however, for many 'knowledge commodities' the system has become more demand-financed (and possibly more demand driven than before). A number of developments has resulted in a change of roles; problem owners, problem solvers, traditional and new financiers react differently in different cases. Compare the international utilisation of knowledge (Reich, 1991).

The demand-side financed approach fits in better with the behaviour of a farmer as an acting person with regard to information and knowledge products. Farmers are increasingly faced with problems that cannot be solved by the present knowledge infrastructure. It has become difficult to address a question. Efficiencies of demand would preferably result in 'one office counter at the corner' for all the questions. A realistic alternative is the regional knowledge network. Interviews have shown that the views on this phenomenon differ considerably.

For the project group *the main question* about the farmers' position was: 'How does an actor create an environment in which motivated networks respond effectively and efficiently to his questions/problems?'

3.4    Analysis of objectives and means

In the search for final objectives of regional knowledge networks, one will experience that a hierarchy of objectives and means (instruments) does exist. In the analysis the first question was:
'What are the objectives of the means *knowledge network*?'
The answer is the 'stimulation of innovation', but this is not a final objective as such; it is a means for another objective. This leads to the second question:
'What are the objectives for the means *stimulation of innovation*?'
The result of the continued and more detailed analysis of RKN's outcomes was the following:
1.    Improved social processes of developing options and contributions to GNP and general well being.
2.    Furthering of knowledge exchange, and linkage of knowledge generation with knowledge utilisation.
3.    Catalysing problem perception by so called initiators and brokers which start and facilitate the process.

3.5    Identification of problems

In the development and functioning of knowledge networks the following thresholds between demand (problem owners), supply (problem solvers) and initiators and facilitators (brokers) have been identified.
•    Difficulties at the demand side may be:
     *  problems in identifying the right question
     *  unawareness of being a problem owner
     *  difficulties in addressing the question.
•    Difficulties at the supply side may be:
     *  knowledge sells when the commercial value is recognised, intrinsic value is not sufficient
     *  the search by problem solvers is limited to familiar grounds
     *  lack of market orientation and directedness to own references.
•    Difficulties the brokers might meet:
     *  unawareness of the existence of problems
     *  the price of taking initiatives
     *  lack of insight into the availability of knowledge.
•    In a knowledge network the actors communicate; problems are
     *  problem owners and problem solvers do not understand each other
     *  the search for problem solvers is limited to familiar grounds.

The efficiency of regional networks does not only depend on the presence of all the necessary actors to play their roles in the process of exchange. For the process itself it is important that in the sharing the problem and the exchanging the views, much room is given to analysis and reflection. This is not easy for actors whose daily occupations demand negotiation and policy making. Farmers, managers, representatives and civil servants have to be aware of

the characteristics of a knowledge network in order to avoid the techniques of an interest network.

3.6    Summary of problems in regional networks

Problems connected with the establishment of broad working regional knowledge networks in which problem owners and problem solvers participate and in which sometimes problem posers (see paragraph 2.1, point 3), initiators, and brokers play facilitating roles, are the following:
1.    The questions come from the region and the answers may not be regionally available.
2.    Problems connected with for example changing markets and environmental regulations are not always recognised by farmers. An initiator (the State) or a broker (farmer organisation or knowledge institution) is a necessary to provide the information or to pose the problem.
3.    In the past farmers have become used to get clear answers to concrete questions. To an increasing extent the questions diverge and are vague in initial stages; the answers have to apply to very specific situations. AKN has difficulties picking up a problem-solving approach.


**4.    Working mechanisms in networks**

This section explores working mechanisms of RKN's.

4.1    Possible roles of the actors and types of questions

The problem owner has a knowledge problem, he gives expression to this problem and may organise a knowledge network or participate in it. The problem solvers recognise knowledge questions, they offer their knowledge and participate in knowledge networks. Brokers help in matching demand and supply. Sometimes brokers help to explore problems or counsel problem owners.

These roles are different according to specific situations. Sometimes the questions are familiar and can be answered in AKN, whereas in other situations the questions are new and difficult to address.

The Dutch policy is that 'the need for knowledge by the government and target groups in the rural areas (agriculture, nature conservation and outdoor recreation) has expanded to comprise other disciplines. Besides typically agricultural disciplines such as crop production, soil fertility and animal health there is a need for general biology, biochemistry, information technology, management science, marketing and business economics. Education and research in these fields are often better developed elsewhere than at the agricultural institutions' (Minister of Agriculture, Nature Management and Fisheries, 1995).

When lack of knowledge is felt, four situations can be distinguished; these four situations indicate at the same time the efforts the problem solvers

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have to make to generate solutions. The four situations partially explain the perceptions of roles.

1.  Conventional questions within AKN

    When lack of concrete knowledge is felt, the problem owner will react fast and address the right person in AKN. For example 'do we have new varieties of chrysanthemum?' The traditional conventional questions are about technological development including the physical infrastructure and functioning of the market.

    The role of the problem solvers is to make clear what they can offer at what price. In this situation brokers have no functions.

2.  Conventional questions outside AKN

    For example: solving a humidity problem in a greenhouse with technology from tropical swimming pools. The broker might support the brainstorm about possible occurrences and contact candidate problem solvers and facilitate the communication between representatives of different sub cultures. Conventional questions outside AKN are on new technologies (without link to AKN) and the legal system (linked through the social-economic extension of AKN).

    Knowledge institutions could act as broker. They have the position in AKN to offer this service. A pitfall is that brokers take over the role of the problem owner. In addition, the knowledge institution should regard its own strengths and weaknesses, and be a broker when necessary. Marketing concepts of knowledge institutions possibly hamper this function.

3.  New questions within AKN

    New questions arise as a consequence of changes in State policy or public opinion, or when new products are wanted on the markets. Important fields for new questions within AKN are the development of labour organisations, the qualifications of workers, the production and quality chains, and the natural environment.

    In these situations the ability of the problem owner to recognise the problems is a vital point. Sometimes latent problems have to be analysed and articulated (a problem posing role) in order to draw the desired attention. The central government often has the position to overview these issues and every now and then it takes the role of posing the problem.

4.  New questions outside AKN

    Most questions in this area are addressed to one of the three other fields once the question has been formulated. Examples of new questions outside AKN are common when the subject is about ethics and political position, the social system and human well-being.

    In the previous paragraphs the existence of conventional and new questions and the introduction of market principles for competitive knowledge commodities were brought forward. In addition it was mentioned that more emphasis has been put on knowledge utilisation in order to balance the three main functions of AKN: knowledge generation, knowledge exchange and knowledge utilisation.

    The hypothesis is that these different characteristics in the new situation are elements of different working systems. Different systems have different

accelerators and inhibitors, different bottle necks and discrepancies, and require different interventions.

## 4.2 A system to deal with conventional questions

In the case of an identified conventional question, the question is put and the solution/recipe is given. In most cases the answers on these questions are available on the free market. On the free market the customer pays. Where the State subsidises the extension services, the customer pays less than the price of the product or he does not pay at all. This is the classical situation of utilising knowledge.

*1st picture*
OLD SITUATION:      all questions


supply-side
financing                    answer

The model is based on the idea that, once a question is identified, researchers develop a solution and that farmers adopt the invention and turn it into an innovation. The State funds the knowledge institutions for their efforts (supply-side financing). The main systems problem is to identify the question and address it to scientists. A careful analysis should guarantee a prospective planning for research, extension and education.

## 4.3 A system to deal with new questions

In case a new question is put, two types of questions are identified: (seemingly) clear questions and (seemingly) vague questions. A clear question can be easily addressed to a problem solver. In case of a vague question, the problem owner possibly activates a RKN. Sometimes these questions have competitive potential and become a market product. Sometimes they are not competitive and must be solved in non-commercial networks by problem solvers from subsidised institutions.

For new questions three dominant situations have been identified:

- In case of utilisation on the knowledge market, the relevant data for a question are available and the address of the problem solver is easily identified. Competitive knowledge can be paid for by the problem owner in a market situation. This situation is comparable with the treatment of conventional questions.
- In case of exchange, the identification of the questions and the search for problem solvers are the subject of pursuit and learning conduct in a RKN. The knowledge exchange generally takes place in a pre competitive stage and mostly the problem owners are not yet in the situation to pay for services.

•   When lack of knowledge, which in fact comes down to a lack of available theories and data, has been determined, the demand of a RKN is knowledge generation. In most cases knowledge generation on fundamental issues is not competitive; the problem owners are difficult to identify and the State has to fund this research. In the range from strategic to applied knowledge the level of competitiveness increases and the possibilities to introduce market principles increase subsequently.

<u>2nd picture</u>
NEW SITUATION FOR RKN:

| clear | | vague | clear | demand-side |
|---|---|---|---|---|
| question | | question | question | financing |
| | demand-side | | | |
| UTILISATION | financing | EXCHANGE | GENERATION | |
| recipe | | pursuit and | | |
| solution | supply-side | learning conduct | supply-side | |
| | financing | clear | financing | |
| answer | | question | | answer |
| utilisation purposes | | RKN | | generation purposes |

The model is based on the idea (1) that knowledge is an ability of individuals, (2) that individuals speed up the development of knowledge in interactions and (3) that problem owners are the most motivated and first assigned to develop solutions. Problem owners are prepared to pay for clear answers (demand side financing). The main systems problems of this approach have been summarised before. *A regional knowledge network has the potential to mobilise the creative and innovative abilities of many in order to organise a more holistic, interdisciplinary shared decision at regional levels to develop the enhancement of the sustainable development of agriculture programmes.*

The functioning of regional networks is mainly directed towards knowledge exchange on vague questions of farmers. This process clarifies questions and addresses questions that cannot be answered in the region. Clear questions are directed to knowledge utilisation or knowledge generation processes for efficiency reasons. The two pictures generalise the real situation at large. At the same time they illustrate that in different situations different mechanisms may work and that there are different solutions to different questions and different responses to the market.

4.4   Conventional and new questions in conventional and new situations

It is easy to confuse conventional questions with the conventional situation and the new questions with the new situation. The reason is that in the old situation the difference between conventional and new questions, between clear and vague questions, and between free and paid advice was not made. Most questions were conventional: the AKN was closed and the pre assumption was that AKN would answer all the questions. Most questions were clear: it was either an economic or a technological problem. In the AKN most

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knowledge was free: research, extension and education were paid at large by the government or public bodies. Or knowledge was seemingly free; for example the extension service of suppliers.

## 4.5    Dispositions, roles and leadership

Difficulties as mentioned in paragraph 1.5 can be connected to different dispositions which problem owners can have towards problems. These dispositions may have a mental or a professional background.

Mental dispositions are a matter of mood and character. De Bono (1985) assigns colours to mental dispositions, for example red (intuition), black (advocate of the devil), blue (negotiating), green (creative analysis), yellow (opportunism), white (facts). Mental dispositions apply in particular to vague questions. The differences in dispositions may exist at different levels. Examples of increase in level are: responding to solutions, improving problem solving ability, and curiosity, the desire to know.

Professional dispositions are for example reflected by styles of farming. Van de Ploeg (1994) refers to Hofstee for the definition of styles of farming: the complex but integrated set of notions, norms, knowledge elements, experiences, etcetera held by a group of farmers in a specific region, that describes the way farming practice should be carried out. Van der Ploeg illustrates the different styles of farming with an example from Friesland: huge farmers, intensive farmers, greedy farmers, cowman and cow breeders score on specific areas in a field with the two dimensions technology and market. It is likely that farmers with different styles of farming respond different to the alternative answers given on clear questions.

Participants in RKN's take different roles in different stages and in different cases. The role may be problem owner, problem solver, initiator or broker; the role depends too from the type of question, dispositions and levels of disposition. Changing roles in problem identification and problem solving implies change of leadership. This makes the functioning of RKN's more difficult.

## 5.    Conclusions

Interviews have shown that the views on regional knowledge networks differ considerably. In all the cases the central question is: 'How would the problem owner be able to build and maintain a motivated and dynamic network, responding efficiently and effectively to his question/problem?'

Problems that arise with RKN's are:
1. answers to regional questions are not always available in the region, especially not in closed shops;
2. problems that accompany new conditions (more market, more environment, more ethics) are often not recognised (in time) by the problem owner;
3. in the past, many farmers were used to recipes: ready-made solutions to their problems; at present it has become increasingly difficult to provide

ready-made solutions and the farmer is expected to master a certain level of problem solving.

There are several approaches to these problems.

- Problem solving
  Problem solving is in the first place a mental process. The disposition of the problem owner is a critical success factor. In the past, for the appreciation of a recipe it was sufficient to pay attention to 'theory' as far as it offered solutions to actual problems. In the future, the problem-solving attitude requires a disposition which is directed to the improvement of individual learning processes. This ability is an important objective for vocational education and adult education.
- Recognition of questions
  In regional networks, farmers with a problem-solving attitude will have a powerful instrument to analyse the information and knowledge questions. The identification of problems could be a specialism of those with a good intuition. The different qualities of regional actors and the different angles of approach will increase the problem-solving capacity at large. Knowledge institutions may offer services for RKN's at initial stages when questions are vague.
- Regional questions
  For the effective treatment of identified problems that cannot be solved in the region, it is necessary that these questions are collected for treatment at supra-regional levels and sometimes to multi-disciplinary panels.

'The enhancement of the sustainable development of natural resource management gives rise to a new type of communication professional, whose skills have little to do with 'extension'. He/she has a thorough grasp of the social actor perspective, and feels at home at the interface between natural resources (which are the realm of biophysical scientists), and the stake holders in those resources whose activities threaten their continued use' (Röling, 1994).

The consequence of this analysis could be a differentiated governmental approach to (1) supply-side financing knowledge generation (for example for fundamental research) and (2) demand-side financing of demand articulation (for example for realisation of regional policies).

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# THE DYNAMICS IN THE LAST DECADE OF THE TECHNICAL EFFICIENCY OF ITALIAN FARMS

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## Abstract

*This study has analysed the technical efficiency of the panel of the FADN-CEE Italian farms. 2001 farms were processed, and the period examined is 1983-91. This work represents the first study with a national panel. The economic model used is a quadratic function of time (Cornwell etc.) in which the output is tied to the principal output used in the different areas and for the different productions. It is the first time that the Cornwell model has been applied to Italian RICA farms.*

*The study highlights the low levels of technical efficiency of most farms. In the second half of the '80s the technical efficiency of farms gets lower and lower.*

*In some groups of farms the reduction is due to price-controlling policies implemented by the EEC.*

**Key-words**: panel analysis, efficiency, success.

## 1.    Introduction

Modern society increasingly requires policy that addresses single social groups and economic sectors. For this reason social sciences are turning their attention to analysing the behaviour of single individuals. This is possible thanks to the greater amount of information available, and to the development of statistical methodology.

In this study we intend to observe how this behaviour goes beyond the average or aggregate data. A study relating only to cross-sections, although it is more exhaustive than a study of universal data, can only describe the aggregation of individual behaviour. In the same way, the use of the analysis of historical series of aggregate data, although it is able to take in the general dynamic, does not permit its analysis at the level of single individual behaviour.

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Only through the reading of longitudinal data, that is to say through a duplicate time-space dimension, is it possible to analyse and distinguish the relationships between and among single individual operators.

For this reason the farms under observation from 1983-1991 were extracted from the data bank FADN-INEA, in order to identify the relationships that can be established between economic success and the general level of technical efficiency in the use of productive factors, both in relation to single performances and to their temporal dynamic.

This study intends to report the results of research carried out within the RAISA-CNR project, which aimed to identify the 'success' factors within the various kinds of farms, and in particular three disadvantaged areas and also the most productive ones in the country.

In this context we will try to answer some questions that arose during the study: is a successful farm necessarily efficient? If so, are the terms synonymous, or is is possible to identify room for manoeuvre between them, generated by factors that can be found in the various productive units?

## 2.    The data base

The data used refers to all the farms in the national INEA data bank during the observation period 1983-91 and which were divided into a preliminary territorial subdivision.

-      Farms on the northern plains.
-      Farms in the northern hills and mountains.
-      Farms on the southern plains.
-      Farms in the southern hills and mountains.

The analysis has basic limits due to the characteristics of the sample:
-      for example, there is not a rigorous sampling because the sample studied is a sub-sample of the FADN-INEA farms. Indeed, only 2001 farms constitute the panel.
-      The FADN-INEA farms represent the areas where they are most numerous, but there are areas of the territory which are not documented.
-      the information given is only accounts information; data is not given on the farmer's family, systematic relations with other productive sectors, etcetera.
-      the data often refers to outliers, etcetera.

However, the FADN-INEA data bank is the only source of information available for the whole country.

Initially the whole sample was checked for the technical reliability of the various farms, such as: the single and general gross output, the size of the arable land and of the breeding farms, etcetera. This initial identification enabled the elimination of farms with a negative gross output, or with unit output levels which were technically impossible.

A second control phase of the sample was carried out during the identification of the each productive frontier. The method of calculation adopted enabled the isolation, within the terms of error of the function of production, of the component not correlated with the regressors (Kmenta and Dréze, 1966), which synthesizes all the factors, distributed casually, which generate disturbing elements (climatic shocks, data collecting errors, etc.).

For the objectives of this study the sample has been divided according to the productive OTE, with the aim of identifying homogenous groups relative to the output achieved.

The frontiers identified therefore refer to the following sub-samples (type of farming):

1 - General agriculture.
-     North                       n. 144
-     South-plain               n. 119
-     South-hills-mount.       n. 104
2 - Hortofloriculture.
-                                 n. 152
3 - Viticulture
-                                 n. 109
4 - Fruit and other arboreal cultivations
-     South                       n.  86
-     North                       n.  99
5 - Bovines
-     south                       n.  77
-     hills and mounts.North    n. 143
-     plain north               n. 338
6 - Other herbivores
-                                 n.  54
7 - Polyculture
-     north                       n.  80
-     south                       n. 152
8 - Polyelevage
-                                 n.  54
9 - ixed
-     north                       n. 195
-     south                       n.  95

The identification of each frontier also involved a preliminary transformation of the data, in order to deflate the values of the monetary variables and eliminate in this way the disturbing influence of inflation. For this purpose the values of PLV, total costs, specific costs per crop (fertilisers, antiparasites, hired material etc.), other specific costs, etc., were deflated using the specific ISTAT index numbers. The other productive factors, land and soil, were used considering the hectares of SAU and the total farm work expressed in hours, and are therefore measured in physical terms. As a partial expression of the qualitative level of the land capital, and given the inconsistency of the monetary 'values'

present in the INEA data bank, the variable of irrigated surface was taken into consideration.


## 3.    The method of estimate used

The state of the art concerning the measurement of technical efficiency, based on the identification of functions of production, is particularly well-documented, especially geared towards the identification and the analysis of 'frontiers' which are defined methodologically for the first time by the efforts of Farrell in 1957 1).

We directed our interest towards the frontier analysis which characterises a second line of study, directed at the identification of the parametric frontiers for which it is appropriate to find a specific fuctional form on which econometric analyses can be carried out.

The econometric approach with regard to the estimate of the frontiers production is characterised by the identification of inefficiency, with an appropriate term of stocastic disturbance within the parametric model which defines the frontier; Schmidt (1986), Bauer (1990), Battese (1992) and Greene (1993) offer surveys of the various approaches; moreover, Battese (1992) provides an ample survey of the studies of the agricultural sector.

In this study we will limit ourselves to considering the approaches proposed in the case of *panel data*, in which *N* productive units are followed by *T* temporal intervals. With $X_{it}$ we indicate the vector *k x 1* of the input variables obseved at the time *t*, with β the vector *k x 1* of the unknown coefficients, the potential output of the *i* -rd at the time *t* is linked to the combination of the inputs of the frontier function:

$$Y^P_{it} = f(X_{it}, \beta) \qquad\qquad i = 1,...,N, \ \ t = 1,...,T$$

constitutes the technological constraint faced by all the productive units, which for simplicity it is assumed produce one single output; in the real world we do not observe $Y^P_{it}$ because of the presence of two possible causes of deviation from the potential product: the intrinsic variability of the productive processes and the systematic movements linked to inefficiency.
Therefore we will write:

$$Y_{it} = f(X_{it}, \beta) \, e^{\varepsilon_{it}}$$

where the stocastic error $\varepsilon_{it}$ in a multiplicative way can be broken down in the following way: $\varepsilon_{it} = V_{it} - u_{it}$, where $u_{it} \geq 0, V i,t,$ is a term of error which has mean different from zero and which therefore reflects the deviations of the frontier of production, while captures errors of measurement and each other variation which does not have systematic errors. The nature of the frontier is

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1)    For a complete survey of the techniques for measuring efficiency (Cfr. Maietta, 1992; Battese 1991).

therefore intrinsicly stocastic since not all the causes of deviation from the frontier are under the control of the farms. We also assume that the two terms of error are uncorrelated

$(E\ (\ u_{it}\ V_{js}) = 0,\ V\ i,\ t,\ j,\ s\ ).$

Let us suppose that, after a transformation, generally a logarithmic one, the production function is linear in its parameters. That restricts the functional forms that we can use, in spite of the sufficiently ample range of choices available: translog, Cobb-Douglas, Leontief, etcetera.
Now we can again write

$$y_{it} = \alpha_{it}\ \beta + v_{it} - u_{it} \tag{1}$$

where $\alpha$ denotes the intercept of the frontier of production and $y_{it}$ and $x_{it}$ are appropriate transformations of $Y_{it}$ and $X_{it}$ .
Moreover, defining $\alpha_{it} = \alpha + u_{it}$ we obtain:

$$y_{it} = \alpha_{it}\ \beta + v_{it} \tag{2}$$

The various models adopted in in research literature differentiate themselves because of their assumptions concerning the term $\alpha_{it}$ :

a.  Inefficiency is constant in time: $\alpha_{it} = \alpha_i$. Schmidt and Sickles (1984) adopt this model without making assumptions concerning the distribution of $u_{it}$; in Italy the model has been applied to agriculture in the Marche region by Bartola et al. Battese and Coelli (1988) assume a normal distribution interrupted by $u_{it}$ .

b.  The inefficiency is a quadratic function of time with variable coefficients for the diverse productive unities:

$$\alpha_{it} = \theta_{i0} + \theta_{i1}t + \theta_{i2}t^2$$

(Cornwell et al., 1990). In this way a parsimonious and sufficiently flexible representation is obtained of the dynamic of the individual effects. Applications of this model can be found in Barla and Perelman (1990) and Fecher and Pestieau (1993).

c.  The inefficiency results in the interaction of an individual term and of a temporal term:

$$\alpha_{it} = \theta_t \delta_i$$

(Lee and Schmidt, 1993). Compared with the preceding model the dynamic of the inefficiency is not subject to restrictions, even if the principal limit is that the order is constant and equal to that imposed by $\delta_i$;

d.    The temporal term has a parametric specification:

$$\alpha_{it} = [\, 1 + exp(\, bt + ct^2)]^{-1}\, \delta_i.$$

The model is a particular case of the preceding one since it allocates a functional form to $\theta_i$; even in this case the temporal pattern of the inefficiency is common to all the companies. Kumbahakar (1990) adopts this model using a particular distributive hypothesis on $\delta_i$ .

The 'panel' nature of the available information offers various advantages to the sectional analysis:

(i)    the possibility of calculating the technical inefficiency in a consistent manner (to increase the number of observations per individual);

(ii)    one can avoid resorting to distributive assumptions, which privilege theoretical distributions from the mathematical point of view, but are not very attractive from the theoretical point of view;

(iii)    one can confront the problem of the correlation between the explanational variables and the inefficiency (Hausman and Taylor, 1981 and Schmidt and Sickles, 1984).

Precisely for the purposes of this study we turned our attention to the model with temporal variations of the efficiency, identified at point b. by Cornwell et al. (1990) which represents an attempt to eliminate the hypothesis of temporal invariability of the levels of efficiency, in order to allow the separation of the inefficiency from the rest of the statistical noise 1).

## 4.    Empirical Results

The models selected for each kind of farm are reported in table 1. In this table the estimate of the coefficients of the frontier of production together with the standard error are reported. The choice of the models was made applying Hausman's test. The dynamic of the technical efficiency is reported in the graph no. 1 - 4 in to appendices.

The analysis revealed several basic aspects:

-    the average rate of technical efficiency is in most cases rather limited. Only in the specialised wine-producing farms and in the dairy farms do the average values exceed 50%;

-    in the areas in the northern plains the efficiency level is always superior to the other production areas;

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1)    The estimate of the two models and the relative specification tests was carried out in GAUSSI. The bookshop Time Series makes available the traditional estimating *within* and *GLS* for the the model with invariable individual effects in time. The programs relating to the calculation using instrumental variables and to the Cornwell model were written in the same language; further information is available from the second author.

-   the 'horse power' variables, which express the degree of farm mechanisa-
    tion and the 'irrigated surface', indicator of the quality of the 'land capi-
    tal', do not have a sifnificant role in the calculated models;
-   the dynamic of technical efficiency behaves differently for each group,
    which is a sign of heterogenous behaviour and situations as a function of
    the kind of output. In this case a strong influence is exercised by the Com-
    mon Market Organisation of each product. For example, in the case of
    milk, the effect of the production quotas introduced in the 80's are clear;
-   the lack of productive specialisation generally has a penalising effect, and
    technical efficiency goes down when there is poly-breeding or poly-crops.

## 5.   Links between efficiency and success

During the studies carried out by the finalized RAISA-CNR project,
Pennacchi (1995) proposed an empirical measure of the success status of the
farms, which took into consideration both the absolute level of net farm in-
come and the hourly payment for work.

The parameters were analysed both in absolute terms and in relation to
the dynamic assumed by them in the course of the every three years. The objec-
tive in this case was to consider at a higher level not only the farms that had
higher values but also those which through time bettered their position.

The analysis therefore led us to identify a parameter of sythesis with a
range of variation from 1 to 20 successively aggregated in four categories:
farms with less than 10 million of lire of gross output (G.O.), unsuccessful, inter-
mediate and successful farms.

Following therefore the same method and using the indices of efficiency
which derived from the econometric analysis of the efficiency, we put the sam-
ple into several stratas. In our case the frequency distribution was carried out
by dividing the field of variation into the following four classes (range 0-100):

-   totally efficient farms        Ind. eff. < than 25
-   intermediate inefficient       Ind. eff. ≥ than 25 < than 50
-   intermediate efficient         Ind. eff. ≥ than 50 < than 75
-   efficient                      Ind. eff. ≥ than 75

In table 2 we report the absolute frequencies of he farms according to the
two classifications, both for the whole sample and for the single territorial and
altimetric area.

An initial comparison reveals a tendential convergence of the two ana-
lysed parameters. This means a greater number of farms which have the same
degree of efficiency and success. One particular case is the farms with G.O.<
than 10 million where it appears clear that it is impossible to reach the effi-
ciency objectives.

A second characteristic is the position of most of the farms in the interme-
diate category. However, there are situations which are strongly contrasting:

successful farms which are partially of totally inefficient and others in which the phenomenon appears in the opposite sense.

Continuing the identification, and despite the extreme sythesis of the phenomenon, it is possible to compare some of the indications concerning the single productive areas. In particular, in the northern plains areas, one can find almost all the farms with complete success and efficiency. Moreover, a consistent number of farms can be identified which reach the status of success even with low levels of efficiency. In other words the data confirms the possibility of obtaining satisfactory incomes in the northern plains areas, linked to the various socio-structural conditions in which they operate. Their size is on average above 20 ha of land. Moreover, the farms have a high degree of specialisation in dairy breeding which in every case provides a high income from labour per operator.

Proceeding altimetrically and regionally the correlation between success and efficiency diminishes. In the hill and mountain areas of the south there are no cases of complete success and efficiency.

| Dynamic of | Efficiency | | Success | |
|---|---|---|---|---|
| the farms | n. | % | n. | % |
| fall | 611 | 30.53 | 429 | 21.44 |
| rise-fall | 123 | 6.15 | 69 | 3.45 |
| fall-rise | 91 | 4.55 | 70 | 3.50 |
| stable | 992 | 49.58 | 1,121 | 56.02 |
| rise | 184 | 9.20 | 312 | 15.59 |

Taking the analysis further we studied the sample at a level of higher disaggregation which could enable us to examine the evolutive aspects. Therefore the single points (range 0-20, were related according to the distribution of frequency in table 3. Observing the single absolute frequencies several aspects worthy of note emerged. In the first place, apart from the absolute levels of efficiency and success, in both the characteristics observed most of the farms (56% in the case success and 49% in the case of effficiency) have a tendential stability (points: 4,9,14,19). The second most representative characteristic is that of a general fall in performances (points: 1,6,11,16) and then a group of unstable enterprises, and finally those which are improving during the priod of observation (5,10,15, 20).

The picture that emerges is therefore one of a general staticity for both the characteristics which nevertheless have partially opposing tendencies. While in the case of success more than 15% of the farms improve their situation, in that of efficiency the phenomenon only occurs in 9.2% of the farms. The worsening of the performances is diametrically opposite. In this case 30% of the

farms have the same characteristic, whereas in the case of success the figure is 21%.


## 6.    Conclusions

This study represents the first recognition of the problem of the efficiency of the farms that constitute the INEA panel. We have focused on the measurement of the individual performances, using appropriate frontier production models suggested by the research literature on the panel data. Particular emphasis was given to the analysis of the temporal dynamic of technical efficiency. The results obtained have a reduced value as a result of non-sample nature of he data. Other limits are closely connected to the econometric techniques used: in particular - concerning the functional form adopted for the frontiers production - which is the traditional Cobb-Douglas; it was then assumed that technical progress is neutral. These simplifications are removable without excessive burdens, so that the question of the solidity of the results with regard to the functional form and to the modelation of technical progress could be studied.

In conclusion - a picture emerges of the structural inefficiency of the agricultural sector - which is coherent with the studies of cross-sections which have interested us. The dynamics identified do not imply a homogeneous behaviour for the techno-economic orientations; sometimes the dynamic can be interpreted as a consequence of the choices of agricultural policy at the Common Market level - as in the case of bovines - for which the sudden fall in the levels of efficiency as the decade draws to a close, coincide with a tightening up of the productive controls imposed on the sector. For other productive groups - the final picture is not very fluid - and with reasonable certainty we can exclude important movements in the direction of recovery in terms of efficiency in the period considered.

Concerning the relationship between efficiency and success, some elements emerge. For example, it is impossible for farms with less than 10 million G.O. to be efficient. This is a sign that once again should lead to a redefinition of the strategy of Extention, often directed at the simple transfer of innovations according to standardized models, in the ambitious attempt to improve the level of technical efficiency (Pennacchi F. et al. 1993; J.D. van der Ploeg 1990). Moreover, in the Northern plain area, because of the sizes and the productive directions, the lack of efficiency does not prevent a high RN being obtained, while in the hill and mountain areas, good levels of income can only be obtained with high levels of technical efficiency.


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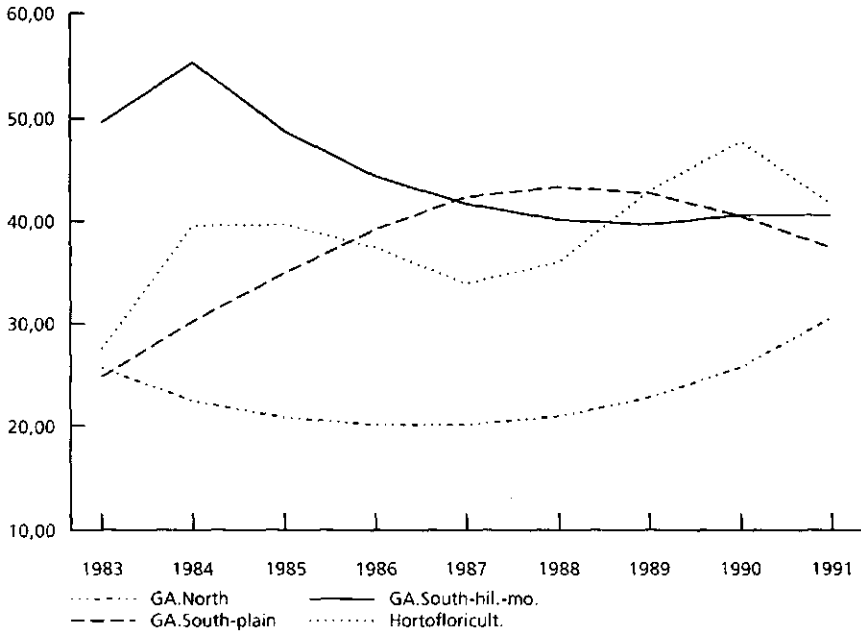
*Figure 1   Trend of the efficiency: crops production*
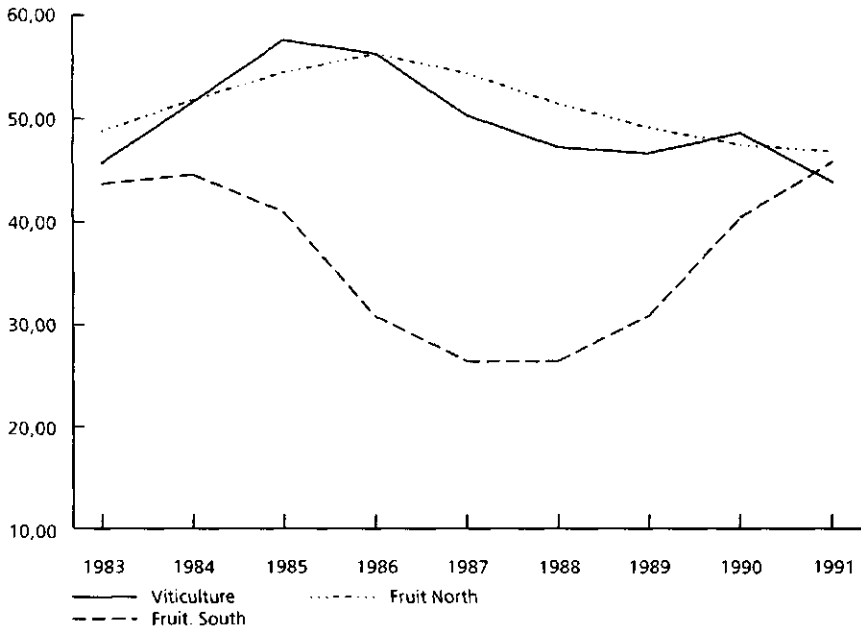


*Figure 2   Trend of the efficiency: permanent crops*
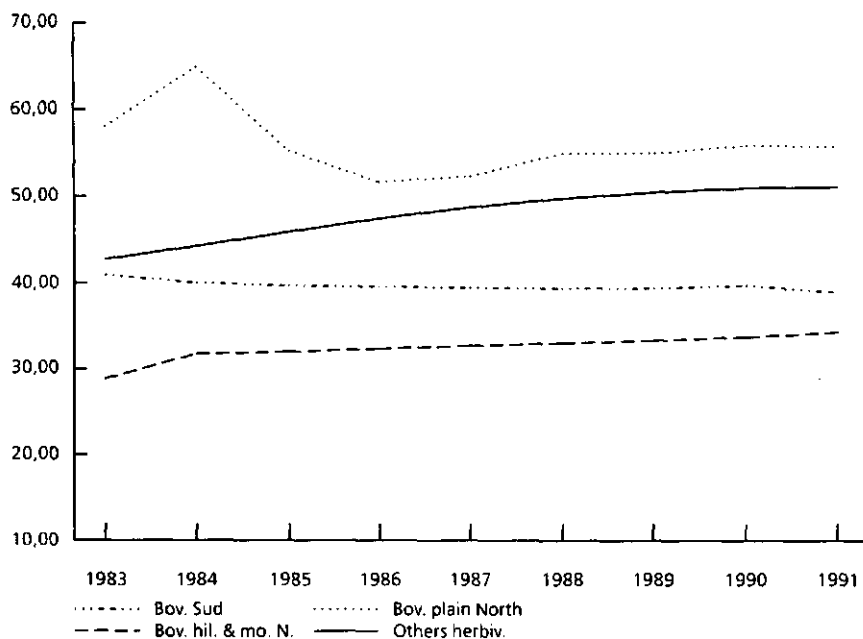
*Figure 3   Trend of the efficiency: grazin livestock*
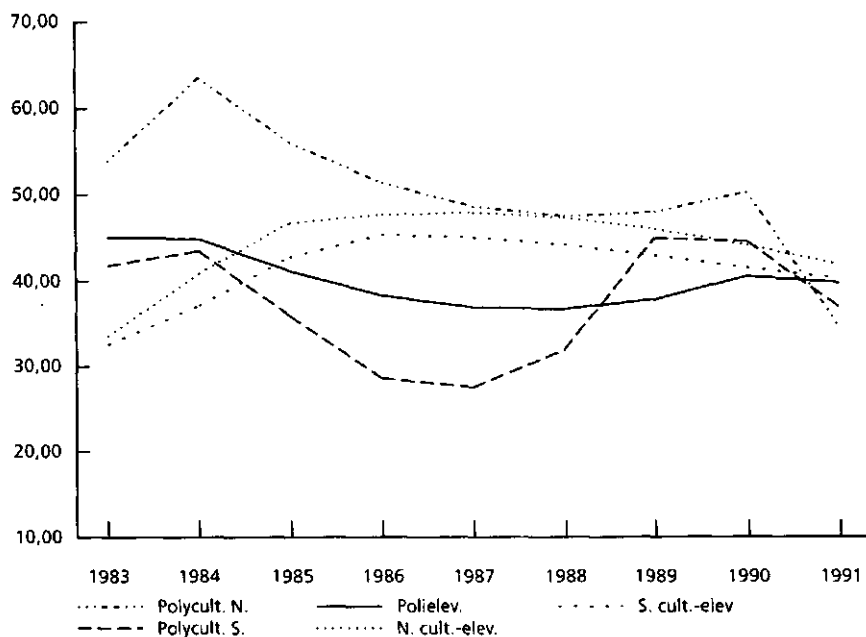


*Figure 4   Trend of the efficiency: not specialization farming*

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# THE ROLE OF INFORMATION IN PERSONNEL MANAGEMENT IN HORTICULTURE UNDER GLASS

(Support of the workshop as a method of investigation for information policy of the Ministry of Agriculture)

Dr. J.T.W. Alleblas [1]

## Abstract

This investigation is part of an umbrella study in which farmers and growers were asked what information they required. The umbrella study consists of six parts, each with its own method of investigation and analysis.

The prime objective of this study was to find differences and similarities, as observed by employers, when taking on, keeping, and dismissing employees. A better insight into these differences and similarities may show the relevance of the information which may help to improve personnel management.

Entrepreneurs hardly plan the input of labour. They simply rely on the ready availability from personnel and family. The growers in this study hardly ever mention anything about a shortage or surplus of labour. Work assessment interviews are seldom or never held; entrepreneurs usually believe that corrective indications during work are sufficient. Many of them have difficulties keeping labourers motivated.

A secondary objective was to find out how the method of investigation used (an interview followed by a workshop) contributes to the information and technology policy of the Ministry of Agriculture, Nature management and Fisheries.

In a chronological order the steps of the method and the backgrounds are illiminated. The workshop method is not an isolated phenomenon; it should be seen as a combination of aspects and activities that give sense to the workshop as a qualitative method of investigation.

The paper summarizes a number of positive aspects of the method. In a critical reflection, the possible negative implications are considered. Eventually, the conclusion may be drawn that the positive aspects clearly prevail. Under certain conditions, the workshop method has a strong explorative character and has a natural tendency to shift the frontiers of thinking and philosophizing about sensitive problems.

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## 1. Background and formulation of the problem

It has been shown that there is a great need for socio-economic research for the benefit of the further development of information technology (NRLO, 1991). Policy and especially the resulting actions aimed at the development of practical applications of information technology, should be based on a substantial knowlegde of the processes involved in agricultural entrepreneurs' objectives. It is generally recognized that this knowledge should come foremost from the entrepreneurs themselves. For want of a proven research method, it is difficult to gather this knowledge.

In jointly carried out research, the Agricultural Economics Research Institute (LEI-DLO) and the Agricultural University Wageningen (LUW) have developed and tested such a research method. The project consists of six sub-projects and its title is translated as 'Development of research methods into the relation between objectives, decision making, and information need of agricultural entrepreneurs' (abbreviated as 'Dobi').

The sub-projects differ in research topic as well as in the method of research employed. When the project was set up, a reasonable pluriformity in the used methods was attempted. Some of the partial studies use a quantitative method (factor analysis, regression analysis, averages from data bases) and others use a qualitative method (interviews, knowledge acquisition, workshops, discussions) or a combination of both (data gathering and discussion on the mutual differences and similarities).

Central to this study is the workshop, which is a qualitative research method. This method is used relatively often for research where knowledge acquisition must be voiced by means of regulated and/or free discussions.

## 2. Objectives and focus

In view of the structure of the Dobi project, each component project necessarily has two objectives. The first objective differs per partial study and is directly related to the chosen research topic. Although the method of investigation differs, the second objective of each partial study is identical and can be described as 'the analysis and testing of the used method'.

The specific problem that comes up in this partial study, is related to the difficulties in personnel management in horticulture under glass. LEI-DLO has reported about this problem in a separate research report (Alleblas, 1994).

In this report, together with a group of spray carnation growers, the backgrounds of effective personnel management are discussed. A starting point for the discussion is the role information plays for the entrepreneur. The research is mainly aimed at tracing the differences and similarities that employers observe when hiring, maintaining and dismissing employees. Insight into this could reveal the importance of certain information for personnel management. Growers of spray carnations have specific problems with the labour supply. Farms work with a constant staffing of two to three man-years for a large part of the year. Mainly during the two peak periods a lot of improvisation is

called for to attract sufficient labourers. Often the problems are also solved by appealing to the family and to a flexible input from existing personnel.

During peaks the entrepreneur seeks assistance from part-timers and casual workers. Activities such as harvesting, sorting and disbudding are relatively difficult and require some skills that are often found among pupils and housewives. The growing of carnations has a time-consuming aspect to it, especially during peaks, and for economic reasons the work must be done by relatively cheap workers. Precisely because during peak periods many labourers are present on the farm, labour supply is difficult and demands organizational qualities from the entrepreneur.

## 3. Representativeness and limitations

The group of entrepreneurs who took part in the workshop has been tracked down by mediation of the Nederlandse Tuinbouw Studiegroepen (Netherlands Horticultural Study Groups, NTS). They were already active in a study group and were used to communicating within a group. This was a prerequisite for participation in the workshop because the topic is a sensitive one and should be treated without any reservations.

The research into personnel problems has a limited representativeness. However, it is important to view this limited representativeness in the light of the second objective of the research, where the research method and its testing within the framework of the information policy is central. Also because this research objective is an important aspect of the project, the disadvantage of a relatively low degree of representativeness is not of crucial importance.

## 4. Information in personnel management

The information was based on the list of questions on personnel management put before 10 growers of spray carnations. These 10 included four one-man businesses, 3 firms and 3 partnerships. The average age of the growers was 35. Personnel per firm averaged 11. The total labour input expressed in AWUs (Annual Working Units) was 6. Between them the growers had 9,500 $m^2$ of spray carnations under glass and 1,500 $m^2$ of other crops.

*Recruitment*

Most growers do not make a labour plan for the next crop. When peaks are expected they simply call people who worked for them the year before. These are often housewives or students as these can work flexible hours on a part-time basis. Young people are popular because of low wage costs.

Popular methods to recruit casual workers are advertisements in local papers and by word of mouth. For the recruitment of permanent workers the help of job centres or employment agencies is sought. Motivation, flexibility,

adaptability, age and the same country of origin as the other workers in the group were defined as the main recruitment criteria.

*Labour organization*

All growers use a standard form for the registration of workers. However, data on productivity, quality of the work done, personnel shortages or redundancies are seldom found. Absenteeism is recorded (illness, holidays or leave) by most.

Performance interviews do not take place. Giving directions or correcting workers on the job is seen as simpler and more effective.

Most employees record data to determine wages. This is often done on work sheets which are handed to the accountant who determines the final pay.

*Motivating workers*

To keep up workers' motivation employers usually give extra payments. However, it is felt that the benefita of bonuses are short-lived. Extra payments should not be handed out regularly and should be accounted for. A bonus plan drawn up at the start of the season may act as an incentive. Immaterial rewards are seldom used. Participation in the decision-making process is generally limited to talking things over during coffee breaks. Motivation is generally kept up by a mix of material and immaterial rewards.

## 5.    Recommendations

The recommendations should be seen as an inventory of all possible incentives to improve personnel management in horticulture under glass. The priorities have been indicated by the growers themselves. Besides growers, there are no other parties involved in this research; this could mean the recommendations are somewhat biased. They would probably have been different if the opinions of others had been asked (employees, labour mediators, agricultural and horticultural organizations, etcetera).

*Recommendations for growers*

1.    In spite of the efforts already made by some individuals, growers should take their image as employer more seriously. They lag behind other employers in this respect.
2.    Growers should create more agreeable working conditions. Unnecessary physical stress should be avoided and adequate provisions should be made for dirty and unhealthy work.

## Recommendations for growers' organizations

1.   Growers' organizations should act more swiftly and adequately in their response to negative publicity from third parties.
2.   Growers' organizations should take a tougher stance in Collective Labour Contract consultations. Flexible working hours, adaptable contract periods and more facilities for occasional work (a labour scheme for students) should be high on their agenda.

## Recommendations for job centres and employment agencies

1.   Job centres and employment agencies should make a more adequate selection of suitable workers for the horticulturist branch.
2.   It is the primary task of job centres and employment agencies to motivate potential workers. They should also make more of an effort for short-term vacancies.

## Recommendations for government authorities

1.   The gap between gross and net wages should be narrowed. Gross wages and some premiums should also go down.
2.   The Unemployment Act should allow for more flexibility:
     -   unemployment benefits might be subjected to seasonal adjustments (winter rates: 100%, summer rates 50%);
     -   temporary benefits during alterations should be applied with more flexibility.

## 6.    Remarks on the method of investigation

### Clear starting points

As a starting point for the research, the 'Information Model Horticulture Under Glass' has been chosen. The availability of a detailed version in the form of the cluster 'Personeelsbeheer' (SITU, 1989), makes the model perfectly suitable for the research. The detailed model forms a clear and recognizable framework and has proven to be of great importance to the research. Precisely because of its integral description of the information supply on a farm, an information model in this form provides an excellent starting point for further analysis of the backgrounds of this supply.

It is also important that this part of the research method neutralizes the influence of the researcher on the end result. Although the researcher chooses the domain (personnel management), the analysis of that domain has, as it were, been delegated to the participants of the workshop.

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## Oral inquiry

As a preparation for the discussion sessions of the workshop, a question-naire was drawn up. The interview was held in the entrepreneurs' own farm environment, enabling them to feel at ease and consequently giving them the peace and inspiration to answer the questions in all their facets. A second ad-vantage of the own (farm) environment is the possibility of illustrating the reasoning by means of practical circumstances.

## Workshop plan

After the questionnaires were studied and answered, the horticulturists' answers relating to eight selected processes were put on spreadsheets; this increased the involvement of the participants considerably during the presenta-tion of the results. The size of the group was such that everyone could be in-volved in the discussion and there was ample time to voice one's opinion.

## Working towards a climax

The aim of the research was to eventually come to recommendations for improving personnel management. These recommendations also formed a measure of the success of the research. The direct involvement of the entrepre-neurs, who experienced an awakening and a learning process during the re-search, is an important part of this research method. The draft report has been discussed with the horticulturists, which resulted in a few adaptations and some highlighting.

## Selection problems

Research with the Detailed Information Model Horticulture Under Glass (SITU, 1987) and the cluster model Personnel Management (SITU, 1989) as a starting point, gives two selection problems, which especially arise from the degree of detail of the model. First a choice of domain must be made on the basis of the preliminary research, in this case 'personnel management', after which a further thinning out or selection is made of (sub-)parts; this results in research into the role of information in personnel management.

## Reflection

The risk of a small group is that a few dominant participants could decide on the discussion topics. It is the task of the researcher to be aware of this. Fur-thermore, it is almost impossible to present calculated averages with statistical reliability margins.

There is no single answer to the question what the ideal size of the group would be for such research. In the research of the role of information in per-sonnel management with the group of ten entrepreneurs, excellent experience was gained. Everyone had ample time to have their say, the problems were

widely and extensively covered, and the entrepreneurs were very motivated. This was not in the last place thanks to the fact that everyone was well aware of the value of their own input.

The enumeration and implementation of the recommendations in this form does not pretend to be an ideal or representative solution to the problems of personnel management in horticulture under glass. For this, the recommendations in the follow-up research should be looked at more closely. When judging the recommendations with respect to their contents, one should be aware of the entrepreneurs' hallmark. Had other parties (employees, agricultural and horticultural organizations, job mediators etcetera) been involved with the research, the list of recommendations would probably have had a different emphasis.

## 7.  Final conclusions

1.  For personnel management to be successful, pragmatic actions should be given a higher priority than the use of a model's set of details.
2.  The fact that in a given personnel management area little or no information is recorded does not necessarily mean that no information is used in that area. Non-recorded information can also play a major role in successful personnel management.
3.  There is some competition between the use of information technology, the traditional use of information stored in the brain and a flexible attitude for a relatively swift solution of personnel management problems.
4.  As personnel management has become more complex, written information is relied on more heavily in some areas.
5.  Personnel management information systems will have to compete with the tendency of most glasshouse growers to go to third parties to find a solution to problems.
6.  Employers' recommendations for improved personnel management can be used by policy-makers to formulate policy targets and constraints.
7.  For a successful information policy, a strategy should be drawn up which is future-oriented and takes into account the diversity of employers' needs.
8.  When gaps in information systems have been identified, a set of objectives can be drawn up as a basis for a new information policy.
9.  The analysing description of this investigation is characteristic of the method used and may be of help in future steps and research guidance.

## 8.  Epilogue

To conclude, the explorative nature of the research method will be briefly brought to the attention. This means that, as opposed to many other research methods, this method offers fertile ground for broadening the topic and at the same time it stimulates the participants a shifting of boundaries concerning

thought and philosophy. During the workshop, together they delve through a research field that, though it is limited (domain), nevertheless at the same time offers the participants ample space for further filling in that field, by providing them with maximum freedom and input.

The method has the possibility of entering unknown areas and involving others in this. It is precisely the aspect of unexpected turns and the often connected unpredictable revenues that make the method attractive and form a natural counterforce against occurring saturation effects and decreasing revenues from some of the other methods. Explorative research in this form therefore keeps its vitality in the course of the research and consequently has a relatively large capacity for the tracing, identification and, possibly, solving of problems.

Especially with regards to the possibility of solving problems, one may wonder what eventually can be done with the wealth of information for future policy. It may be concluded that information policy is only successful if a strategy is developed based on sound practical applications in the sense that the diversity of entrepreneurs' practical needs is taken into account.

Besides a supposed theoretical optimum in information supply, where for many entrepreneurs the same basic elements are present, a certain spread has been shown in the use of information that must be explicitly expressed in policy applications. In general, this concerns the acceptance by policy of entrepreneurs' different types of objectives and the possible information technology that should be tuned to them. A description of the concrete starting-points is beyond the scope of this paper. In a separate research report, however, LEI-DLO pays attention to them (Alleblas, 1994).

Further, it is not inconceivable and even likely that a combination of different qualitative and quantitative methods for policy support will have a relatively good outcome. Within Dobi research, attention is also paid to these problems with the help of the results of the various partial studies and by carrying out a joint partial study; in the course of 1995 this will be publicized (Alleblas and Beers, 1995).

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# EDINBURGH FARMER DECISION MAKING STUDY: ELEMENTS IMPORTANT TO THE FARMER

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**Abstract**

*The use of a modified soft system approach (based on Checkland, 1981 & 1990 and Wilson & Morren, 1990) is described in an effort to understand the elements important in the decision making of small to medium sized farmers in the East of Scotland. Business decision making processes were observed as were those involved in the decision making process, the sources of information used, and the factors which motivated the farmers.*

**Key-words** : Decision making / Soft System.

## 1.    Introduction

Decision making is an area which has received much attention from economists and psychologists alike. The complexity of the decision making process is recognised by economists, who in an attempt to understand the process force assumptions, distinguish individual cases, undertake (sometimes inadequate) measurements, and employ abstract reasoning. This, it is argued, is necessary because the area is so complex that it has initially to be simplified. Once simplified, it is further argued, reconstruction allows the discipline to gain a more comprehensive understanding of the process. Unfortunately, the history of economics would appear to indicate that in such studies are easily side tracked or unable to bring an holistic view to many areas, with the result that when in-

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depth understanding is gained, it is in very specific instances and areas. As a consequence a fuller picture of processes which are clearly defined, (and definable) can be difficult to construct. Those which are most successful and readily illustrated are in the development and use of expert systems. In more complex situations, such as decision making, the traditional methods of enquiry are currently unable to produce such an holistic picture and ultimately understanding is limited.

Psychologists take a different approach to investigations of this nature. They observe situations and develop hypothesis. These hypothesis are then tested through further systematic observation, leading to a revision of the original hypothesis, and further testing. The problem with this approach is that, in an attempt understand the initial phenomena, a tread wheel can easily develop with investigation sustained in ever-continuing circuits of modifying hypothesis and testing. Like the economic approach the psychologists are able to contribute cameos which explain elements of processes such as decision making, but are unable to produce an holistic picture or understanding.

In this study the factors important to, and the decision making undertaken by, small to medium sized farmers was of paramount importance. The intention was not to replicate decision making but to discover (uncover) a system which will perform adequately to predict, at least, elements of decision making behaviour. The employment of the soft systems element is simply an alternative method of gaining further understanding of how individual farmers operate. It is used to shed additional light on a part of the decision making process, from the perspective of the decision maker (farmer), in an effort to gain further understanding of it.

Decision making is a complex area of study, if for no other reasons than it involves individuals making decisions, either singly or in groups, and that the factors affecting the decision making progress are specific to the perceptions and experiences of the individuals. Predicting outcomes in specific situations is therefore neither a clear-cut nor easy process. Literature and experience shed some light on the areas which might be considered when investigating the decision making process. Individuals are bounded in their capacity to make decisions by limited powers of processing (Simon, 1990). This leads to rational decision making which is necessarily based on partial information and inadequate analysis. The method used to solve a problem, or arrive at a solution is concomitant upon the individual differences and perceptions of factors bearing upon the individual. Additionally, information processing is affected by experiences and prior knowledge shown through the work of Shanteau (1998) where problems are broken down into their constituent parts for solution, before being reconstructed to solve the whole problem. The location and nature of much farming in the United Kingdom is such that the lifestyle is necessarily individualistic. This leads farmers and their families to work in relative isolation, and consequently to lay greater emphasis on social, and other contacts outside their own business, than might be the case in other businesses. Tetlock (1985) identifies the fact that decisions are influenced by what he describes as 'social factors'. The area of social accountability is not however confined to those outside the farm business. Those surrounding the farmer (decision maker) will

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have influence on the decision making process because of the need to justify the decision to those who can assess the consequences or effects of the decision (Simonson, 1989). However, when looking at a specific group of individuals (in this case farmers), acting independently, it is useful to make an assessment of the relevant areas and appropriate factors in the decision making process which they are most likely to specifically use in operating their business.

The soft systems methodology was employed as a means of focusing interviews held with individual farmers. The primary area of interest was to discover if there was a process which each farmer used in business decision making. Secondary interests included; who, along with the farmer, was instrumental in business decision making processes; the source(s) of information which farmers saw as being useful and credible; and the elements which motivated individual farmers.

Soft systems methodology was used as a method for gaining understanding of, and identifying the factors involved in, the decision making process(es). Further, the soft system methodology was used because it is a method of enquiry for problem solving in areas which are difficult to define. The methodology was formulated by Checkland (1981), and subsequently modified by him (1990), to 'identify observable and purposeful human activities to which individuals attribute perceptions'. This is done in the light of gaining understanding of the decision making process(s), which would otherwise be more difficult because of the problems associated with the complexity and essential qualities, properties, and nature of a system which is not fully understood. Checkland's theory, that 'every human activity system has an infinite number of possible accounts; each valid in terms of their particular *Weltanschauungen* 1)', is based on the individuality of interpretations of decision making by those involved in the decision making.

In this investigation the full scope of the soft systems methodology has been modified from those recommended by Checkland (1981&1990) as it was not the intention in this research to alter participants decision making processes and perceptions, but to understand them. For this reason three clearly defined stages are being employed in this study.

The first stage is to make sense of the decision making situation by enquiry. The methods employed are the gathering of basic facts from written sources and open minded enquiry to collect information from individuals (using semi-structured interviews).

The second stage is the applications of systems thinking and conceptual model building. In this a series of hypothesis are postulated to explain the decision making process and from these to formulate conceptual models.

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1) German: partly translated as world view(s) or paradigm(s); consisting of our experience, feelings, emotions, attitudes, values, beliefs, morals, tastes, intelligence, and store of knowledge; expressed among other ways in the meanings given to situations and what improvements are preferred.

The third stage is the presentation to, and discussion of the conceptual models with, the participants. This is to allow the participants to question, develop, explain and modify the proposed model, and to reflect their perception of reality. From this discussion modification of the initial models takes place.

This paper deals with the initial part of the second stage only. The first stage is embedded in the work of compiling the questionnaires for the main (252 respondent) study. At the date of writing the third stage has yet to be undertaken.

## 2.    Method

6 East of Scotland farmers, three predominantly arable and three predominantly hill sheep, were selected randomly from the 252 farmers who had co-operated in a main study in decision making described in McGregor et al., 1995. The farmers participated in a series of interviews with the aim of developing case studies, based on a modified soft systems approach.

## 3.    Is a process identifiable?

When questioned about decision making the initial response of the majority of farmers was that they did not undertake decision making: 'It just goes on year in, year out. The farm carries itself'. This may be either a denial of the process or a misconception of what decision making process(es) comprise.

All of the farmers interviewed displayed tentative processes which underlay the business decision making in which they were involved. At the one extreme some farmers did not have a process to meet the requirements of the business or for planning work, preferring to take each decision as the need arose, on the assumption that any decision taken at that point would be 'best-fit'. 'I feel I'm more inclined to make decisions all the way through. I don't have set plans that I work to'. These farmers displayed innovativeness in their approach to running their business. Their business was diversified through the range of crops and operations employed and they were willing to experiment with new methods or ideas. They were aware of the concept of risk but did not feel threatened by it because of the size of their turnover and variety of their operations. 'I suppose you could put it down to R&D as much as anything else'. 'I suspect it probably puts a higher risk in, but I also suspect that over the piece it provides the opportunity of a higher reward'. At the other extreme some farmers preferred to have a set work pattern worked out well in advance. 'I know that on a given date I will be doing such-and-such, because it's always been done that way'. 'The guys that I use to labour will know that they are going to be here a certain week in July for sheering ewes, or something like that'. Close questioning for this method of working illicited the fact that they had all tried to use different working patterns in the past, but local climatic

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and topographic conditions had led each to particular situations in which they had what for them was a 'disastrous failure'. Such a failure was invariably expressed in economic terms. These farmers professed the desire to be innovative in their business, but claimed that the risks were too high (and they were unable to spread the risks because of the restrictions place upon them by the type of farming in which they were engaged, or the location) As a consequence they had all, over time moved to more traditionally proven working practices.

The decision making processes, however, differed according to the type of decision which was being undertaken. For example, when asked to consider the process which would be employed in changing the variety of a particular crop or breed of livestock, all of the participants essentially considered:
-       whether they could afford the change;
-       the benefits that would accrue to themselves;
-       the benefits that would accrue to the business;
-       their personal ease at living with the change;
-       the ease of everyone else (primarily family) involved in the business.

When asked about the purchase of new or replacement machinery, they saw this as an *ad hoc* decision related directly to whether the business budget could afford it. However, underlying this initial response it became apparent that inappropriate, old or obsolete machinery was always pressed into service for as long as possible, and unlike many decisions which were taken at the end/start of the financial year and depended upon the perceived financial health of the business operation. The timing of a purchase coincided with factors such as the irretrievable breakdown, or fear of a breakdown, at a crucial stage in the work pattern of the business. Considerations such as the perception of a good deal *vis a vis* the price, credit arrangement, higher specification, or value for money in the purchase of the equipment were important in acting as a catalyst in motivating the farmer to take the decision to buy.

Some of the farmers felt that they did not employ decision making except in strategic situations. They justified this by stating that decisions did not have to be made on a day-to-day basis because the rules and criteria for operating the farm business were straight forward and simply required implementation rather than decisions. However, in terms of whether this was implementation or decision making normal operational decisions were taken as necessary during the course of operating the business, in what one participant described as 'real time'. By that he meant that decisions were taken, by himself as the need arose, without reference to others. 'Well, say at the moment we're puting fertiliser and chemicals on. If I miss an opportunity to get them on, then I've got to be prepared to say what's the best way round this'. This independence in taking decisions was seen as being important to all of the participant farmers. Negotiation with others involved in managing the business was not an area which any of them relished, primarily because of the 'emotional overhead that you have in a family business'. They all looked for 'a cleaner decision making process......with a great deal grey area removed from it'. This may account for the emphasis which all participant farmers laid managing the business on their own.

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## 4.    Who, along with the farmer, is instrumental in business decision making?

Most farmers denied that anyone else took an active role in managing the business, only admitting to discussing what might be described as strategic, large financial operations, or exceptionally risky operations, with other business and family members. Seeking clarification of this method of operation it became apparent that this involvement of others in these matters was seen very much as a sharing of responsibility in the event of the decision being unfavourable (loss making) for the enterprise. However, in day to day management, there was much more discussion of the techniques which were being employed, than individual farmers would directly admit to. '(My wife is involved) ...more in major decisions, such as we'll discuss the general strategy for quartering, or do we try something new, or do we invest in a piece of machinery. Anything like that, yes, we discuss that. That's the stuff'.

Family members, although not necessarily partners in the business were the first line of support for the farmer. The spouse was frequently a partner in the business, but only consulted in large financial decisions which were out of the ordinary; 'If I need to consider new machinery, then I will ask her out of courtesy'. 'It's important that I involve her in major financial matters'. Those children of the farmer working on the farm, and expected to succeed in the business were frequently involved in more strategic decisions regarding the farm business, but only in an advisory capacity. The day-to-day operation of the business was seen to be the prerogative of the farmer, with only specifically delegated areas under the control of the individual child; 'When he's up the hill (with the sheep) it's up to him to decide what has to be done with the flock. He doesn't have to keep running to me about that, but I have to be involved when money has to be spent'.

Involving non-family members in the running of the business tends to be spasmodic, or related to specific needs. Agricultural advisors or consultants are the main source of assistance in making decisions to do with the business. They are called upon by the farmer to become involved in a particular area of the business operation and are expected to confine themselves purely to that area in which they have been consulted. Other non-family members are viewed with some scepticism because of their perceived lack of objectiveness. In particular bank managers were seen as being particularly unhelpful because of their charging policies and lack of independence. Banking policies were perceived to have been formulated at some 'central office' which was remote from the needs of the individual farmer and the farming community in general. They lacked the confidence of close relationships which bank managers and their farmer clients had formerly enjoyed. Likewise, interference in the running of the business by the banks was resented by the farmers who claimed that their borrowing requirements were short-term to meet shortfalls prior to selling stock or grain, and payment of subsidies. Of particular resentment were the charges made by the banks for every aspect of their involvement, from arrangement fees to interest payments. 'You have to pay to see him'.

Professional consultations, particularly with solicitors and accountants were seen as a 'necessary evil' when the need arose. Universally the solicitor was seen as fixed, with the farmer intergenerationally using the same firm of solicitors. This was more out of habit than good service. Accountants were seen as being easily changed, particularly if they were too demanding in their requirements of the farmer.

## 5.    Sources of Information

The main sources of information were from other farmers, meetings, agricultural advisors and consultants. The consultants and advisors were used not only to gain specific information on topics of interest, but as a means of benchmarking the business: 'We're involved in organisations so that we get information back to show how our performance is in relation to other places. We quite often make changes on the basis that, for similar types of operations, we may not be doing as well in some areas as they are. So you have something to look at, and you look at that and see what we can change here, or how we can alter this to get up with the best guys'. The integrity of the advisor and consultant was such that those farmers who employed them generally felt that out of all the sources of information available they were.. 'the only one I would take at face value would be a professional advisor like the college. I wouldn't need to go along and see their system'.

Representatives are seen as being useful for specific technical information, particularly if an operation has not gone as expected. Interestingly, the information gained from the representative is often not acted on as the representative might expect 'I don't then go and....very seldom do I then go straightaway and do exactly what they say. I'm inclined to tailor that to what I feel myself'. 'So it's really a case of getting the information from, hopefully a number of sources, including myself, and then mull it over and come with what I feel is the best solution from there'.

The press is seen as being of negligible use as the information contained in it is often late in relation to other sources which the farmer has. Additionally, it is often seen as being of little use because it is written in such general terms as to be of little specific use in the circumstances of the individual farmer. Of further interest is the fact that it was universally seen as being unworthy of action because it was expected to be inaccurate. Farmers, however, were relatively avid readers of the farming and farming related press. Although they held the foregoing attitudes farmers received enjoyment from keeping abreast of current developments in their areas of particular interest.

Farmers are of great interest to other farmers because they are in the same area of business. For this reason they are seen as competition, but also of assistance, and as such they were usually 'monitored'. Their actions and results gauged in relation to the local farming community. Self reporting of performance between farmers was distrusted. 'I'm not inclined to give that kind of information a great deal of weight, because it's a pointless exercise trying to make decisions on gossip'. '...at face value they may well say that they are sell-

ing their bulls for £1,000, when they're 12 months old, and sound very impressive, but when one went along and saw their system then one would realise that they sold their best bull for £1,000, but the majority were sold for £700-£800, perhaps. And with one's own eyes you would see how effective or efficient their system really was'.

## 6.    Motivation for farmers

Tempered by other factors the maximising of income of the business is by far the most important element for the farmer. 'It's first, in relation to the capital required to do it'. 'I'm looking for minimum input and maximum output'. Interestingly, all the farmers who described themselves as innovative also saw themselves in terms of being business oriented. This perception they each thought was different from most other farmers '(my)......attitude to running the farm is.....probably different to a lot of my friends'. 'My attitude to running the farm is that I'm running a business'. 'The business is there to provide an income for me and my family, to provide as nice a lifestyle as that can produce. That's number one priority'.

The disadvantage of long and unsociable hours was seen in the context of the farm work having peaks and troughs. The peaks called for long unsociably, but not necessarily physically demanding work, but these peaks were perceived to last for short periods. The troughs were associated with shorter working days and the ability to enjoy leisure; 'As time goes on your decisions do become more constrained by what you wish to get from life'. As you get older then choosing between a 5% increase in profits or a ½ days golfing, then golfing would win!'.

The uncertainty associated with the Common Agricultural Policy and support systems was seen as an interference in their management of the farm business, but a welcome on in that it provided additional income. Although they did not like, or support the system, they saw the necessity to ensure that they understood it sufficiently to make maximum benefit from it. As such the motivation in operating it, and in particular being involved in Environmentally Sensitive Area schemes derived motivation in being able to undertake specific work which they might not otherwise be able to. The fact that aspects of the schemes did not meet with their approval was outweighed by the financial benefits which accrued directly from the management of the scheme or the physical enhancement of the farm business assets.

Individual farmers were motivated by the lifestyle, partly as custodians of the landscape, but also in being independent in the day-to-day managing of the business.

## 7.    Future work

The use of initial interviews has led to the development of 'rich pictures' and has identified the areas which are of relevance to individual farmers. There

were a range of specific areas peculiar to individual farmers, but the areas of primary importance to all the farmers involved were the accessing of appropriate information, and the motivation of themselves and their business associates. Of necessity this paper has therefore concentrated on these areas as they have the broadest application across all of the farmers participating. It is envisaged that much more detailed information, in the form of specific case studies developed out of individual interviews with participating farmers, and the use of vignettes to capture decision making in realistic, but hypothetical situations, will enable the significance of the individual factors involved in the decision making process to be assessed in the future. The synthesis which arises from this methodology will enable the processes underlying the business decision making to be more clearly identified, analysed, and understood.

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# INFORMATION SEARCH AND PROCESSING STRATEGIES OF HORTICULTURAL GROWERS IN A LOCATION DECISION GAME

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## Abstract

To examine the information search and processing strategies of horticultural growers, who are searching for a new location, a location decision game was developed and executed with 14 growers. A game environment for examining information search and processing strategies is used to exclude previouslu existing information concerning the alternative locations which the growers may have in memory.

The observed information search and processing strategies are rather diverse, but most growers first simplified the problem by screening the alternatives based on information for a few important attributes for all locations. This pre-selection was based on non-compensatory decision rules. An evoked set, consisting of a few relevant locations, was submitted for a more detailed examination. This subsequent evaluation was mostly based on compensatory decision rules.

The use of process tracing methods, such as this decision game, to examine decision making processes contributes to increased insight in the information search and processing underlying decision making in a laboratory setting. However, additional research is required to fully comprehend location decisions in a real life situation.

**Key-words**: location decision, information search and processing, process tracing methods

## 1.    Introduction

Decisions regarding relocation are a topical subject of concern for many horticultural growers in the Netherlands, due to external phenomena (e.g. urbanisation) as well as internal circumstances (e.g. possibilities for expansion). The choice of a new location is an important strategic decision, which affects

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both the structure and income potential of the horticultural holding as well as the social life of the grower and his family for a long period.

Growers who are considering a relocation are confronted with a web of information and information providers concerning alternative locations. The main objective of this paper is to get insight into how growers find their way in this web of information. A grower does not have the capacity to acquire and process all available information, so he must be selective. Payne et al. (1993) found that decision makers compromise between the desire to make a good decision and the desire to minimize the cognitive resources used in making the decision. Which information search and processing strategies can be used by the decision maker to balance accuracy and effort?

*Information search and processing strategies*

A main distinction in strategies can be made between non-compensatory and compensatory strategies. Non-compensatory strategies do not permit trade-offs. A bad value of an attribute cannot be compensated by a good value of another attribute. Compensatory strategies on the contrary, do make trade-offs. Good values of one attribute can offset bad values of another (Payne et al., 1993). Hogarth (1987) has suggested that people find making explicit trade-offs emotionally uncomfortable, because compensatory strategies confront conflict. Thus, decision makers may avoid strategies that are compensatory not only because they are difficult to execute (cognitive effort), but also because they require the explicit resolution of difficult value trade-offs (conflicts).

Another distinction between strategies concerns whether the search and processing of alternatives proceed across or within attributes. The former is often called holistic or alternative-based, and the latter is called dimensional or attribute-based processing. In alternative based processing, multiple attributes of a single alternative are considered before information about a second alternative is processed. In contrast, in attribute-based processing, the values of several alternatives on a single attribute are processed before information about a second attribute is processed. Attribute based processing is assumed to be cognitively easier (Payne et al., 1993).

Table 1    *Information search and processing strategies*

|  | non-compensatory | compensatory |
|---|---|---|
| **Alternative based** | Conjunctive model | Additive model |
| **Attribute based** | Elimination by Aspects | Additive difference model |

Although more information search and processing models are described in the literature, for purpose of review we will restrict ourselves to four general information search and processing models (table 1). Other models discussed in the literature are more detailed and are adapted from these four models described by Payne (1976).

With the *additive model*, the process of choosing among multidimensional alternatives is assumed to proceed as follows. Each alternative in a choice set is evaluated separately. A value, either objective or subjective, is arrived at for each component or dimension of an alternative. The components are then combined in an additive fashion resulting in an overall value for that alternative. Comparisons are then made among the overall values of the alternatives and the one with the greatest value is chosen. The additive model is a purely compensatory strategy.

In the *additive difference model*, proposed by Tversky (1969), the alternatives are compared directly on each dimension, a difference is determined, and the results are summed together to reach a decision. This model is based on a choice between two alternatives. However, when dealing with a multi-alternative choice, the decision maker starts to make a choice by using the additive difference model on two alternatives. The best of those two alternatives will become a standard to which each of the remaining alternatives is compared. The additive difference model is also a compensatory decision strategy.

The most well know non-compensatory strategy is the *Elimination By Aspects model* (EBA), first described by Tversky (1972). In this model, cutoff values for the most important attribute are established, and all alternatives with values for that attribute below the cutoff are eliminated. For the remaining alternatives, this process is continued for the second most important attribute and so until there is one alternative remaining.

The *conjunctive model* implies that an alternative must have a certain minimum value on all the relevant dimensions in order to be chosen. This model is based on Simon's (1957) principle of satisficing. The decision maker will stop searching for information when he has found an alternative which meets his minimum requirements on all relevant attributes. The conjunctive model is a non-compensatory model, because an alternative is eliminated when it has a low value on a relevant attribute. This low value can not be compensated by a high value on another attribute. The difference with the elimination by aspects model is that the conjunctive model is an alternative based search strategy, which means information is searched per alternative for each relevant attribute. Elimination by aspects on the contrary is an attribute based search strategy.

Payne (1976) found that decision makers often make use of more than one of these strategies described above during the same decision making process. Confronted with complex decisions, the less cognitively demanding strategies conjunctive and elimination by aspects might be called early in the decision process as a way of simplifying the decision task by quickly eliminating alternatives until only a few alternatives remained as choice possibilities. The decision maker might then make use of more cognitively demanding strategies and examine the remaining alternatives in more detail (Payne, 1976). The first part of such complex decision process is often called the *screening phase* and the second part is the *trade-off phase*.

Process tracing methods can be used to gain insight into information search and processing strategies. Well known process tracing methods are ver-

bal protocols, in which the decision maker has to think aloud, and information search methods, in which physical behaviour is monitored, used to acquire information as people make decisions. By means of observing what information is considered and the order in which it is acquired, insight is acquired into the cognitive processes underlying the decisions (Carrol and Johnson, 1990).

*Objectives of the study*

A question which arises from here is how do Dutch growers actually balance accuracy and effort? In other words, what information search and processing activities precede a location decision? What phases of information search and processing can be distinguished and which strategies are used in these phases?

An information search method, in the form of a location decision game (LDG), will be used to examine the information search and processing strategies of growers who are looking for a new location.

In this paper both the observed information search and processing strategies in the experiment and the use of a location decision game to examine decision making processes are discussed. Other aspects of the decision game will be the subject of later publications.

## 2. Materials and methods

To examine the information search and processing strategies of growers who are looking for a new location, a workshop was organised in which a search method was used in the form of a Location Decision Game (LDG).

*The workshop*

A workshop is a meeting of a small group of subjects in which information is gathered from those subjects by filling out questionnaires, and in our case by playing a decision game. The questionnaires consisted of questions concerning the location decision making process and some personal characteristics. In this paper, we will restrict the discussion to the location decision game.

*Subjects*

The subjects for this workshop were a selected group of growers who intended to relocate in the near future. They were selected from the respondents of an earlier survey held in 1993 (Hopman et al., 1994). An invitation was sent to 30 growers. After they received this invitation, all invited growers were asked by telephone if they would accept the invitation. From those 30 growers, 18 growers promised to participate. Only 14 growers participated in the workshop. The low response (47%) was mainly due to a temporary disinterest in the subject because of the bad economic situation in horticulture and time constraints. The fact that 4 growers did not appear at the workshop, although they

had promised to participate, might be explained by the extreme high temperatures on the day the workshop was held.

*The Location Decision Game*

The main part of the workshop consisted of the Location Decision Game (LDG) executed on a computer. The LDG was based on a method developed by Trip et al. (1994a). Trip developed the game to simulate the cultivar choice of Chrysanthemum growers to trace information search behaviour during this choice process.

The LDG consisted of an information matrix in which information on 7 alternative locations was hidden. The growers were asked to choose a new location for their firm out of these 7 locations. The alternative locations were named A-G. Each alternative location was described by information about the following 9 attributes:
1) parcel (size, shape, price);
2) production circumstances (climate, light intensity, disease pressure);
3) living conditions (kind of village, landscape, religion etcetera);
4) knowledge infrastructure;
5) labour supply;
6) infrastructure;
7) supply industries;
8) auction (distance and size);
9) the attitude of local authorities towards horticulture.

The growers were informed about the contents of the nine attributes before they started the decision game. The values of the attributes were based on real horticultural locations. The values were hidden from the respondent until the respondent explicitly asked for the information by opening an information cell of the matrix. Figure 1 shows the information board as it was presented to the growers on the workshop. On this information board, 4 information cells were already opened by the respondent. The latest opened cell (4)

| Location\attribute | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 Location A | *1* | | | | | | | | |
| 2 Location B | *2* | * | 3** | 4* | | | | | |
| 3 Location C | | | | | | | | | |
| 4 Location D | | | | | | | | | |
| 5 Location E | | | | | | | | | |
| 6 Location F | | | | | | | | | |
| 7 Location G | | | | | | | | | |

Attribute: Living conditions

Number of accessible information cells: 28

Figure 1    The information board

delivered information about scores of Location B for attribute 3 (living conditions). The respondents were allowed to open a maximum of 32 cells of information. This was done to force the respondents to be selective with the available information (Trip et al., 1994b).

The computer program recorded which cells were opened and in what sequence they were opened. The respondents could make notes about the information in the cells on a preprinted note form.

*From recorded information search patterns to information search and processing strategies*

From each participating grower an information search pattern was recorded by the computer program. In figure 2 an example of such a pattern is given. Grower 5 started his information search by accessing information about the first two attributes (parcel and production circumstances) for all alternatives. This first search activity was attribute-based. After evaluating information for these two attributes, locations 2 and 5 were eliminated. Consulting the notes he made on the note form, it became clear that the elimination was based on bad scores of the eliminated locations on attribute 2.

After this first elimination, grower 5 carried on with accessing information on attributes 3 and 5 (living conditions, labour supply) of (bearly) all remaining alternatives. After this attribute based search, 3 and 7 were eliminated. After this elimination, information on attribute 6 was accessed. The information search was still attribute based. Based on the information found, location 1 was eliminated. At that point, just two alternatives were left, and it seems he had changed the search strategy from attribute-based non-compensatory to alternative-based compensatory search. The locations 4 and 6 were examined in more detail using a compensatory strategy. Finally Grower 5 chose location 4.

Grower 5 made use of two search strategies. He first narrowed down the number of alternative locations by means of non-compensatory strategies (elimination by aspects) until two alternatives were remained. For those two locations, all relevant information was accessed and a definite choice was made by means of compensatory strategies (additive model). The search pattern clearly shows the two phases (screening and trade-off) of decision making, marked by a strategy change.

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      1    2    3    4    5    6    7    8    9
1  *  1**14**15*░░░*23**26*░░░░░░░░░░░░░░░
2  *  2**13*░░░░░░░░░░░░░░░░░░░░░░░░░░░░░
3  *  3**12**18*░░░*22*░░░░░░░░░░░░░░░░░
4  *  4**11**17*░░░*21**24**29**30**31*
5  *  5**10*░░░░░░░░░░░░░░░░░░░░░░░░░░░
6  *  6** 9**16*░░░*20**25**27**28**32*
7  *  7** 8*░░░░░░░*19*░░░░░░░░░░░░░░░░░
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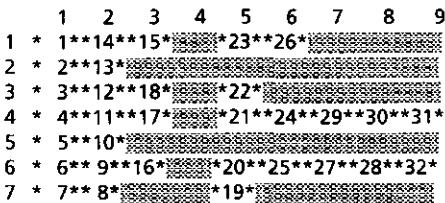
*Figure 2   Recorded search pattern of grower 5*

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All search patterns of the 14 growers were qualitatively examined in the way we describe above. We determined if the growers made use of a screening phase and a trade off phase and we determined which strategies were used in each phase.

Further, the number of locations considered in both phases, the number of attributes accessed and the number of information cells opened in both phases are determined.

## 3.    Results

The results of the analyses of the search patterns are presented in table 2. With the help of the note form, different phases could be distinguished for most patterns and the strategies used in those phases could be determined. However, in two cases the patterns were rather unstructured and no strategies could be determined for each phase (grower 8 and 11).

In general the classification into a screening phase and trade-off phase seemed to be usefull and therefore used in table 2 as a main classification.

*Number of phases*

In almost all cases, more then one phase could be distinguished. In only two cases could no clear distinction be made between phases (grower 2 and 10). Grower 2 came to a decision by using only the Elimination By Aspects strategy, which means that he executed an attribute-based search for all relevant attributes and eliminated those alternatives which scored below the cut-off level.

Grower 10 only made use of the additive strategy. Before he started the game, he first selected the four most important attributes and acquired information (alternative based) on each relevant attribute for all alternative locations. At the end, he selected the alternative with the best overall score.

In five cases, even more than two phases could be distinguished. The first and second phase then could be seen as, respectively, the screening and the trade-off phase In the third phase, information cells were opened in a rather unstructured manner. It is possible the grower has already made a decision and was just opening cells of alternatives he did not choose in order to confirm that he had made the right decision. In one case (grower 6), the trade-off was even interrupted by a phase in which the grower acquired information on alternatives he already had eliminated, probably also to confirm his decisions. After this check, he went on with examining the two alternatives which had passed the screening phase.

The search pattern of grower 14 could be divided into 4 phases. In a first screening, he made use of the EBA strategy. After this first screening, the number of alternatives was reduced further by a conjunctive strategy, and for two remaining alternative locations an additive strategy was executed. After the choice was made, some information cells were opened probably to confirm the choice. So this grower made use of two strategies in the screening phase.

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*Tabel 2    The results of the analyses of the search patterns of 14 growers*

| | | strategies | | | # cells | | # attributes | | # locations | |
|---|---|---|---|---|---|---|---|---|---|---|
| grower | # phases | screen-ing | trade-off | confir-mation | screen-ing | trade-off | screen-ing | trade-off | screen-ing | trade-off |
| 1 | 2 | CONJ | ADD | | 24 | 8 | 4 | 4 | 7 | 3 |
| 2 | 1 | | EBA | | (29) | | (6) | | (7) | |
| 3 | 2 | CONJ | ADD | | 22 | 10 | 4 | 3 | 7 | 4 |
| 4 | 3 | EBA | ADD | CC | 7 | 20 | 1 | 5 | 7 | 4 |
| 5 | 2 | EBA | ADD | | 26 | 6 | 5 | 3 | 7 | 2 |
| 6 | 4 | EBA | ADD ADD | CC | 10 | 7 6 | 2 | 7 | 7 | 2 |
| 7 | 3 | EBA | CONJ | CC | 14 | 9 | 2 | 5 | 7 | 3 |
| 8 | ? | EBA | | | | | | | | |
| 9 | 3 | EBA | ADD | CC | 11 | 11 | 2 | 7 | 7 | 2 |
| 10 | 1 | | ADD | | (30) | | (4) | | (7) | |
| 11 | ? | EBA | | | | | | | | |
| 12 | 2 | EBA | ADD | | 19 | 12 | 4 | 4 | 7 | 3 |
| 13 | 2 | CONJ | ADD | | 21 | 11 | 5 | 4 | 7 | 2 |
| 14 | 4 | EBA CONJ | ADD | CC | 7 12 | 10 | 1 6 | 6 | 7 | 2 |
| Aver-age score* | | | | | 17.3 | 11 | 3.6 | 4.8 | 7 | 2.7 |

*EBA = Elimination By Aspects*            *CONJ= Conjunctive*
*ADD = Additive*                          *CC = Confirmation (provisional) Choice*

*  The scores between brackets are not used to compute the average scores.*

### The screening phase

Except for the two cases in which just one phase could be determined (grower 2&10) in all cases a clear screening phase could be distinguished, including the two which were rather unstructured (grower 8 & 11).

Elimination By Aspects was the most frequently used strategy in the screening phase. Even the search patterns which we could not completely classify first started with an elimination by aspects strategy on one or two attributes. Only 4 growers made use of a conjunctive strategy. Those growers acquired information per alternative on a few relevant attributes and stopped considering an alternative when one of the relevant attributes was below the cut-off level. One grower (grower 14) made use of both EBA and the conjunctive strategy.

In the ten cases in which more then one phase could be distinguished, 17.3 information cells were opened in the screening phase on average. The number of locations considered were reduced from 7 at the beginning to 2.7 at the end of the screening phase on average. On average, 3.6 attributes were taken into account in the screening phase.

*The trade-off phase*

In the trade-off phase, the additive strategy was most used by the growers. Only in one case was conjunctive strategy used in the second phase (grower 7). On average, 11 information cells were opened in the trade-off phase for 2.7 locations. Thus,in the trade-off phase the amount of information per location is higher then in the screening phase, respectively 4.3[1] cells per location in the trade-off phase and 2.4[1] cells per location in the screening phase. The number of attributes of which information was acquired was also higher in the trade-off phase (4.8) in comparison with the screening phase (3.6).

## 4. Discussion and Conclusions

The following general aspects of information search and processing could be distinguished. Findings of other authors (Olshavsky, 1979; Onken et al. 1985; Payne et al., 1993) were confirmed, as most of these patterns showed two distinct phases. In a first phase, the complex problem was simplified by reducing the number of alternatives to consider. This simplification or screening was based on non-compensatory strategies; Elimination By Aspects and the conjunctive strategy. In the second phase, a more detailed examination of the remaining alternatives was carried out. In this phase, the more cognitively demanding strategy (the additive model) was mostly used. Two growers used only one strategy to come to a decision, and no distinct phases could be distinguished in the search patterns of those two growers.

It was remarkable that in some cases growers acquired information on alternatives which already were eliminated. This post-decision behaviour is in accordance with Wierenga & van Raay (1987) who stated that decision makers, in their case consumers, often acquire information to justify decisions which are already made.

The classification of the different patterns to a certain strategy was in some cases rather difficult. The use of the note forms was very helpful to get some more information about how the grower had processed the information and to make the right classification. However, the use of the note form also had an important disadvantage. Because growers could make notes about the information they acquired, it was not necessary for them to process this information immediately. So the sequence in which the information was searched might not always mean that the information was processed in the same sequence.

In the decision game, the growers had to deal with a structured choice problem and they only had to make a choice out of 7 alternative locations. In contrast with this game, real life location decision making processes are rather unstructured, the number of alternatives enormous and the information is not offered in a simple matrix. In a real decision process, the growers first have to figure out which attributes should be taken into account. Moreover, the information is gathered from different sources and the information is often offered per alternative. Therefore, it may be assumed that in real life decisions the in-

formation is searched by alternative followed by an attribute-based processing instead of attribute-based search and processing.

However, it may also be assumed that an initial (pre-attentive) screening of the alternatives is based on information in the grower's memory and this information is probably processed by attribute, making use of non-compensatory strategies to reduce the alternatives to a feasible subset. Hopman et al. (1994) found that in real location decisions of Dutch horticultural growers, the most important attribute on which the number of alternative locations was reduced was the distance from the present location. This screening on one attribute, of which the information is assumed to be present in the grower's memory, can be seen as an attribute-based non-compensatory strategy.

In the experiment with the Location Decision Game, the pre-existing information concerning alternative locations was not used, which also meant different prejudices for locations could not influence the decision, and that all growers had a 'clean' start at the beginning of the decision game. The important influence of these prejudices on the real life decision became clear afterwards, when the growers were told from which location the chosen game location was derived. Some growers were surprised, and said that if they had known the name of the location before they would never have chosen the location.

The use of process tracing methods, in our case a decision game, to examine decision making processes can contribute to increased insight into the information search and processing underlying a decision. However, it should be taken into account that the decision was made in a game situation. To analyse real life decision behaviour, further research is required.

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# MULTI-AGENT MODELS: AN APPROACH TO BE EXPLORED TO IMPROVE INDIVIDUAL DECISION-MAKING AIDS

J.M. Attonaty, G. Pasquier 1)

## Abstract

*This paper is about the use of the multi-actors model to take into account interactions between different actors, to improve individual decision making.*

*Up till now the Grignon management research focused on decision making assistance for a unique actor.*

*But nowadays an actor's decisions are interelated with other actors.*

*We study such a problem in a small county of Ardeche(France). The local leaders want to maintain small farm diversified providing quality products on limited markets. Some resources are limited; besides that some new farming techniques could modify ecological balances and be detrimental to the touristic image. The new regulations issued either by the EU Commission or by the local authorities have an important regional impact.*

*Our first objective is to explicit with the local actors the problems able to occur in this county evolution.*

*We develop a multiactor model which describes the influence of climate and market changes on a set of different actors: farmers, traders, bankers, waters suppliers, regulators.*

*These actors are represented by a frame: an independant agent which include communication protocols, data bases, decision making protocols. The different agents are acting according to a discrete time schedule simulation process. Our former decision models are used, with the actors, to formalise their strategies in reaction to climate and market changes.*

**Key-words** : Agriculture, Individual decision making, Artificial Intelligence, Multi-agents systems, Discrete events simulation.

## 1.    Introduction

Until now, here in Grignon, we have simply approached decision-making aid problems on the level of a single agent by creating methods and tools to amplify dialogue between consultants and farmers.

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Two approaches were used. The first based on the use of knowledge-based models that simulate the development of a process managed by an actor. These models are made up from two sub-models: the process model developed using different techniques (mechanical, statistical, etcetera models) and the management model which calls on Artificial Intelligence based knowledge representation techniques.

The second approach is used in more complex cases or when the knowledge is not well founded or is obsolete. It calls on the use of company game playing principles.

However, very often, the decisions made by an agent have repercussions on other agents: the market might be modified, biological balances undermined, global resources saturated, etcetera.

We examined this problem in a micro-region of the Ardèche (France). The local decision-makers want to retain small, diversified farms providing an acceptable income. To this end, their policy is based on the production of high quality fruit using a sensible irrigation policy.

Our initial aim, alongside the different local agents, is to demonstrate the problems that could potentially occur in the development of this micro-region so as to improve the advice offered to farmers.

In this paper, we successively present:
1.    The characteristics of the micro-region being studied.
2.    An analysis of the region on the basis of the system's principle.
3.    Methodological choices concerning modelling and simulation in accordance with the main hypotheses that we have made.
4.    The chosen model, being the main lines of the generic representational model of an agent and its use in the simulator.
5.    Finally, at this initial research stage, we conclude by presenting the problems already encountered and those that we anticipate.


## 2.    The characteristics of the micro-region being studied

The plateau of the Haut-Vivarais is in the north of the Ardèche region. Its altitude ranges between 200 and 600 metres. It includes 62 districts and covers an area of approximately 87,000 ha, of which 39,000 ha are farmed. In 1988, there were 2,500 farms, 1,800 of which were full-time enterprises. The number has fallen by 22% since 1979, less rapidly than in the rest of the region. This is unquestionably linked to the development of fruit production which began around 1950. Most of the fruit production is based around cherries, apricots and peaches. Orchards cover over 2,000 ha (800 ha of cherry-trees, 700 ha of apricot-trees, 400 ha of peach-trees. The gross product of this fruit production is around 80 million Francs and represents 30 to 40% of the total gross product of the micro-region. The fruit production is essentially distributed by four co-operatives and, to a certain extent, sold on local markets.

The aim of the local decision-makers is to maintain small, diversified farms providing an acceptable income.

Given the economic value of the fruit productions, which have an excellent image both in terms of their intrinsic quality and their origin, the decision-makers envisage increasing the planted land area to 3,000 ha. Increasing the production of high quality fruit is therefore their *initial goal*.

However, the summertime hydric deficit, associated with the low water retention of the soil, makes it impossible to envisage a systematic production of high quality fruit. Consequently, they envisage increasing the irrigated surface area from 1,000 to 3,000 ha with the water supplied from the hill lakes and pumped from the Rhône river. This extension to the irrigated network presupposes major investments to use a rare resource. Thus, making water savings and valorizing its use represents their *second goal*.

In addition, tourism is a considerable resource in the region and the rivers (particularly the Ardèche) play a role in promoting the image of the region. A considerable use of water for irrigation could have an influence on the flow rates of the rivers and the quality of the water. An initial study demonstrated the possibility of irrigation without modifying the flow rates of the rivers, but the problem represented by the influence of the hill lakes on the water quality has not yet been settled. Maintaining water quality is therefore their *third goal*.

## 3. Analysis of the region on the basis of the system's principle

The means of action available to the local decision-makers is limited and, above all, based on incitement: experiments using new techniques, market surveys, definition of specifications, targeting development and consultancy measures. In this particular field, they feel the need to understand the region and its dynamics as a whole and to have the means to monitor its development. One of their concerns is the coherence of individual decisions. They want to avoid situations where decisions, apparently made on an individual basis, lead to individual and overall catastrophes through market saturation or degradation of the physical environment.

The need to take an overall view seems essential if the aid to individual decisions is to be improved. The question is how to take this overall approach, a complex entirety made up from a large number of agents with numerous personal and often contradictory goals, into account.

The system's principle taken in its simplest sense of 'a set of elements in dynamic interaction organized around a goal', provided us with an initial instrument to analyze and represent this complex entirety.

By considering the micro-region as a system, we shall therefore attempt to:
- list the elements included in the system;
- then look at the way it operates by describing the interactions.

## 3.1 The elements included in the system

We were able to distinguish two main categories of agents in this micro-region. The first provides information and constraints and no measures can be taken concerning them:
- the climatic environment;
- the national and international markets;
- those making national and European Union regulations.
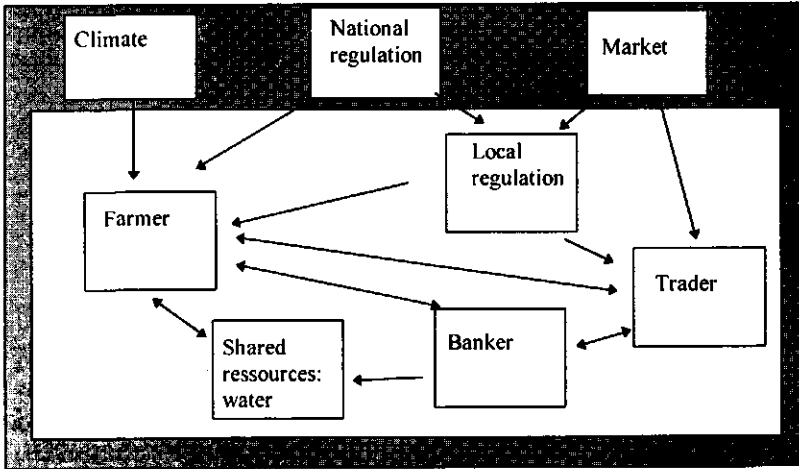


The second is made up from families of local agents:
- farmers who supply products, consume water, borrow and reimburse;
- water suppliers who draw up contracts with farmers, invest, lend and reimburse;
- traders who buy raw products from the farmers and process them, seek out markets and invest;
- bankers who loan and are reimbursed within the framework of their regulations, and who have the capacity of declaring their contractors bankrupt;
- makers of local regulations who can authorize or forbid irrigation, dictate the characteristics of commercialized products for a given year, define specifications corresponding to quality labels.

## 3.2 How the system operates

Having studied the system, we are able to advance three strong hypotheses.
A - he operation of the system is the result of the operational interaction of each of the individual agents.
B - Each agent has, more or less implicitly, a constantly revised action plan that is continuously used to determine the measures he takes. We

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have already had occasion to use this hypothesis in developing decision aid tools for farmers. This allowed us to construct decision aid models based on the representation of knowledge mobilized by a farmer to manage a given process (J.M. Attonaty, L.G. Soler 1991; Chatelin et al. 1994).

| PERIOD | ACTION RULES |
|---|---|
| Flowering | If frost,<br>If frost is average or heavy,<br>Decide to revisit the orchard in a fortnight. |
| Flowering + fortnight | If average or heavy frost on flowering,<br>See condition of buds,<br>If floral buds destroyed,<br>Cancel irrigation water order, Gather information on frost compensation from the administration, Answers awaited towards August. |
| Maturity | Inquire about authorized calibers from the interprofessional organization,<br>Inquire about market prices from processors,<br>Decide on the trader partner to use, Harvest according to regulations,Sell. |
| August | If the floral buds were destroyed during the Spring,<br>If frost compensation was provided,<br>Receive any compensation provided |
| September | Receive payment for the apricots,Make fund estimates,Analyze forecast results in terms of personal goals,<br>If orchard growth is the long term aim,and if the forecast results are satisfactory,and if the funds are satisfactory,<br>Ask for a bank loan. |
| November | If the loan is given,<br>Plant, Update the reimbursement calendar, Make fund forecasts. |
| February | Receive accounting results, Analyze, Review personal goals. |

(*) This action plan is very simplified. It is simply intended to help give an understanding and provided a starting point for discussions with our local contacts.

We examine three types of action:
a - Real and irreversible actions, such as planting an orchard, building a dam, granting a loan.
b - Virtual actions, setting up plans, forecasts.
c - Gathering information from other agents.

As an example, inset 1 shows a highly schematic action plan for an apricot producer(*).
C - The actions of the different agents take place over time which represents a fundamental part of the system.

Apricot producer action plan (*)

## 4. Modelling and simulation

The hypotheses presented in the study of the real system directed the methodological choices presented below.

### 4.1 Choice of a multi-agent model

Multi-agent modelling of a complex phenomenon requires the reproduction of an artificial world that resembles the world observed through the agents comprising it and the interactions that exist between them. We can therefore represent a social system using a collection of individual and co-operative agents: the autonomous agents (Bond and Gasser, 1988).

This presentation of the system in the form of independent agents is reminiscent of the concepts held by the first economists and the pioneers in the field of Artificial Intelligence.

For the former, we are content to simply quote Adam Smith: 'It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest' (Vriend 94).

For the latter, we refer to the organizational hypotheses used for agents as summarized by (Heudin 94).

- The system is made up from a population of autonomous agents (in the sense used for artificial intelligence).
- Each agent defines his responses to events in his local environment and his interactions with the other agents.
- There is no hierarchy between agents.
- There are no rules dictating an overall behaviour.
- All behaviour, ownership or structure on an overall level results from an interaction between agents.

Consequently, we were led towards creating a multi-agent model and using it within the framework of a simulator. This solution makes it possible to provide a representational framework for the different local agents, to formalize and discuss the collected data, validate and question the model, and simulate different development scenarios in collaboration with the local decision-makers.

### 4.2 Hypotheses used in our multi-agent model

Apart from the general Artificial Intelligence hypotheses that we have used, we are led to present a number of definitions and provide a set of simplifying and thus restrictive hypotheses.

- The agent. This definition is taken from Ferber and Gallab, 1988: 'An agent may be considered as a physical or abstract entity able to act on himself and on his environment, communicate with other agents and whose behaviour is the result of his observations, his knowledge and interactions with the other agents'.
- The duration of the actions. All actions considered are instantaneous and do not consume any time.

This hypothesis is not a problem for a decision such as observing the condition of an orchard. For actions which, in the real world, take time, such as a request for a loan, the hypothesis implies that they be broken down into a number of actions: request of a loan from the farmer, receipt of the request from the bank, processing the request, answer, receipt of the answer.

- The risks. Risks (frost, rain, product prices) play a fundamental role in the development of the simulated system. A data base covering climatic and market price conditions for a number of years makes it possible to generate the conditions of the simulated years in an problematical or determinist manner.

## 4.3 Distributed simulation for discrete events

The use of a multi-agent model within the framework of a simulator poses a number of problems. For some authors, such as (Gasser 88; Gasser 92), multi-agent systems provide a modelling method but are far from adequate in making a temporal analysis of the system. Time is a major component in the system being studied. This is why it is necessary to bring together multi-agent modelling and the simulation of discrete events. A large number of publications have, whilst demonstrating the difficulties involved in associating these two systems, also shown that solutions do exist (Guessoum 94; Dado 93). Amongst these, we have chosen distributed simulation for discrete events (Misra & Chandy 81; Misra 86).

In the discrete event simulation model, the simulated system changes the sequential states at fixed dates. However, in a distributed system, events occur at irregular intervals and are not synchronized.

A distributed system is fundamentally parallel.

## 5. Modelling and simulation: setting up the system

Distributed simulation for discrete events for cognitive agents (Labidi and Lejouad, 1993) is therefore the basis for the chosen model. We successively envisage:
- the structure of the generic agent;
- the different types of chosen agents;
- communication between the different agents;
- the controller and the general running of the simulator.

## 5.1 Structure of the generic agent

The generic agent has the components corresponding to the main functions of a cognitive type independent agent: knowledge of his field, communication, a time and activity management plan and a local controller.

Diagram boxes:
- KNOWLEDGE: Digital data; Calculation procedures; Decision procedures
- COMMUNICATIONS: Relations; Structure of messages and contents; Mailbox
- LOCAL CONTROLLER: Internal control; Distributed simulation control
- FORECASTING PLAN
- CURRENT PLAN
- General control
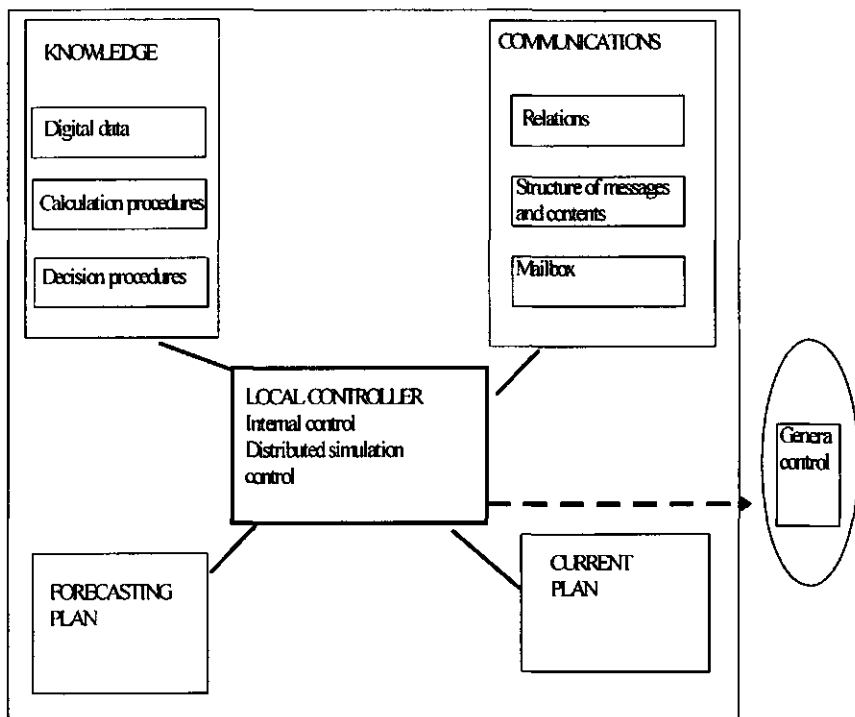
## 5.1.1    Agent's knowledge of his field

This can be broken down into three sections:
- A digital data set. Example for a farmer: surface area and age of planta-tions, indebtedness, funds spent and forecast funds.
- Procedural calculation base:

These calculation procedures correspond to the consequences of actions taken.

Example for a farmer: plant apricot-trees is translated by a calculation defining the increased surface area of planted apricot-trees.
- A base for decision-making procedures:

These take the form of production rules: If <condition>, then <action>.

The conditions are based on data base elements, the agent's internal clock or the messages received by the agent.

The actions are represented by different types of procedures: data updat-ing, calculations and even procedure modifications, these then become meta-procedures. Thus the decision to plant cherry-trees on a fruit-production farm which, until now, has only had apricot-trees, will lead to the introduction of new procedures for monitoring the orchard and a procedural modification to the way the economic result is calculated.

```
Example 1 for a farmer agent :

Data
  Funds (n)              = 85,000
  Apricot surf (10,n)    = 2.5
  Apricot surf (3,n) =   4.2
Calculation procedure
  Forecast funds (n+1)  =  Funds (n) + Revenue (n+1) - Expenditures (n+1) - Investment
(n+1) -
                            reimbursement (n+1)
Decision-making procedure
  If (period = autumn)    ---> forecast funds
```

```
Example 2 for an irrigation body agent

Data
  Total demanded water (m)    =  3,000
  Total available water (m)   =  2,500
Decision-making procedure
  If (Total demanded water (m) > Total available water (m)) -->
  Supplied water (i,m) = Demanded water (i,m) * (Total available water (m) / Total deman-
ded water (m))
```

## 5.1.2    Communications

Each agent knows with whom he can dialogue and how this exchange takes place.

- *Relations:* Each agent knows the agents with whom he must dialogue to obtain information, a loan, sell a product, obtain water. The relations module assembles all this information.
- *Communications:* He also knows how to dialogue. For example, to request a loan, he must provide the bank with a statement of assets and his current annuities.

To this end, we have prepared a message that incorporates elements shared by all messages: origin, destination, date, reply-by date, type (question, answer, information), nature and a specific content giving the nature of message.

There is a limit to the number of message types.

- *Communication protocols:* A protocol makes it possible to establish the attitudes of the agents in the dialogue: number of receiving agents, whether or not the addressed person can reply.

  We have chosen several protocols to cover situations where one or more agents are addressed. In all cases, the addressed agents must answer each question.

- *The mailbox:* Each message is sent to the addressed person's mailbox. It is filed according to the reply-by date so that it can be treated in sufficient time.

```
Example: Message 1
Origin                      : Farmer Smith
Destination                 : Banque Crédit Agricole Privas
Date                        : September
Reply-by date               : November
Type                        : Question
Nature                      : Loan request
Content of loan request
    Amount                  : 120,000
    Nature                  : long term with preferential rate
    Reimbursement per ha :    1,500


Example: Message 2
Origin                      : Banque Crédit Agricole Privas
Destination                 : Farmer Smith
Date                        : November
Reply-by date               : November
Type                        : Answer
Nature                      : Loan request answer
Content of loan request answer
    Amount                  : 0
    Type of loan            : NONE
    Repayment dates         : NONE
```

### 5.1.3   The plan

Each agent contains two plans: the forecasting plan and the current plan.

- *The forecasting plan:* It is the part of the agent's knowledge of the chronology of his actions.
  It is stable and periodically revised.It formalizes the action plan of an agent, as shown in the example in chapter (2.2.2.3). It is made up from a series of production rules based on date <condition> --> <action>.
  Actions are represented by procedures, sending messages, receiving messages, updating the current plan. These rules are filed according to the initiation date.

- *The current plan:* The rules governing the current plan take the same form as those of the forecasting plan.
  These rules are those of the forecasting plan in which the date is that of the local clock and that the conditions have been checked. They are also provided by the mailbox, and the dates given to continue and complete a decision-making procedure requiring interventions from other agents. The rules are transient. Updating and use is carried out by the agent's local controller.

### 5.1.4    The local controller

At the beginning of the simulation, he finds the date of the first rule to be activated in the forecasting plan and notes this on the 'general simulation control' list whose operation is described below.

During the simulation, for the current date (that when the agent is activated in the general control list, which then becomes that of the local clock).

● He incorporates the rules to be activated in the forecasting plan in the current plan and the messages to be handled are read are placed in the mailbox.

He orders and then initiates the rules and handles the messages.The carrying out of the rules leads to their being cleared, but can lead to the introduction of new elements in the current plan.

● If he sends a message to another agent, he checks on the 'general control' list that this agent will be activated, at the latest, by the reply-by date contained in the message.

● Finally, he examines the forecasting plan and the mailbox to establish its next activation date. He writes this date into the 'general control' list and deactivates.

### 5.2    The different types of agents

The generic agent will make it possible to generate, using the heritage technique of object languages, a whole series of agent types: Farmer, Financier, Water supplier, Rule maker, Climate, Market.

Each type has its knowledge of its field structured in a unique manner in compliance with the generic agent.

On the basis of each type, we instanciate a set of individualized agents in accordance with their digital data.



GENERIC AGENT

Farmer    Bankers    Traders    Shared ressources    Environment    Rules maker

Type 1    Type 2    Type 4    CM    Coop    Market    Wate    Vivar    locaux    rational
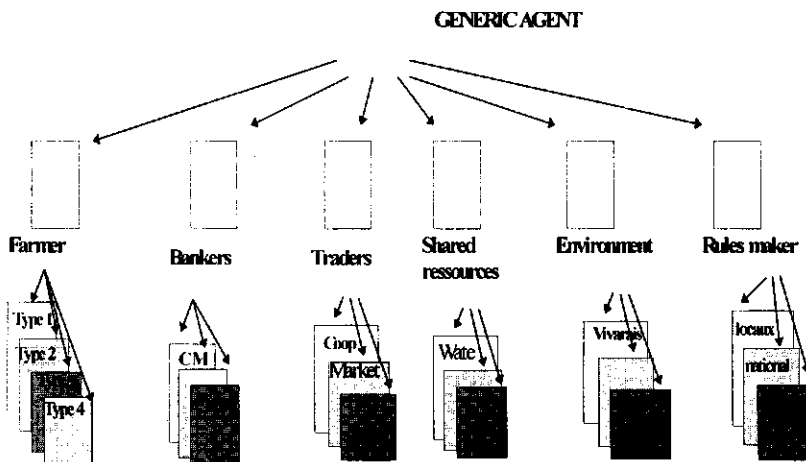
## 5.3    The controller and the general running of the simulator

The general controller has a chronologically classified list of agents to activate. It contains the current date and an activation procedure for the agents.

Prior to any simulation, the agent types and agents are instanciated and the procedural bases, forecasting plans and data are created.

For a simulation, the Environment agents and the Market data are completed in a random manner or by a choice of observed chronological series.

On starting up the simulation:

Each agent initiates his current plan and informs the general controller of the first date it was activated.

Until the final date:

The general controller uses the chronologically organized list of agents to be activated and activates those agents on the closest possible date.
- Each activated agent carries out the procedures of that date.
- Where messages are sent to another agent, he informs the general controller of the dates on which the answers should be given.
- At the end of the activation, he informs the general controller of his next activation date.


## 6.    State of research and prospects

A model, whether or not computerized, has for some time appeared to us to be an instrument able to improve dialogue between a consultant and a farmer. Given the demand of regional decision-makers, we are trying to develop this system by constructing a model to simulate different scenarios and give the different decision-makers time to think and dialogue prior to making decisions.

The research progress made in the field of multi-agent models and distributed simulation have allowed us to lay out the main lines for an adapted simulator. However, we are only at the conceptual analysis stage and certain elements have not yet been entirely specified. We must now analyze the implementation possibilities of this model on a standard micro computer and choose a standard programming language to develop a prototype.

The definition of the generic agent has already given us the required data collection grid. In addition, models previously used for strategic decision-making aids have provided us with frameworks to compile information and the interactive means to collect decision-making rules. It is still necessary to define an information collection process to complete the information already obtained. We can thus, in the near future, envisage experimenting with a simple model based on real data.

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However, a large number of questions still need to be answered. These include:

* The contents of a agent's knowledge needs to be refined. As this is a multi-agent model, a possible approach consists in defining a agent through those that are in relation with this agent. This would give their understanding of the agent through a definition of the elements necessary for them to understand him and carry out a dialogue with him.
* Typology. It is out of the question to list an agent for each physical agent. This is why they are grouped into a number of types. How to choose these types? The typologies already defined are based on standard criteria such as structure, age, etcetera but our model gives great importance to the decision-making rules and, more generally, to the piloting model. How can we enrich the typology by taking these elements into consideration?
* The problem of changing scale represents the hidden side of this problem: how, with the results of a model that only includes a few agent types and a limited number of agents, to extrapolate on a micro-region level? Is it even worth doing or should we simply be content with the trends shown by the model and use the quantitative results in a qualitative manner?
* How to use the model with the decision-makers to create a dialogue, make questioning easier and lead to collective mutual apprenticeship? The way the model is used can lead to conflict situations, coalitions, refusals and exclusions. These problems should be envisaged prior to the first work session as the failure of a first meeting could lead to the research being aborted.
* Certain aspects of the project have not yet been looked into. This is the case of the interfaces and the dynamic restitution of the simulation, the computerized and social verification and validation of the model and the obtained results, as well as the enrichment of the model on the basis of the results.
* Another fundamental problem is to construct a method to analyze the reasons for the development of the simulated system (blockages, development of a collective behaviour pattern, etcetera) and to find the origins in the modelling or the available knowledge.

Generally speaking, this research calls on wide-ranging and specialized knowledge covering artificial intelligence and computers through to human relations and knowing how to run a group.

An international research programme would certainly be profitable in bringing researchers with different competences and who are interested by

both the theoretical and practical aspects of this approach, together around the theme of collective decision aids.

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# BUSINESS GOALS AND FIRM RESULTS OF CHRYSANTHEMUM GROWERS

G. Trip, R.B.M. Huirne & J.A. Renkema 1)

## Abstract

Defining business goals is often mentioned as an essential part of the management process. Goals are needed to serve as practical guidelines in the management process of planning, implementing and evaluating decisions. This paper describes results derived from 26 chrysanthemum growers, focussed on two tasks: (1) consistency of growers over time in choosing goals from a given list and (2) their ability to decompose a general goal (profit maximization in cultivar choice) into specific goals. Finally, the results were compared with the actual financial result of their firm.

It turns out that the growers are only consistent over time to a small degree (average Spearman rank correlation +0.32), but they are fairly well in decomposing a general goal (on average 8.5 specific goals were mentioned). The results of both tasks are somewhat correlated (Pearsonian correlation +0.40). The first task shows no correlation at all with the actual firm results, the second shows a small positive correlation (Pearsonian correlation +0.30). These results are preliminary; more tasks that have been performed by the same group will be analysed and described in forthcoming research.

**Key-words** : management, goals, firm results, horticulture.

## 1. Introduction

Many books and articles on business economics have stressed the importance of management as an important factor for success. Farm businesses are no exception to this rule. Differences in physical and financial yield between farmers operating under the same conditions must be attributed to differences in management (Kay et al., 1994). Management can be described as decision making in order to reach certain established goals. The existence of goals is crucial for every business. As Kay (ibidem: p.12) puts it: 'Goal attainment is the engine that drives management. Without goals, the business has no direction and goes nowhere.'

The main interest of this paper is to see if individual entrepreneurs (26 chrysanthemum growers) are consistent over time with respect to their goals

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and if they are able to decompose a general goal (profit maximization) into specific goals. Two tasks were presented to the growers. The first, performed twice, consisted of choosing the *critical success factors* for their firms. In the second task growers were asked to mention as many relevant factors as possible in comparing (two) cultivars in the case of profit maximization. In scoring this task a *value tree* was used. Finally, the results of these tasks are compared with the actual financial result of the firms. First, however, the two main functions of defining goals are presented.

These results are preliminary; more tasks that have been performed by the same group will be analysed and described in forthcoming research.

## 2. Hierarchy in goals

Several authors indicate a hierarchy in business goals. Starting point for every business should be some kind of a mission or an entrepreneurial *vision* of a desirable image of the future (Noell, 1994). In order to realize this vision, strategic thinking is needed, which is 'a way of thinking about how to reach future states and competitive advantages' (ibidem: p.123). The product of such thinking should be general (or strategic, fundamental or higher-level) goals (or objectives). The second phase is to translate these general goals into specific (or operational, detailed or lower-level) goals. Each step in the hierarchic system (see figure 1) can either be seen as a goal in itself or as a means for accomplishing a higher level goal (Clemen, 1991: p.434). So, every goal can be seen as a means and every means can be seen as a goal. The hierarchy can be elaborated almost *ad infinitum:* there is always a more fundamental goal to be found at the top, and there are always more specific goals to be found at the bottom. This theoretical finding has important implications for research focussed on goals held by entrepreneurs. For instance, if an entrepreneur chooses goal S, which is very specific, it does not imply that he is not interested in goal G, the more general goal. He may have a practical attitude and see the connection between S and G. Another entrepreneur who chooses the general goal G may still be interested in accomplishing goal S (as a means to accomplish G). So, although they choose different goals, the difference between them is merely optical illusion.

The exact borders between the steps in the hierarchy are not so important for the actual management in business practice. Important in order to make a (business) operation successful is that (1) goals are *motivating* for all the people involved in the business and (2) goals can serve as *practical guidelines* in the management process of planning, implementing and evaluating decisions. These are the two main functions of defining goals.

Specific requirements of goals and goal-definition can be seen in the light of these two basic functions. In order to create motivation as well as consensus among the people involved it is useful to start at a high level in the hierarchy of goals. Keeney (1988: p.466) stresses the importance of focusing on values - 'a form of constraint-free thinking about what you wish to achieve or what you wish to have' - before just comparing alternatives on the basis of opera-
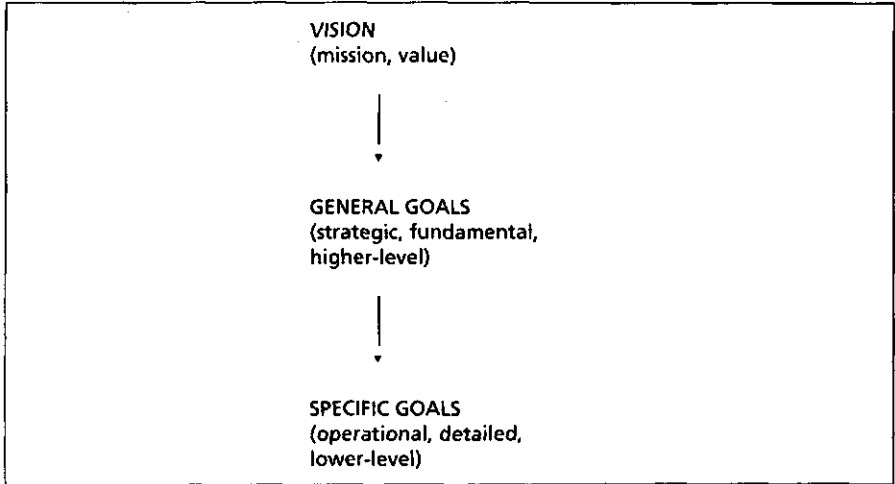
```
┌─────────────────────────────────────────────────────────────────┐
│                    VISION                                         │
│                    (mission, value)                               │
│                                                                   │
│                         │                                         │
│                         ▼                                         │
│                                                                   │
│                    GENERAL GOALS                                  │
│                    (strategic, fundamental,                       │
│                    higher-level)                                  │
│                                                                   │
│                         │                                         │
│                         ▼                                         │
│                                                                   │
│                    SPECIFIC GOALS                                 │
│                    (operational, detailed,                        │
│                    lower-level)                                   │
└─────────────────────────────────────────────────────────────────┘
```

*Figure 1   Hierarchy in business goals*

tional goals. Other suggestions for keeping up motivation are given by Castle et al. (1987) who recommend a mix of easy and hard to accomplish goals: 'accomplishing the easy goals will give you encouragement and incentive to tackle the more difficult ones' and also to be flexible: 'as conditions change and you learn more about yourself and your capabilities, be ready to revise your goals' (ibidem; p.11).

Kay and Edwards (1994: pp. 9-10) give the following four characteristics of (operational) goals, which can be read as requirements to make them useable as practical guidelines in the management process. Goals should be written, specific, measurable and have a timetable (with deadline).

## 3.    Methods of eliciting goals

In measuring goals and values basically two ways can be followed (Wilson et al., 1966, cited in Mitchell, 1969). The first, commonly used method is to directly ask respondents and draw conclusions from their verbal or written answers. This method varies among studies with respect to the nature of the questions (closed versus open) and the scale used for measuring. The second, rarely used, method tries to draw conclusions on goals and values via the observed behaviour of a decision maker.

In this paper the first, direct, method is applied to a group of 26 Dutch chrysanthemum growers. They were asked to complete several worksheets on different moments in time during one year (November 1993 till November 1994). Some worksheets consisted of closed questions, others of open ques-

tions. Attention is paid to the consistency over time and the ability of growers to formulate goals and strategies in open questions.

Finally, the abilities of the growers towards goal definition are related to the economic performance of their firms, in order to answer the main research question of this paper: do growers with clear and consistent goals get better results.

## 4.    Critical success factors

The concept of critical success factors (CSF) is a way to communicate with entrepreneurs about how to reach their goals. It says that although all decisions on the firm may be important and usually have to be made in connection, some decisions are extremely critical in reaching the entrepreneur's goals. These decisions, so called critical success factors, can be seen as the crucial means to accomplish (general) goals or as specific goals themselves. Anyway, they need extra attention in the management process. The entrepreneur can use these factors for instance as a basis for defining his information needs (Rockart, 1979).

Critical success factors reflect the personal strategy on how to reach personal goals. Critical success factors will depend on the situation in which the firm operates (the internal and external environment of the firm), the (general) goals of the entrepreneur and his personal strategy. In this research 26 chrysanthemum growers were asked twice (November 1993 and, one year later, November 1994) to score (on a scale from 1 to 5) and to choose their personal CSF from a given list; see table 1. The first time each respondent was asked to add three other critical success factors, relevant for his situation. 11 growers succeeded in adding three factors, 12 added two factors, 3 added only one factor. These other critical success factors show a broad range, from 'cost control' to 'having a good mood'.

Choice of personnel as a possible critical success factor has become more important during the year (a rise from 3.9 to 4.3 on a scale from 1 to 5; see table 1), whereas the decision to reinvest (at the right time) loses importance (a fall from 4.2 to 3.6). The other decisions keep their relative position during the year. Most important are: climate control, production planning, control light and dark, cultivar choice and the firm layout, less important are: water supply system, fertilizer supply, disease control and plant density.

The (Pearsonian) correlation coefficient of the average scores between November 1993 and November 1994 is +0.65; the (Spearman) rank correlation +0.77, calculated from table 1. However, on an individual level the correlations are much lower, on average +0.32 (Spearman rank correlation), in some (three) cases even slightly negative. A negative correlation means that the grower involved has inconsistent preferences over time: a factor ranked relatively high (low) in the past tends to get a relatively low (high) position after one year. A low, yet positive, correlation means that in general the grower tends to rank the factors in the same order, however there are quite some deviations from this general pattern; this turns out to be the case for the majority of the

growers (18 cases in which the Spearman correlation is between 0 and 0.50). Only five growers are reasonably consistent over time; their Spearman correlation coefficient lies above 0.50.

Table 1    Average scores and ranking of possible critical success factors of 26 chrysanthemum growers; Likert-type scale 1-5 (unimportant-very important)

| Critical success factor | November 1993 | | November 1994 | |
|---|---|---|---|---|
| | score | rank | score | rank |
| Climate control | 4.6 | 1 | 4.6 | 1 |
| Production planning | 4.5 | 2 | 4.5 | 2/3 |
| Control light and dark | 4.5 | 3 | 4.5 | 2/3 |
| Cultivar choice | 4.4 | 4 | 4.3 | 4 |
| Firm layout | 4.2 | 5/6 | 4.3 | 5/6 |
| Reinvestment (greenhouses etc.) | 4.2 | 5/6 | 3.6 | 11 |
| Plant density | 4.1 | 7 | 4.0 | 7 |
| Fertilizer supply | 4.0 | 8 | 3.9 | 8/9/10 |
| Choice of personnel | 3.9 | 9 | 4.3 | 5/6 |
| Disease control | 3.8 | 10 | 3.9 | 8/9/10 |
| Water supply system | 3.4 | 11 | 3.9 | 8/9/10 |

It is interesting to look whether the consistent growers performed better (i.e. have better financial results) during this year than their less consistent, or inconsistent colleagues. Gross returns per year on each firm were available for measuring the performance (and unfortunately no reliable information on costs was available). In order to make it a fair comparison, though, the level of gross returns has been adjusted for relevant differences in the firm structure. By means of a regression analysis (based on the figures of 26 firms) a normative level of gross returns has been calculated: high for modern, well-equipped firms and low for older firms. The financial performance was then defined as the ratio of the real and the normative level (Trip et al., in preparation).

Surprisingly, there was no relation between the level of consistency in ranking critical success factors (measured by the Spearman rank correlation) and the level of financial performance ($R = -0.03$).

## 5.    The value tree for choosing chrysanthemum cultivars

A so-called value tree (or objectives hierarchy) is a useful instrument in solving choice problems. The branches of a value tree connect the general goal(s) of the problem with the specific goals. It can be seen as an elaboration of the goal hierarchy (figure 1). Figure 2 shows an example of a value tree for comparing chrysanthemum cultivars (i.e. varieties). The general objective is maximizing the profit (per year), given the firm's production structure, i.e. given the fixed costs of production. Profit depends on the selling price, the

quantity to sell and the level of variable costs. The quantity to sell depends on the plant density, the waste and the length of a production cycle (which is almost the same as the growing time of the plants). This decomposition of profit into five components can be seen in the left part of the value tree. At the end (right part) of the tree these five components are 'explained' by physical attributes of cultivars. For instance, the waste in production of a specific cultivar depends on the rate of experience with it (is there much knowledge on how to grow it?), the disease rate (is this cultivar susceptible to various kinds of insects, viruses, bacteria or fungi?) and the plant density in relation to the plant size. These end-attributes can be seen as the most specific (or lowest-level) goals: choose the cultivar with the smallest size, the largest experience, the smallest disease rate, etcetera.

According to Clemen (1991) a value tree should meet five criteria: complete, as small as possible, attributes at the ends must be operational and provide an easy way to measure the performance, not redundant, decomposed as far as possible. Following these rules figure 2 was built and presented separately to three experts in the area of chrysanthemum research and extension. They added two attributes 'density/size' and 'energy (temperature)' and also pointed out some other goals (e.g. low risk) and restrictions (e.g. some growers are allergic to pollen) that may be important in comparing cultivars. Finally they gave points to reflect their opinions on how important each attribute is in comparing cultivars in order to choose the best. The average weights given by these experts are presented in figure 2; at each branching 100 points are divided.

| | | |
|---|---|---|
| - plant density ---<br>**17** | - plant size | **100** |
| - waste ------------<br>**7** | - experience<br>- disease rate<br>- density/size | **22**<br>**48**<br>**30** |
| - growing time ---<br>**18** | - generative growth<br>- uniformity in flowering | **62**<br>**38** |
| profit -------- | | |
| - price --------------<br>**37** | - market changes<br>- fragility<br>- appearance | **68**<br>**9**<br>**23** |
| - variable costs ---<br>**21** | - harvest labour<br>- chemicals<br>- license-costs<br>- energy (temperature) | **55**<br>**13**<br>**24**<br>**8** |

Figure 2 Value tree for comparing cultivars; average weights given by experts

The weight of a specific attribute will basically depend on three factors: its economic relevance, the degree to which it can be predicted and the degree of variation it shows between cultivars. The final weight of attributes at the top end of the tree can be calculated by multiplication, e.g. the relative weight of the attribute 'market changes' is 0.37*68 = 25. Table 2 shows these relative weights.

Table 2    List of attributes for comparing cultivars, ordered to their relative importance

| Rank | Attribute | Relative weight |
|------|-----------|-----------------|
| 1. | Market changes | 25 |
| 2. | Plant size | 17 |
| 3. | Harvest labour | 12 |
| 4. | Generative growth | 11 |
| 5. | Appearance | 8 |
| 6. | Uniformity in flowering | 7 |
| 7. | License-costs | 5 |
| 8/10. | Disease rate | 3 |
| | Fragility | 3 |
| | Chemicals | 3 |
| 11/13. | Experience | 2 |
| | Density/size | 2 |
| | Energy (temperature) | 2 |
| | Total | 100 |

This theoretic value tree was used as an instrument to test growers: (1) do they know the relevant aspects of the cultivar-choice problem and (2) are they able to translate a general goal into specific goals? Being able to build a value tree may be an important step in the management process, because it requires careful consideration of what is important for the decision and it helps to translate a broad objective into smaller objectives that can be measured (Winterfeldt and Edwards, 1986). This ability was tested by asking growers to individually perform the following task. 'Advise grower Chris who is looking for a new cultivar, which will be either cultivar P or Q. Chris wants to maximize his financial result. Advice him by *mentioning as many factors as possible that are relevant* in comparing cultivar P with Q.' In order to give an idea of what was expected in this task, one factor was given, namely the attribute 'reaction time' which is common language for the length of the 'generative growth' period. The growers were given about five minutes for this task, which means that there was no time for careful consideration. However, since cultivar choice is a problem that they were all familiar with at their firms, consideration should have happened in earlier occasions and they now could show the fruits of it.

In scoring the answers the value tree of figure 3 was used, which is a further elaboration of figure 2. After investigating the answers to the task three more end-attributes were added because they seem relevant as well: 'vegeta-

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tive growth', '% highest quality' and 'other labour'. Other changes from figure 2 were the elimination of the attribute 'density/size' (being redundant with 'plant size') and the combination of 'energy (temperature)' and 'license-costs' into one attribute 'other costs'. The amount of points (the numbers in the figure) given for mentioning a specific end-attribute (the right-end of the tree) is roughly based on the relative importance given to it by the experts (table 2).

Moving from a general attribute to its more specific subattributes, i.e. from left to right in the tree, the following rules are applied for scoring. Let X denote the amount of points for the general attribute and $Y_1, Y_2, Y_3, ...$ the points given to the subattributes at the next level of the tree, then: $X \geq Y_i$ for all i (preferably $X > Y_i$ for all i) and $1 < \sum Y_i / X \leq 2$ (preferably $\sum Y_i / X \approx 1.5$). These rules ensure that the reward for mentioning a general attribute is higher than mentioning just one of its specific subattributes, however mentioning all its subattributes is rewarded higher than just mentioning the general attribute. The turning point is at mentioning about two third of the subattributes. In order to avoid rewarding redundancy total scores are counted from right to left in the value tree in such a way that points for mentioning general attributes are only given in so far they do not exceed points already given for subattributes. This leads to a maximum score of 22 points (20 points for the 14



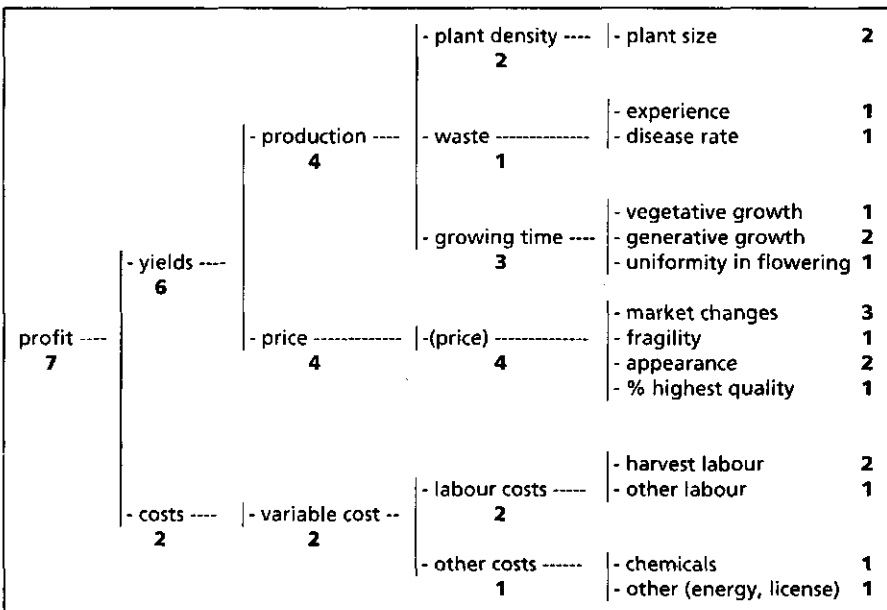Figure 3   Value tree for comparing cultivars; points used for scoring growers in a task
Other attributes not directly related to profit:
availability high quality of young plants, production throughout the year, compatible with other cultivars, compatible with firm structure (modernity, assimilation lamps), low risk, ecologically sound, low pollen count (in case of allergy), suitable for painting          **(max 2)**

profit-related attributes at the right end of the tree and 2 points for attributes not (directly) related to profit - see figure 3).

The average number of factors given by growers in this task is 9.5 (1 factor was given in advance, 8.5 factors were added). The average score is 11.7, ranging from 7 till 15, the majority (17 out of 26 growers) scoring in the range 10-12.

Again the individual scores were compared with the financial firm performance to see if they were (positively) correlated. This time a small correlation (R =+0.30) was the result. This means that in a (one-sided) test the hypothesis of no correlation can be rejected with a possible chance of being wrong of 0.07.

This task also seems to be positively correlated with the previously described task (measuring consistency in stated critical success factors): R = +0.40.

## 6.    Conclusion and discussion

Though often mentioned as an essential part in the management process, it is hard to show the impact of goal definition. In this paper two tasks were presented to measure capabilities of entrepreneurs in goal definition. The first task consisted of choosing critical success factors at different moments, to see whether or not the entrepreneur was consistent over time. The results of this task (i.e. the rate of consistency) had no correlation at all with the actual financial firm result. The second task consisted of decomposing the general goal of profit maximization into specific goals. Now the results showed a positive, yet small, correlation (+0.30) with the financial firm result.

There are several explanations for the lack of (high) correlation. First, it must be kept in mind that goal definition is only part of the management process of planning, implementing and evaluating decisions and, furthermore, these tasks only deal with a certain aspect (consistency in task 1) or a specific (although important) problem (cultivar choice in task 2). Second, the contents of the tasks or the way in which they were performed may be invalid for measuring the real *goal performance* of an entrepreneur, e.g. consistency (in the first task) may be not only a virtue, but also a sign of limited vision. Also the fact that there was no money incentive may have played a role. Finally, the importance of goal definition may be overrated.

In future research more empirical material will be analysed to see what aspects of defining business goals are important for entrepreneurs.

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# EDINBURGH STUDY OF FARM DECISION-MAKING ON FARMS MODELLING THE RELATIONSHIP BETWEEN PERSONAL CHARACTERISTICS, RELATIONSHIP BETWEEN FARMERS' ATTITUDES AND BEHAVIOUR: A MODEL OF FARMER STRESS

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G. Gibson 4), R. Grieve 2)

## Abstract

*This paper formulates a model of farming stress in which individual personality and coping triats affect farming behaviour. Structural equation modelling is used to test the adequacy of the models of stress on farm decision-making behaviour.*

**Key-words** : Farmers; Stress, Traits, Attitudes; Structural Equation Modelling.

## 1.    Stress & Coping

Recent publicity has highlighted the stressful nature of farming and the increased number of farming suicides (Sunday Times Nov 1st 1993). This paper focuses on the problems of farming stress and its relationship to personality, using some of the data available from this study (EFDMS) to investigate a model of stressed behaviour in farming.

There is a long history of research on health and personality. It is thought that personality traits and situational factors combine in such a way that some individuals construe their physical symptoms to be a problem requiring medical attention while others with identical or more severe symptoms do not. Personality types have been linked to heart disease (Freidman & Rosenman 1974), cancer (Krantz & Glass 1984) and a number of conditions where no pre-existing

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medical condition has been found, these latter symptoms are then labelled psychosomatic.

One of the strongest personality traits is that of anxiety-neuroticism and the concept of anxiety related to that of stress has resulted in a large body of clinical research (Krantz et al. 1985). Anxiety is defined as feelings of uncertainty and helplessness in the face of danger; therefore by using the personality trait of neuroticism it is possible to study the relationships involved in stressed behaviour. The main component of stress is helplessness leading to depression, anxiety and psychosomatic illness. Stress is used to explain not just a variety of illnesses but also other failings. Pessimistic explanatory style in children is associated with poorer grades, poorer athletic performance and low morale, and a pessimistic explanatory style in early adulthood is a risk factor for poor health in middle and late adulthood. Therefore a pessimistic attitude may be a contributing factor to stressed behaviour.

Everyone has stressful periods in their lives but not everyone produces debilitating symptoms. An important mediating factor in dealing with stress is the coping style adopted by the individual.

There is evidence for both stability and variability in the methods individuals use to cope with stressful situations and that coping appears strongly related to the situation (Pearlin et al. 1981, Folkman et al. 1986). A number of coping methods can be described, these are avoidance, distraction, emotion-focused and task-oriented coping. Examples of these might include, doing nothing, going to the cinema, crying or just tackling the problem. Task oriented coping is recognised as the most useful method of coping (Folkman et al. 1986, Endler & Magnusson 1990). Coping stratregies are likely to be an important element in any model of stressed behaviour.

## 2.    Traits

The Edinburgh Farming Decision-Making Study (EFDMS) has chosen to model decision-making on family farms by taking a more general approach. Many aspects of behaviour are explained by assuming that an individual is predisposed to act in a specific way because of the attitudes they hold, or because of their type of personality. This tendency to behave in a predictable manner is described as a stable disposition to act in this way, or a personality trait.

Traits are identified by statistical analysis of questionnaire items. Factor analysis assumes that behaviours that function together are related to one another. This process of analysis leads to 'factors' called, in this case, traits. These are named in terms of the characteristics that dominate them. The most commonly measured personality traits are labelled according to their factor analysis; these are; extraversion- introversion; agreeableness-disagreeableness; conscientiousness - unreliablity; neuroticism- calm; and open to-closed to new ideas (Costa & McCrae 1992).

Attitude traits are just as easily recognised in all areas of human life, French farmers confront their government over subsidies; in the UK an animal protester dies to stop veal calves going for export etcetera. Attitudes are

thought to motivate behaviour and exert a selective influence at various stages of information processing that is, through attention, perception, retrieval (Allport 1935, Asch 1952).

By aggregation and generalising attitude items we can, as in personality traits predict that *on average* an individual exhibiting a specific trait will *in general* behave in a predictable manner (Fishbein & Ajzen 1975).

Unlike personality trait theory where factor analysis was used to empirically derive the personality 'types'; attitudinal theory offers prediction through the expectancy - value model of relationships. The theory of reasoned action indicates that the intention to act is the best predictor of behaviour in conjunction with belief and attitude. Intention is another psychological construct distinct from attitude which represents motivation or goal directed behaviour. Attitudes accounted for in this model are those towards the behaviour and also what is termed the subjective norm, that is, how significant others influenced the intention to act. The following equation states that people are rational and will behave in a way that will produce 'good' outcomes for the individual, and further, this will be with the approval of other people whom they respect.

$$B \quad BI = w_1 A_B + w_2 SN$$

where B is behaviour; BI behavioural Intention; $A_B$ is the attitude toward the behavioural act; SN is the subjective norm; and $w_1$ and $w_2$ are empirical weights indicating the relative importance of the first and second terms.

It is important to aggregate attitude relevant measures of behaviour just as it is to aggregate attitude relevant areas when assessing an attitude. Fishbein & Ajzen (1975) have shown that if this is followed moderately high correlations can be obtained.

The above model resembles the utility models used in economic theory (Arrow 1951). The theory states that behavioural intentions have a utility and this utility is the sum of the products of the likliehoods and values of the various outcomes aligned to each of the alternatives. Like the utility model, this often fails to account for the heuristics used as well as the variety of variables affecting the individual decisions makers. Research indicates that the above model can be improved by the inclusion of moral values, past experience (Gorsuch & Ortberg 1983, Beck & Ajzen 1991, Bentler & Speckart 1979, Fredricks & Dossett 1983). The role of intention in the model has been questioned as past experience explained *more of the variance than did intention* (Bentler & Speckart 1979).

Because of the inadequacies of the theory there is a need to move attitude research away from hypothesis testing in the first instance, and measure empirically as many variables as possible. Factor analysis and rotation is the best method for deriving the traits, but the items must be valid and reliable as well as having a normal distribution in the population (Klein 1993). However, is no current method of measuring more than one attitude at a time i.e. it is highly unlikely that a single attitude affects behaviour. It is more likely that an attitude is held as a resultant imbalance between other attitudes and this is most likely to be observed at particular times in farming, due to legislation etcetera

for instance having a positive attitude towards a conservation organisation and environmental grants and this is be held in congruence with an attitude towards intensive farming and profit.

## 3.     Structural Equation Modelling

Once traits are established the econometric approach and the psychometric approach can meet in structural equation modelling where the covariances among there factor structures can form the starting point of hypothesis testing. Causal theory for the data can be specified and tested, while latent variables can be postulated to account for the causality. Structural equation modelling can be used when there are significant correlations or covariance among the variables, where there is a minimum of five subjects to each of the variables and the results of the factor analysis are normally distributed within the population and the population studied exceeds 150. Models are said to fit well when the covariance matrix is reproduced as closely as possible and the maximum likelihood function is a good a fit as possible.

## 4.     Methodology

The objective of this paper is to show that structural equation modelling can be used to combine knowledge of an individual farmers traits and coping strategies in a model of stressed behaviour. The data used in the nalysis were drawn from a larger database collected as part of the Ediburgh Study of Farm Decision Making on Farms (ESDMF). The study surveyed 253 east coast of Scotland farmers participated in this study (243 males, 10 females). These were selected randomly from two stratas - less favoured area sheep and cattle and intensive arable farms. The average age was 48.4 years, and average number of years in education was 12.2 years. Farm size ranged from 30 acres to 9,667 acres. Data was collected between February and June 1994 using a combination of a number of questionnaires developed specifically for the study or in established usage. The following were used in this study.

The Edinburgh Farming Enterprise Scale (EFES) to define the demographic characteristics of the farmer, farm and business information.
The Edinburgh Farming Implementation Scale (EFIS) determined farm behaviour.
The Edinburgh Farming Attitudes Scale(EFAS) assessed farming attitudes
The standard questionnaires used in the study were as follows:
NEO (Costa & McCrae 1992), measured the five personality traits
Raven's Standard Progressive Matrices, (Raven et al. 1992) measured cognitive ability
National Aptitude for Reading Test (NART), (Nelson 1982) measured crystallised cognitive ability.
General Health Questionnaire (GHQ) Goldberg & Williams (1988), measured psychological distress. Coping in a Stressful Situation (CISS) (Endler & Parker1980) measured theCoping style.

### 5. Analysis of Stress variables

The scale measuring farmers attitudes (EFAS) was investigated by Principal Component Analysis (PCA) and factor analysis. This analysis factored out seven important attitudes, one of these was an attitude of pessimism regarding the future of farming. This attitude was defined by the following questions (signs indicate the direction of the attitude):

*It would be nice to give up farming.  +*
*Farming is satisfying.  -*
*Young people should not be encouraged to farm  -*
*Farmers get lots of support from friends and family.  +*
*Farmers generally enjoy their job.  -*
*Farmers in Britain are demoralised.  +*
*Other employment would be better than farming.  +*
*Farming is depressing.  -*
*Farmers should keep themselves to themselves.  +*
*Prices of crops and stock are bound to fall in the future.  +*
*Farming is a job with a lot of scope to do things your own way.*

These questions when summed, give a measure of farmers' **general** level of pessimism with farming, not each farmer's own specific situation. The pessimistic attitude factor had a significant correlation with reported farming behaviour from one factor of the EFIS scale - stressed behaviour. Stressed behaviour was reported as:-

*Is it difficult to meet your farm business/financial commitments? +*
*Is it difficult to meet your personal financial commitments? +*
*Is it easy to manage the farm business to suit yourself? +*
*Has farm business debt changed in the last five years? +*
*Is it difficult to find time to meet friends and family? +*

There were a number of large and highly significant correlations between psychological variables, the pessimistic attitude and stressed behaviour factors. Five scales related to different aspects of stress were found to be significantly intercorrelated. These were;

♦ EFAS pessimism.
♦ EFIS Stressed behaviour.
♦ Neuroticism this scale was measured using the NEO Five factor Personality Inventory (NEO) which provides a good measure of a general, life long tendency toward negative emotions.
♦ Emotion-Focused Coping this is a scale derived from the Coping Inventory for Stressful Situations (CISS). which assesses the degree to which a person reacts to stress by experiencing and expressing negative emotions.
♦ General Health Questionnaire (GHQ) this measures recently experienced psychological distress.
The correlations are shown in table 1.

## 6.    Model of Stress

A structural equation modelling approach was used to confirm the causal direction among the five variables identified above. The computer programme used was EQS (Bentler 1989) and this was run on a 486 computer.

The initial model tested hypothesised that neuroticism was the antecedent variable, pessimistic attitude and the emotion oriented coping were mediating variables; and stressed behaviour and psychological distress were outcome variables. This transactional model did not fit the data very well.

This model was modified and it was assumed neuroticism had an effect on a pessimistic attitude, psychological distress and emotion focused coping leading to stressed behaviour. This model proved a better fit. The goodness of fit is shown by the amount of shared variance that is accounted for by the model. Goodness of fit criterion are met when the chi-squared index is non significant and the Bentler-Bonnet and Comparative fit indices are greater than 0.9. Models which obtain reasonable values across numerous indices warrant more confidence than those which show a more mixed result. A summary of the fit statistics is given below (figure 1). This model indicates that the personality trait of neuroticism has a direct effect on the amount of distress experienced, the type of coping strategy used and the amount of reported pessimism regarding the future of farming , and leads to a greater amount of reported stressed behaviour.

A more economical model, the negative affectivity model (figure 2) was tested in competition with the modified transactional model. This model makes the conceptually economical assumption that all five measures included in this exercise are the result of a general latent variable that tends to make people report negatively about all aspects of their lives. In psychological research this is known as negative affectivity. This model provided a good fit to the data but was not so successful a fit as modified transactional model. The latter model indicated that personality dimension of neuroticism has a strong influence on pessimistic attitudes to farming and tends to increase the dysfunctional coping strategies (i.e. tend to use more emotion than task oriented coping).

It should be noted that farmers with higher neuroticism scores have a greater tendency toward states of psychological distress and this in turn influences self-reported 'stressed' behaviour in farming practice. However, from the information on the farm business it was possible to relate the behavioural questions such as *'find it difficult to meet personal and financial commitments'* with the reported high levels of debt.


## 7.    Conclusions

This small study, based on the empirical results of individual attitudes and personality traits coupled with aggregated farming behaviours is able, with the assistance of structural equation modelling to provide a successful model of the stressed farmer. The resulting well-fitting model showed that the personality trait of neuroticism influences the amount of psychological distress experienced

by an individual which in turn has an effect on farming behaviour, and this is corroborated with the amount of liabilities held.

Modelling is an economical way of capturing the associations in a multivariate setting. In the present study it proved useful in testing competing models of stress among farmers.

Table 1    Pessimistic Attitude:-Correlation with Psychological Factors (All correlations significant at p<.01)

| | Neuroticism | Emotion Coping | Psychological Distress | EFAS Pessimism | EFIS Stressed Behav |
|---|---|---|---|---|---|
| Neuroticism | 1 | | | | |
| Emotion Coping | .68 | 1 | | | |
| Psychological Distress | .56 | .44 | 1 | | |
| EFAS Pessimism | .42 | .24 | .31 | 1 | |
| EFIS Stressed Behaviour. | .21 | .19 | .31 | .23 | 1 |

## 8.    Acknowledgements

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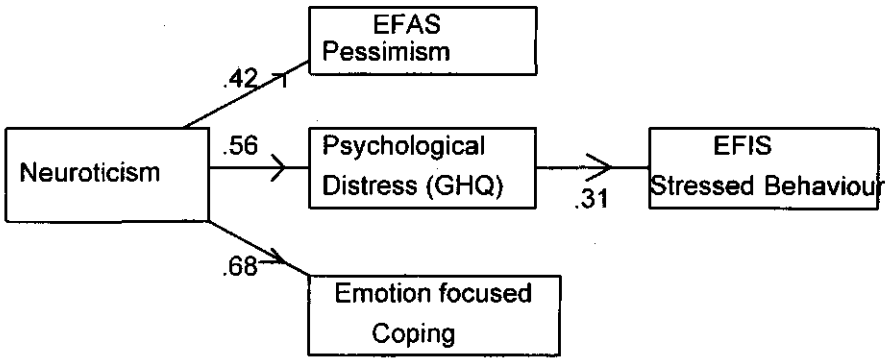
Chi square = 11.3, p = .08

Bentler-Bonnet normed fit index = .96

Bentler-Bonnet non normed fit index = .97

Comparative fit index = .98

*Figure 1   Modified Transactional Model*
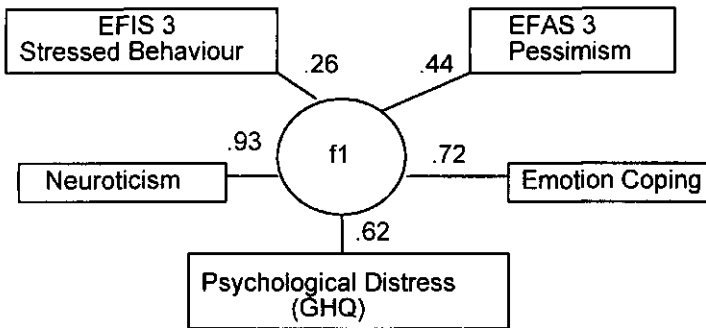


Chi-square = 19.1, p = .002

Bentler-Bonnet normed fit index = .94

Bentler-Bonnet non normed fit index =.91

Comparative fit index = .95

*Figure 2   Negative Affectivity Model*

# A MODEL OF PROBLEM DEFINITION: AN APPLICATION TO SWEDISH FARMERS' ADAPTATION TO DEREGULATION OF AGRICULTURE AND EU-MEMBERSHIP

Professor Bo Öhlmér 1), Associate professor Kent Olson 2), Professor Berndt Brehmer 3)

## Abstract

*Decision making activities can be grouped into phases. In earlier reports in this series, various phases and subfunctions have been discussed and a model of the first subfunction, problem detection, has been developed and verified. In this article, a model of the second subfunction, problem definition, is discussed and tested. A general model of problem definition as a part of unique decision making (in contrast to repetitive) is used to model Swedish farmers' search, analysis and evaluation of ideas of actions that may solve the problem of adaptation to deregulation of agriculture and EU-membership. Farmers' search, analysis and evaluation of ideas of actions are modelled in a recursive system of simultaneous equations. The parameters are estimated using the LISREL method. Data collected with a retrospective questionnaire sent to a sample of farmers randomly selected from a database of Swedish farmers supported the model.*

*A model of problem definition at this level of detail will help to understand how farmers actually search, analyze and evaluate ideas of solutions to their unique problems, and how to support this process.*

**Key-words** : Decision making, farm management, psychological models.

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## 1. Problem and aim

Problem solving or decision making activities can be grouped into phases. Simon (1965) suggested three phases or functions: intelligence, design and choice. Mintzberg et al. (1976) identified a similar trichotomy of phases or functions: identification, development and selection. They divided the functions into subfunctions:
- identification into recognition and diagnoses;
- development into either search or development (depending on the existence of ready-made solutions or not); and
- selection into screen, evaluation-choice and authorization.

Hogarth (1987) defined the following phases: acquisition of information, processing, output, action and outcome; and he discussed the influence of the task environment and the decision maker's schema (mental model). In later evaluations of the Interstate Managerial Study, Johnson (1978 p. 125) suggested six phases: problem definition, observation, analysis, decision, execution and responsibility bearing. Öhlmér et al. (1993) recently investigated farmers' behavior when making decisions to cope with problems caused by changes in the institutional settings. These were unique, rather than repetitive, decisions. We found that farmers need better information and assistance in the subprocesses of scanning, paying attention to and interpreting information than in planning and evaluation. This was shown by the fact that many farmers detected the problem at a very late stage.

Öhlmér et al. (1993) have expanded and verified a standard conceptual model of farmers' decision making behavior at a level where the effect of the supply of information and management assistance can be distinguished. We grouped the decision making activities into:
- *prechoice activities* such as problem detection, problem definition and observation;
- *choice or decision activities* such as planning options, estimating consequences of options, evaluating options and choice of an option;
- *postchoice activities* such as developing an intention to implement, measuring outcome, evaluating outcome and feedback.

In modelling these activities, we identified dependent and independent concepts describing each activity. However, because we analyzed data from case studies, further analyses are needed. A submodel of problem detection has been developed and verified (Öhlmér et al. 1994). In this paper the aim is to test the submodel describing and explaining problem definition, and to suggest how to assist decision makers in problem definition.

## 2. Literature review

A problem is defined as a difference between a perceived and a desired situation. Problem definition is the process of specifying the problem and identifying decision options. Information is acquired from the person's memory and, if this is not sufficient, from written material and other sources external

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to the farm. The information processing includes analyzing the cause of the problem, search for decision options and global evaluation of the options, which results in identifying decision options. In this decision phase, the options are evaluated in general, affective terms (i.e., like or dislike; van Raaij 1988) or in terms of whether the options are compatible with the decision maker's morals, values, beliefs and implications for existing goals (Beach 1993). The global evaluation may lead to direct action in cases of low levels of risk and involvement, and to collection and processing of detailed information, i.e., the next step of the decision process, in case of high involvement.

How a problem is framed in the problem detection phase can strongly affect the identification of option alternatives, because the alternatives will be generated to utilize possibilities, restore reference conditions or otherwise remove the problem as detected.

Alternatives are usually generated with particular problems, objectives and goals in mind. As has been described in the behavioral literature (see the review by, e.g., Hogarth, 1987, or Kleindorfer et al., 1993), many individuals generate alternatives by local search (i.e. close to the existing situation) and identify options in isolation of others. Local search is associated with such terms as incrementalism, anchoring, noncomprehensive analysis, business as usual, not changing a winning horse, narrow problem focus, and non-creative decision making. The isolation effect refers to our approach to simplify problems by dividing them into smaller ones of manageable size and for which we often have standardized solution procedures or earlier experience. However, it is not certain that we will come close to the global optimum in this approach.

The farmers studied by Öhlmér et al. (1993) perceived the problem in terms of its effect on the objectives and goals. These effects determined the degree of seriousness of the problem and also influenced the area of search for options. Sometimes the options were given by the problem, such as buying or not buying a farm for sale. Otherwise the farmers searched for ideas to options in their own memory or from external sources. One farmer read an advertisement for a workshop about beef production and became interested. (He went to the workshop to collect more information and finally chose that option.)

The options considered by the farmers were mostly traditional and within the farming culture even though they may have been new to the farmer. Some options had been known earlier but not considered before. Other options were suggested in the mass media or by advisors. Sometimes options had originality, such as starting milk production in an area outside of traditional milk production areas. In a few cases the options were outside the farming culture, such as selling land for houses and building the houses. In the problem caused by deregulation, some options were given by the government, such as growing non-traditional crops (which were supported financially by the state).

In the search for options, the farmers simultaneously made a preliminary estimation of the consequences and evaluated the ideas of options. In some cases the farmers detected other problems or hindrances in this process, such as when an option had effects on other goals. If the farmers could see a solution to the new problem, they continued the evaluation. Too many new prob-

lems or a new problem without a 'good' solution caused them to drop the option.

The farmers chose only one or a very few options for a closer look in the subsequent phases of the model. If more options were considered, it was because the first options were not good enough. It was difficult to find good options. All farmers kept the alternative of not changing.

Farmers, who perceived the problem to be serious and did not find any options that they thought might solve the problem, perceived the situation as frustrating and out of control.


## 3. Method and model

The Swedish Parliament decided in 1990 to deregulate the Swedish agricultural market and to apply for EC membership. These two decisions mean that Swedish farmers face price decreases, higher price variations, higher price uncertainty and marketing difficulties for their traditional products. In 1990, the experts expected the prices to decrease by 20-30%, and a governmental program to support farmers' adaptation to the new conditions was decided. A model of the Swedish farmers' detection of these changing conditions and the need to adapt in one way or another has been developed and verified by Öhlmér et al. (1994). The problem detection process results in a perceived magnitude of the problem and a perceived uncertainty.

We have divided the problem definition process into three stages:
- information search, which results in identification of ideas to option alternatives;
- estimating consequences of the identified alternatives;
- evaluating the estimated consequences, which results in a definition of the ideas to option alternatives that the farmer wants to study further, plan and choose among.

Farmer behavior is conceptualized in terms of the variables $\eta_1$ - $\eta_6$, where:
- information search is described by the variables $\eta_1$ - $\eta_3$, which results in identification of ideas about options, of which the option most far from the present situation is described in $\eta_4$;
- estimating consequences of the options, which results in perceived consequences, $\eta_5$;
- evaluating the estimated consequences, which results in defined options, of which the option most far from the present situation is described in $\eta_6$.

See table 1. The $\eta$-variables are the endogenous variables, which we want to explain. Each variable depends partly on the variables describing earlier stages of the problem definition behavior, and partly on exogenous variables describing the characteristics of the problem ($\xi_1$ - $\xi_2$), the farmer ($\xi_3$ - $\xi_5$), the farm ($\xi_6$ - $\xi_7$) and the environment ($\xi_8$). See table 2.

*Table 1   Description of the latent endogenous vector (η)*

| Element No | Name | Description |
|---|---|---|
| 1 | Time search | Time spent on information search |
| 2 | Early ext inf | Frequence in use of early external information sources |
| 3 | Proc ext inf | Frequence in use of external sources of more processed information |
| 4 | Option ident | Identified option most far from present solution |
| 5 | Option cons | Consequences of the options that the farmer wants to study further |
| 6 | Option def | Defined option most far from present solution and wich the farmer wants to study further |

*Table 2   Description of the latent exogenous vector (ξ)*

| Element No | Name | Description |
|---|---|---|
| 1 | Per unc | Perceived uncertainty about the problem |
| 2 | Probl magn | Problem magnitude |
| 3 | Abil | Ability of the farmer |
| 4 | Quant | Degree of quantification of price and income changes |
| 5 | Motiv | Motivation of the farmer |
| 6 | Size | Size of the farm |
| 7 | Avoid | Farmer avoidance in seeing new problems (because of having other problems) |
| 8 | Env | Environment of the farm |

The farmer behavior, as conceptualized in the endogenous variables, is formulated in the following system of linear structural relations:

$$\eta = B\eta + \Gamma\xi + \zeta \qquad \qquad \dots (1)$$

where B(6*6) and $\Gamma$(6*8) are coefficient matrices, and $\zeta = (\zeta_1, \zeta_2, \dots \zeta_6)$ is a random vector of residuals. The elements of B represent direct effects of endogenous variables on other endogenous variables. The elements of $\Gamma$ represent direct effects of exogenous variables on endogenous variables. It is assumed that $\zeta$ is uncorrelated with the exogenous variables. It is also assumed that I-B is non-singular, where I is the identity matrix. We get the matrix I-B when we move all η-variables to the left hand side. None of the rows in this matrix should be a linear combination of another row, because then the rank of the matrix is reduced and it may not be possible to identify all parameters.

Based on the results from our case study of farmers' adaptation to deregulation of agriculture and EU-membership (Öhlmér et al. 1993), the following relations are hypothesized:

$$\eta_1 = \sum_{i=2}^{3} \beta_{1i} \, \eta_i + \sum_j \gamma_{1j} \, \xi_j + \zeta \qquad \ldots (2)$$

i.e., time for search ($\eta_1$) is a linear additive function of early external informa-tion ($\eta_2$), processed external information ($\eta_3$), all the exogenous variables ($\xi_j$) and an error term ($\zeta$).

$$\eta_2 = \beta_{21} \, \eta_1 + \beta_{23} \, \eta_3 + \sum_j \gamma_{2j} \xi_j + \zeta \qquad \ldots (3)$$

i.e., early external information ($\eta_2$) is a linear additive function of time for search ($\eta_1$), processed external information ($\eta_3$), all the exogenous variables ($\xi_j$) and an error term ($\zeta$).

$$\eta_3 = \sum_{i=1}^{2} \beta_{3i} \, \eta_i + \sum_j \gamma_{3j} \, \xi_j + \zeta \qquad \ldots (4)$$

i.e., processed external information ($\eta_3$) is a linear additive fuction of time for search ($\eta_1$), early external information ($\eta_2$), all the exogenous variables ($\xi_j$) and an error term ($\zeta$).

$$\eta_4 = \sum_{i=1}^{3} \beta_{4i} \, \eta_i + \beta_{45} \eta_5 + \sum_j \gamma_{4j} \xi_j + \zeta \qquad \ldots (5)$$

i.e., creativity in identified option ($\eta_4$) is a linear additive function of time for search ($\eta_1$), early external information ($\eta_2$), processed external information ($\eta_3$), option consequences ($\eta_5$), all the exogenous variables ($\xi_j$) and an error term ($\zeta$).

$$\eta_5 = \sum_{i=1}^{4} \beta_{5i} \, \eta_i + \sum_j \gamma_{5j} \, \xi_j + \zeta \qquad \ldots (6)$$

i.e., option consequences ($\eta_5$) is a linear additive function of time for search ($\eta_1$), early external information ($\eta_2$), processed external information ($\eta_3$), cre-ativity in identified option ($\eta_4$), all the exogenous variables ($\xi_j$) and an error term ($\zeta$).

$$\eta_6 = \sum_{i=1}^{5} \beta_{6i} \, \eta_i + \sum_j \gamma_{6j} \, \xi_j + \zeta \qquad \ldots (7)$$

i.e., creativity in defined option ($\eta_6$) is a linear additive function of time for search ($\eta_1$), early external information ($\eta_2$), processed external information ($\eta_3$), creativity in identified option ($\eta_4$), option consequences ($\eta_5$), all the exogenous variables ($\xi_j$) and an error term ($\zeta$).

The latent dependent and independent vectors are not observed. Instead, vectors $y = (y_1, y_2, \ldots y_{11})$ and $x = (x_1, x_2, \ldots x_{14})$ are observed such that:

$$y = \Lambda_y \, \eta + \epsilon \qquad \ldots (8)$$

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$$x = \Lambda_x \xi + \delta \qquad \qquad \ldots (9)$$

where $\epsilon$ and $\delta$ are vectors of error terms. The equations represent the multivariate regressions of y on $\eta$ and of x on $\xi$, respectively. The errors $\epsilon$ and $\delta$ are assumed to be uncorrelated between sets but may be correlated within sets. The y-vector is defined in table 3 and the x-vector in table 4.

In estimating many of the latent variables, $\eta$ and $\xi$, with the aid of the observed variables, y and x, and the relations (8) and (9), more than one observed variable have been used for each latent variable. One example is the latent variable $\xi_3$, ability, where the estimation was based on the observed variables $x_3$ (mental model of consequences of price changes), $x_4$ (concept of farm performance), $x_5$ (formal education) and $x_6$ (locus of control). In tables 3 and 4, it is shown which of the observed variables that are used to estimate each latent variable.

Since the latent variables are nonobserved, they do not have a definite scale. To define a scale, the value of one of the $\lambda^y$- or $\lambda^x$-parameters, used in measuring the respective latent variable, is fixed to one. See table 3 and 4. This defines the unit of measurement for each latent variable in relation to one of the observed variable. We have chosen the observed variable that best represents the latent variable in question. The unit will be the same as for the observed variable minus the error term. For some latent variables we have just one observed variable. An example is time spent on information search, $\eta_1$, which is measured with just one observed variable, $y_1$. For such variables we can not estimate the measurement error. We assume the measurement error to be of the same magnitude as for similar latent variables and fix the error term to 0.15, i.e. we assume that the reliability of these variables is 0.85. This assumption is better than using the observed variable directly, which means an assumed reliability of 1.00.

Each y- and x-variable is measured by a question in a questionnaire sent to a sample of farmers randomly selected from a database of Swedish farmers (Lantbruksregistret). The selection was restricted to farms with a need of labour above 1,800 hours per year, which means that the farmers are dependent on their farms for their living. One hundred and ninety three (62%) were answered.

The parameters are estimated with the aid of path analysis and the Maximum Likelihood estimator. The classical form of path analysis consists of solving the structural equations for the dependent variables in terms of the independent and the random disturbance terms to obtain the reduced form equations, estimating the independent variables and then solving for the structural parameters in terms of the regression coefficients. The LISREL method according to Jöreskog et al.(1989) is used, because it is a method suitable for solving structural equation systems with latent variables.

The fit function for the Maximum Likelihood (ML) estimates is derived from the maximum likelihood principle based on the assumption that the observed variables have a multinormal distribution. The fit function for ML may be used to compute parameter estimates even if the distribution of the observed variables deviates from normality. Even standard errors and chi-square

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goodness-of-fit measures may be used if interpreted with caution (Jöreskog et al. 1989, p. 21). ML estimates have been found to be robust against non-normality, see e.g. Monte Carlo studies by Boomsma (1983) and Harlow (1985), and theoretical studies by Browne (1987) and Anderson et al. (1985, 1986).

*Table 3    Definition of the observed endogenous vector (y-vector)*

| y-vector | | | η-vector | | | | | |
|---|---|---|---|---|---|---|---|---|
| No | Name | Definition | $\eta_1$ | $\eta_2$ | $\eta_3$ | $\eta_4$ | $\eta_5$ | $\eta_6$ |
| 1 | SA | Time spent on information search | 1 | | | | | |
| 2 | SAA$_1$ | Use of massmedia, farmer magazines and direct mail | | 1 | | | | |
| 3 | SAA$_2$ | Use of individual service based on mail or telecommunication | | $\lambda_{2,3}$ | | | | |
| 4 | SAA$_3$ | Use of group discussions or work shops | | | $\lambda_{3,4}$ | | | |
| 5 | SAA$_4$ | Use of individual discussions with an advisor or consultant | | | $\lambda_{3,5}$ | | | |
| 6 | SAA$_5$ | Use of the personal network | | | 1 | | | |
| 7 | SAA$_6$ | Use of books, reports etc. | | | $\lambda_{3,7}$ | | | |
| 8 | OID | Option identified (most far from present production) | | | | 1 | | |
| 9 | ECR$_1$ | Estimated consequences on income | | | | | 1 | |
| 10 | ECR$_2$ | Estimated consequences on investments | | | | | $\lambda_{5,10}$ | |
| 11 | ODEF | Option defined for further studies (most far from present production) | | | | | | 1 |

## 4.    Results

The results are illustrated in a path diagram of the final adopted model, see figure 1. $\chi^2 = 147$ at 144 degrees of freedom (p = 0,40), which indicates a good fit of the model. The estimated t-value for each parameter is given in tables 5-7.

Compared to the hypothesized model given in equation (2)-(9) and tables 1 and 2, the parameters with t-values less than 1.5 have been excluded from the analyses. The final adopted model is estimated without these variables. We have chosen the t-level of 1.5 in order to keep too many variables rather than too few in the analysis. The directions (i.e. the signs) of the relations are known, so the t-test is one-sided.

Detection of a problem induces farmers to engage in searching information about ideas about options. They spend more time on information search if the problem magnitude is great or they are more certain that there is a problem. Farmers with a higher ability or a higher motivation and farmers who quantify their judgements about the changing conditions spend more time on searching information than other farmers.

The distance between the present situation and the identified options ($\eta_4$ and $\eta_6$) can be seen as a mesurement of the creativity in finding new alternatives. The level of creativity depended on the problem magnitude, the farmer ability and the degree of quantification in the judgements. Farmers quantifying their judgements consider more creative options. However, when it comes to defining options for further study, the more intuitive farmers are more creative ($\gamma_{6,4} = -0.7$).

Neither the time devoted to information search, nor the frequence in using various information sources did significantly affect the creativity in the option generation. However, the level of information search affected the judgement of option consequences. Farmers with a more frequent use of sources of early information, such as newspapers, perceived lower option consequences ($\beta_{5,2} = -0.8$). Farmers with a more frequent use of sources of more processed information, such as the advisory service or the personal network, perceived greater option consequences ($\beta_{5,3} = 0.8$). The magnitude of the problem had no significant effect on the perceived option consequences, but the consequences were perceived to be slightly lower if they were more certain about the problem ($\gamma_{5,1} = -0.2$).

## 5. Conclusions

The $\chi^2$-values of the model and the t-values of the coefficients show that our final adopted model of problem definition provides a reasonable explanation of the process.

*Table 4    Definition of the observed exogenous vector (x-vector)*

| No | Name | Definition | $\xi_1$ | $\xi_2$ | $\xi_3$ | $\xi_4$ | $\xi_5$ | $\xi_6$ | $\xi_7$ | $\xi_8$ |
|----|------|-----------|-----|-----|-----|-----|-----|-----|-----|-----|
| 1 | PU | Perceived uncer tainty of the problem | 1 | | | | | | | |
| 2 | PR | Magnitude of the problem | | 1 | | | | | | |
| 3 | $mm_2$ | Mental model of consequences of price changes | | | $\lambda_{3,3}$ | | | | | |
| 4 | iconc | Concept of farm performance | | | $\lambda_{3,4}$ | | | | | |
| 5 | educ | Formal education | | | 1 | | | | | |
| 6 | contr | Locus of control | | | $\lambda_{3,6}$ | | | | | |
| 7 | quant | degree of quantification of price and income changes | | | | 1 | | | | |
| 8 | $asp_1$ | Income aspiration | | | | | 1 | | | |
| 9 | $asp_2$ | Acceptable size of investment | | | | | $\lambda_{5,9}$ | | | |
| 10 | $asp_3$ | Limit of additional own work | | | | | $\lambda_{5,10}$ | | | |
| 11 | $size_4$ | Number of employees | | | | | | $\lambda_{6,12}$ | | |
| 12 | $size_5$ | Yearly turnover | | | | | | 1 | | |
| 13 | optype | Existence of other problems | | | | | | | 1 | |
| 14 | loc | Distance to the closest town | | | | | | | | 1 |

Table 5  T-values of y (with exclusion of parameters where the |t-value|< 1.5)

| y-vector | η-vector | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1  SA | - | | | | | |
| 2  $SAA_1$ | | - | | | | |
| 3  $SAA_2$ | | 5,5 | | | | |
| 4  $SAA_3$ | | | 4,8 | | | |
| 5  $SAA_4$ | | | 6,3 | | | |
| 6  $SAA_5$ | | | - | | | |
| 7  $SAA_6$ | | | 6,0 | | | |
| 8  OID | | | | - | | |
| 9  $ECR_1$ | | | | | - | |
| 10  $ECR_2$ | | | | | 4,8 | |
| 11  ODEF | | | | | | - |

Table 6  T-values of $\lambda^x$ (with exclusion of parameters, where the |t-value| < 1.5)

| x-vector | ξ-vector | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1  PU | - | | | | |
| 2  PR | | - | | | |
| 3  $mm_2$ | | | 3.8 | | |
| 4  iconc | | | 3.7 | | |
| 5  educ | | | - | | |
| 6  contr | | | -2.8 | | |
| 7  quant | | | | - | |
| 8  $asp_1$ | | | | | - |
| 9  $asp_2$ | | | | | |
| 10  $asp_3$ | | | | | 4.3 |

Table 7  T-values of $\beta$ (with exclusion of parameters, where the |t-value| < 1.5)

| η-vector | η-vector | | | | | |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 |
| 1  Time search | | | | | | |
| 2  Early ext inf | 1.7 | | | | | |
| 3  Proc ext inf | 3.6 | 4.8 | | | | |
| 4  Option ident | | | | | | |
| 5  Option cons | | -1.6 | 2.0 | | | |
| 6  Option def | | | | | | |

*Table 8   T-values of γ (with exclusion of parameters, where the It-valueI < 1.5)*

| η-vector | ξ-vector 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1  Time search | 2.7 | 2.2 | 4.3 | 3.7 | 3.5 |
| 2  Early ext inf | -1.8 | 1.5 | 2.5 | | |
| 3  Proc ext inf | 1.5 | | 2.8 | | |
| 4  Option ident | | 4.5 | 1.6 | 1.7 | |
| 5  Option conc | -1.6 | | | | 4.4 |
| 6  Option def | | 1.7 | 2.3 | -1.7 | 1.7 |

In order to improve the creativity in farmers' option generation, it is important to improve both farmers' ability and their motivation. The ability seems to have a specially great influence on the whole problem definition process.

Farmers that are more quantitative in their judgements have a more cautious selection of options for further study, but a more creative generation of option ideas. More cautious farmers may collect more information in the form of quantifications, or quantitative judgements may result in a more cautious selection of options.

Providing farmers with more processed information in the form of, e.g., advisory service, induces them to find greater option consequences. However, more information does not seem to improve the creativity in the option generation. The level of creativity is dependent of problem magnitude, ability, degree of quantification and motivation. These factors are related to the ability to perceive and attend. These factors are, thus, more important than the amount of information for option generation.

In our conceptual model as well as in problem detection, the concept of avoidance (as measured by the presence of other important problems) affected both the level of information scanning and attention, and it explained to a great deal why farmers detected the poblem very late or not at all. Avoidance has no significant influence on problem definition.

The different signs of the influence of quantification on the creativity in generating option ideas versus defining options for further studies may depend on differences in the incrementalism. The more intuitive farmers may take a smaller step in a more creative direction, while the quantitative farmers may take a bigger step in a more familiar direction.

The environment, measured as distance to the closest town, was important for problem detection. In problem definition, farmers knew that they needed information, which may explain why differences in the availability of information in the closest environment had no significant influence.

The strong influence of the problem magnitude and the perceived uncertainty stress the importance of the problem detection process on problem definition as well as the whole problem solving.

*Figure 1    Model of problem definition (193 observations)*

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# THE FARM IN AN INCREASINGLY COMPLEX ECONOMIC AND ADMINISTRATIVE ENVIRONMENT THE QUESTION OF EXTERNAL CONTROL

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**Summary**

Major changes are currently underway on farms, due to the reform of the CAP, the GATT, and the demand for protection of natural resources. Farms are under considerable pressure from their socio-economic and administrative environment in the form of service or management contracts. These contracts have a highly limiting effect on farmers' manoeuvering power in the exercise of their activities. But, given this new context, to what extent do farmers lose their grasp on the control of their farms? What are the consequences on the strategies they adopt for counteraction? Which types of indicator should be developed to ensure vigilance regarding the risks of losing their autonomy. Management sciences are traditionally based on the implicit hypothesis of separation between internal and external management. With the help of constructivist epistemology, we have tackled this problem using two theoretical referentials: the systems approach and the theory of resource dependence. Analysis results show that pressure for change leads to several types of external control on farms, and also that farmers are able to react in a number of ways.

**Key words** : family-farm system, external control, perception, vigilance

## 1.    New farm issues

The 1992 Common Agricultural Policy (CAP) reforms and the GATT signed in 1994 have created a new socio-economic context for farms. Production capacity of farms has been cut back through the introduction of production rights using quota systems, and farms have been exposed to the fluctuations of world market prices due to the elimination of EU price support. In addition to this uncertainty, society is making new demands for natural resource protec-

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tion, particularly local actor-groups such as local representatives, associations for the protection of nature, natural parks, private companies, etcetera. These demands usually lead to proposals of technical specifications which hinder and modify the farmers' production systems and management practices.

This new situation has brought with it changes in the relationships between farms and their local and administrative environment, some of which result in conflict. Given these various management situations and actor-group reactions, farms undergo change, develop and contribute to the development of their close environment which proposes or imposes service or management contracts which can be hindering to them.

In this context, farms are increasingly exposed to a high level of uncertainty regarding their future and their capacity to adapt to new situations. To what degree are farms autonomous? This question is once again central to research concerning farm functioning. To what extent do these new situations cause the farmers to lose grasp of the control of their farms and how? How do they adapt? Which indicators should be developed in order for them to remain vigilant regarding their strategy?

These problems will be examined using a multidisciplinary research project carried out on 'agriculture and water quality' in North-Eastern France. The overall research context will be presented first, followed by our conceptual modelling of the farm, and finally the results of research work undertaken with respect to external management.

## 2. Overall research context: agriculture and water quality 1)

Initially, a mineral water company (hereafter referred to as MWC) wished to exert an influence over local farming practices in order to prevent an increase in the nitrates level in groundwater, since this was one of the main causes of nitrates' increase in the hydromineral catchment area. Farming occupies almost all the perimeter and recent changes in production systems (increase of fertilizers and of maize crops) support this fact. A request was thereafter made to the farmers proposing compulsory means contracts (involving compliance with technical specifications). In return, the MWC agreed to pay a subsidy calculated per hectare for a period of 5 to 7 years, also agreed to make the investments necessary for the implementation of new farming practices (about one million French francs), and to regularly carry out on the farm the tasks connected with animal waste management.

Concurrently, in 1989 the MWC proposed a research contract to INRA (French National Institute for Agricultural Research) for developing new farming systems required in order to reduce the risks of nitrates pollution and also maintain a profitable local agriculture. The first phase of the research led to a

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1)  For further information on this research, see Deffontaines et al. (1993 and 1994).

diagnostic assessment of the farming system in question and to the first elements of technical specifications.

This problem created a local dynamic in a management situation involving several actor-groups:

*The MWC* is a leader in the Mineral Water market, and operates in a rural context. (Its staff resides in the area.) This demonstrates the economic importance of the MWC both locally and regionally. The MWC created a subsidiary in 1991: a farming service company (hereafter referred to as AV) responsible for farmer relations and for facilitating the implementation of the new farming systems that result from the application of new technical specifications. It also carries out certain farm tasks and gives technical support to livestock farmers.

*The farms*, 25 in number, are mainly dairy farms: the animal (milk and meat) turnover from the dairy herd represents 80% of the total with milk alone accounting for more than 60%. The farms, which are individual family farms, cover an average area of 120 ha with 45 dairy cows. At the present time, half of the farmers have signed a contract with the MWC (involving the application of technical specifications and MWC technical and financial support) 1).

## 3. Methodology and concepts

Traditionally, management sciences are based on the implicit hypothesis of the separation between that which is internal and external to the company. New research in the field of constructivist epistemology in management has shown this separation to be artificial (Avenier 1993, Le Moigne 1990). Where does the farm stand? In view of its specificities, the farm is not in the same context as an industrial company and it is still an open question as to whether it has the same functioning logic.

In order to examine farm functioning in its new context, and in particular, to include the influence of the environment in the direct management of the farm (the issue of external control), our work used *constructivist epistemologies* based on the postulate of *limited procedural rationality*. Among these epistemologies we examined two complementary theoretical frameworks: the systems approach and the theory of resource dependence.

### 3.1 The systems approach (Von Bertalanffy, 1968) (Le Moigne, 1990)

The research work undertaken by the Agrarian Systems and Development Department of INRA, inspired by the systems approach (Osty, 1978 and 1994, Brossier et al., 1990), has proposed a model of the functioning of the family farm known as the Theory of Adaptive Behaviour (Petit, 1981) based on the Family-Farm System (Brossier, Chia, 1986; Brossier et al., 1991; Marshall et al., 1994). The notion of system has allowed the farm to be examined with respect to the family and its future project. But this model remained too focused on

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1) MWC continues to negotiate with the remaining farmers.

the interdependence that exists between the family and the farm without taking the environment into account, considered still to be an exogenous variable. Yet the perception of the farm as an open system has brought attention to the notion of the limits or boundaries of the farm and to the nature of the interchanges that exist with the environment (Rojot and Bergmann, 1989).
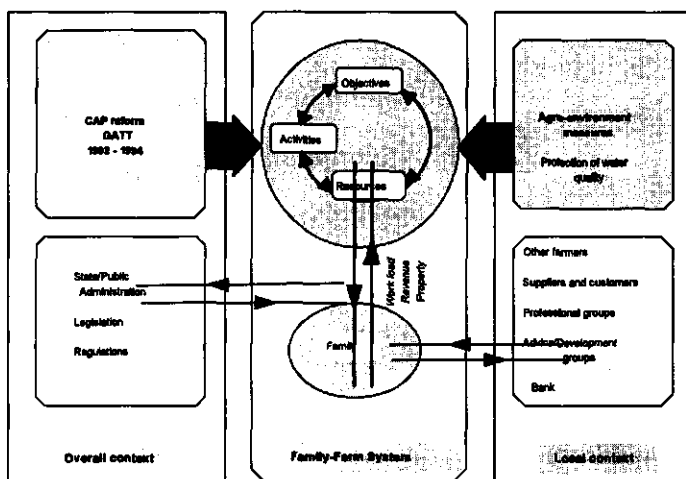


*Diagram 1    Systems representation of the farm in its environment*

This research work is focused on analysis regarding the interchanges between the family-farm system and its environment. Diagram 1 enables us to visualise the pressure for change exerted on this system by new aspects of the local context (protection of water quality) and the national context (CAP reform plus GATT).

But the systems approach does not dispense us from gathering information on the nature of the environment and its components, and on the processes of inter-organisational coordination which are set up between the farms and the other local actor-groups.

## 3.2    The theory of resource dependence

Advanced by Pfeffer and Salancik in 1978, is an organisations theory which covers the problematic of external management of the organisation by the environment (Rojot and Bergmann, 1989). Pfeffer (1982) develops two basic points of this theory:
-       The first point consists of considering that the organisation is intimately connected with its environment, must acquire and maintain resources over which it does not have complete control and depends on other

groups in its environment to obtain them. Thus the organisation, in order to satisfy its needs must obtain the support of these external interest groups. In return for this support, these groups demand compensation from the organisation and this leads to situations where the groups in possession of the resources exert external control on the organisation. The organisation's response to these demands depends on a certain number of factors, the most important of which are: the resource is essential for the activities of the organisation, the external groups are in direct control of the allocation or use of the resource, the organisation has no access to alternative resources, organisation activities or products are visible or can be checked by these groups.

- The second point concerns the role of managers within the organisation. Their tasks consist of 'trying to manage external dependencies whilst fulfilling two objectives: ensure organisation survival and acquire more autonomy and liberty regarding external constraints' (Pfeffer, 1982).

In our case study, the theory of resource dependence is a relevant framework for analysing the relationships between the MWC and the farms within the perimeter. The farmers are in possession of several elements which are necessary resources for MWC. It can be considered that the resource required by MWC is the space in the soil which enables mineral water of a certain quality to be 'stocked'. But this stock space is used in two incompatible ways (Schmid, 1987), since it is used to stock the excess nitrates not used by the plants and also to stock 'clean' mineral water. From a legal point of view, the farmers are the owners of this resource, and as the non-owner of a resource necessary for its product, MWC is trying to procure this resource. Thus this is a case of resource dependence. As previously mentioned, the company is in a dominant position, both politically and economically, and has sought to buy the land. This solution has enabled the company to take possession of more than 40% of the farming land in the perimeter, and since it does not want to farm the land itself, it has let it out to the farmers. So the company uses the land in its negotiations with the farmers. It has thus turned the situation around by becoming the owner of an essential resource for the farmers, leading it to sign a contract with them involving the application of technical specifications 1). The company has strengthened its position by supplying considerable financial support which can be essential for the farmers. So the situation in which the farmers were in possession of the resource needed by MWC has now changed to a situation in which MWC is in possession of the resources needed by the farms.

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1) The technical specifications cover essentially the elimination of maize, planned management of manure and spreading (compost), definition of planned fertilizer application and prohibition of plant-health products, maximum rate of one head of cattle per hectare, development of better farming practices concerning crops (soil cover, rotations) and livestock management (grazing, food diet).

3.3    Research methodology

The research was carried out using interviews and data collection over several years with respect to the farms having signed the contract with MWC.

In addition, six representative farms were followed for five years (monographic studies and modelling). This work was carried out using the participatory approach (or action-research) which involved researchers, the farmers concerned, the MWC and its subsidiary company AV. The general characteristics of the farms studied are given in table 1.


## 4.    Analysis results: types of external control

Farms have always been dominated by upstream and downstream companies (Coudrieau, 1990). Currently there appears to be further loss of control, the types of control being more direct and more visible since local institutions and groups, backed up by Brussels, are increasingly involved in the control process.

Regarding the management situation under study, we feel that farm control can be exerted in different ways and on several levels. Four types of external control of farms can be distinguished:
*       Control of the resources used by the farm: land, work load, investments and revenue support.
*       Control of functioning, i.e. technical processes and production practices, through technical specifications or without them.
*       Control of activities through choice of strategy concerning farm activity (through technical specifications or indirectly).
*       Control of farm objectives and their order of priority, for example set production limits, revenue action through subsidies, etcetera.

4.1    Control of resources

The resources used by MWC to exert control over the farms are land ownership, work supply, and financial resources.

With respect to *land ownership*, MWC is the owner of almost half the farming land in the perimeter. This land is distributed amongst those farmers who have signed the contract with MWC for their use free of charge over a period of 18 years (table 1).

MWC land represents a fair proportion of the SAU (*Surface Agricole Utile*), on average 44% on the six representative farms. Sale of land to MWC represented an important sum for Farmer F and an opportunity not to be missed for Farmers A and D. The precarious financial situation of Farmer B obliged him to sell his land to MWC. The six farmers do not feel that the new land ownership situation involving MWC land allocation has a limiting effect on their production objectives. Concerning MWC recommendations for farming its land, the farmers have received no special requests except that MWC restricts the ploughing of pastures.

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Work supply constitutes another means through which MWC can exert control over farms. The contracts state that MWC, using AV, is responsible for the entire process of animal waste management. Using daily records and periodic observation, this work supply furnished by MWC to the farms can be quan-

Table 1 Farm resources

| | Farmer | A | B | C | D | E | F |
|---|---|---|---|---|---|---|---|
| **General** | Available revenue (AR) in '000 FF | 450 | 70 | 200 | 390 | 180 | 220 |
| | Annuities/AR(%) | 13.3 | 57.3 | 85 | 66.6 | 22.2 | 45.5 |
| **information** | Level of change in production system *) | 2 | 3 | 3 | 1 | 3 | 0 |
| | | | | | | | |
| **Land own-** | MWC land /SAU (%) | 74 | 74 | 11 | 47 | 40 | 17 |
| | Other tenanted farmland/SAU (%) | 1 | 20 | 57 | 17 | 17 | 61 |
| **ership** | | | | | | | |
| | Land sold to MWC (hectares) | 28 | 90 | 0 | 21 | 0 | 30 |
| | | | | | | | |
| **Work sup-** | AV work / Total farm work (%) | 8 | 7.4 | 5.9 | 5.7 | 5.3 | 6 |
| | AV work / Seasonal work (%) | 28 | 17% | 34.4 | 26.6 | 43.8 | 28 |
| **ply** | | | | | | | |
| | Number of AV visits per month | 4.2 | 4.8 | 3.8 | 3.3 | 4.2 | 3 |
| | | | | | | | |
| **Investments** | Total investment ('000 FF) | 1080 | 1050 | 1000 | 1000 | 240 | 200 |
| | | | | | | | |
| | Subsidy ('000 FF) | 116 | 110 | 122 | 115 | 108 | 82 |
| | | | | | | | |
| **Revenue** | MWC subsidy/Gross product (%) | 12.9 | 20 | 15.2 | 11.5 | 19.3 | 9.6 |
| **support** | MWC subsidy/Gross margin (%) | 16.5 | 30 | 22.2 | 15 | 28.5 | 13.9 |
| | MWC subsidy/AR (%) | 25.8 | 157 | 61 | 29.5 | 60 | 37.5 |
| | MWC subsidy/MS (%) | 29.7 | 440 | 400 | 88.5 | 77 | 68.3 |

*) This figure gives an idea of the degree of change in the production system due to the application of technical specifications. It varies from one farm to another. The figure 0 indicates : no change, figure 1 indicates little change, figure 2 indicates average change, figure 3 indicates considerable change to the production system.
S.A.U. (Surface Agricole Utile) : Usable Agricultural Area.

tified. Thus this work supply represents between 5.3% and 8% of the annual work carried out in the farms under study. This is little but taken in a seasonal context represents on average 30% of the work and is therefore important since seasonal work usually involves heavy work-load periods. Most of the farmers interviewed consider that AV plays an important role in work management on the farms.

*Financial resources* constitute yet other means available to MWC for exerting control over the farms, i.e. investments made by MWC and revenue support to farmers. The contract stipulated that MWC make at its own expense the investments required by changes on farms (drying barn and hay harvesting operation building, replacement of maize by lucerne in animal feed). These investments, which vary from one farm to another, represent about 1 million French francs (table 1). Five out of the six farmers consider that the investment choices have not had a limiting technical effect on their activities.

The amount of revenue support, given by MWC to the farmers who have signed the contract for a period of 5 to 7 years, represents a high proportion of the available revenue of these farmers (table 1). MWC subsidies come to about 3/4 of the monetary surplus 1) of Farmers D, E, and F. Farmers B and C, for whom the subsidy comes to more than four times the monetary surplus, find themselves in a critical economic situation. We feel that a high proportion of MWC subsidy in available revenue and in monetary surplus reveals the level of external control.

## 4.2    Control of farm functioning (control of farm practices)

Control of farm functioning refers to the control of technical production processes. It is important to remember that certain practices are quite restricting: zero pesticide, limited fertilizer, barn hay drying, etcetera. Certain farms with more intensive systems have more difficulty in adopting the new systems, and their farmers are usually more reticent about signing the contracts. It is clear that when AV carries out certain tasks, it is involved in farm functioning, but does this bring about a sort of external control? The six farmers interviewed state that AV involvement on their farms is always at their request or by mutual agreement. Obviously, the farmers studied are the first to have signed the contract, and are those for whom the changes were less drastic or who wished to make them, and who are fairly happy to have had this unexpected opportunity to have additional resources. The farm fertilizer application programme is carried out by AV, since it is involved in the animal waste management operations. On the other hand, the cropping pattern plan is generally managed by the farmer himself.

With regards to herd management (diet, feed supply, milk production, mulching, calving programme), all the farmers have stated that AV makes no recommendations and takes no part in these activities. On the other hand, AV does propose technical support with respect to grazing, herd feed supply (physico-chemical analyses of grass and hay analyses are carried out regularly)

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1)    Available Revenue (AR) corresponds to gross product minus current expenses (operational expenses + overhead costs excluding depreciation). Monetary surplus (MS) is Available Revenue minus family-farm system annuities. Monetary surplus is an important indicator because it corresponds to family income and ensures farm growth.

and hay spreading in stables. A technical engineer has recently been recruited by AV in order to give pertinent advice in these areas.

Several aspects can lead to control over functioning. Firstly, the near-permanent presence of AV staff on the farm. Over an annual cycle, we have calculated the average number of visits per month of AV staff to the farm: this varies from 3 to Farmer F, to 4.8 to Farmer B (table 1). Secondly, the relationship between the farmer and AV staff in which the latter can put pressure on the former. But it must be stressed that the farmers consider that so far everything is running smoothly.

## 4.3    Control over activities

The technical specifications of the contract stipulate the elimination of maize crops on farmland within the water protection perimeter. This restriction aside, no production choices are mentioned. Thus, with the exception of Farmer E who signed a contract to eliminate cereal crops, nothing stops the farmers from dropping or developing certain products (cereals, milk, meat, etcetera). In practice, we have recorded no request nor direct action on behalf of AV concerning strategy choices regarding the farms under study. On the other hand, the farmers are under the impression that AV is pushing them indirectly to adopt an extensive 'grass-only' livestock farming system, using the rotation system set down in the technical specifications, fertilizer application programmes, making land areas available to farms and through milk quota management.

## 4.4    Control over objectives

It is extremely difficult for AV to take part in the major decisions regarding the future of the farms and the six farmers do not seek advice in this respect. They say that they have had no limitations regarding production objectives (milk production level, crop production, etcetera) nor regarding development choices for their farms. Two observations can however be made:
-    The farmers having signed the contract do follow the general lines in the application of the technical specifications: conversion to biological farming or development of grass through meat production by developing the beef line.
-    As seen above, MWC recompenses the decrease in turnover and especially farmer revenue through a subsidy. This subsidy is also calculated to incite the farmers to change systems (they are not incited to change systems if the revenue obtained is the same). Playing on revenue, at times to a great degree (see table 1), MWC directly affects the family objectives on the farm. It is true that revenue increase is not the only motivation, but it is important for the farmers.

In order to understand how the farmers perceive this external control, further explanation is essential.

## 5. Farmers' perception of control and comprehensive model

The most important element is not the environment as it stands but the opportunities and constraints as perceived by those involved in its management (Child, 1972; Rojot and Bergmann, 1989). In the field of farm management, Brossier (1974) introduced the notion of perception in the research work he carried out in collaboration with psycho-sociologists in Western France: the farmer makes decisions in accordance with his perception of the situation.

### 5.1 The concept of perception

The concept of perception makes reference to constructivist epistemology, and particularly to its phenomenological or interactionist postulate, i.e. reality does not exist outside our experience and our perception of it. As outside observers, we could easily describe the types and means of external control exerted on the farm using the case study on water quality management, whilst the actors involved in this situation have a different perception of this control. All the farmers interviewed state that their farms are not subject to external control by MWC. Regarding the question concerning the pressure put on them by MWC, all the farmers replied that there was none. The frequent presence of AV staff on the farms does not seem to create a problem for the farmers.

### 5.2 External control model

In order to take the analysis further, we propose a model based on the hypothesis of discontinuity of farm boundaries with its close environment. Using the example presented here, we can distinguish two types of external control exerted on the farm: direct control concerning farm resources and functioning; and indirect control connected with the first which concerns strategy choices of farm activities and family-farm system objectives. These two types of control remain implicit as long as they are not perceived by the farmer. Once they are perceived they become explicit and formal. Then two processes are set off: the first is the outer reaction of the farmer who manifests his disagreement by threats or renegotiation with MWC. For example, some farmers have threatened to call upon the professional farming groups or to contact the press; others have published articles. The second process consists of inner adaptation, which affects the choices of activities and the objectives of the family-farm system (diagram 2). The order of importance of these two processes depends on the management methods of the farmer and his priorities. Hence, the farmer's behaviour depends on two essential points: the degree of change made to his production system and the importance he gives to maintaining his personal control over activity (table 2).

Groups I and II are more in favour of inner adaptation. Groups III and IV are more likely to have outer reactions.

Table 2   Typology of perceptions and reactions to external control

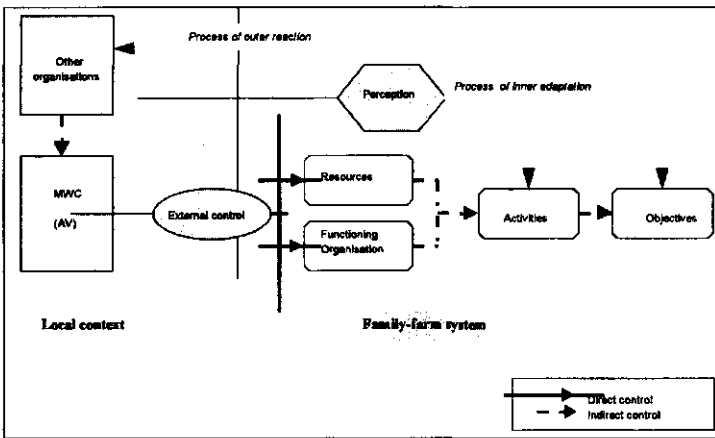|  |  | Degree of change to production system | |
|---|---|---|---|
|  |  | **Low** | **High** |
| *Personal control maintained over activity* | **Low** | **I**<br>Farmer D | **II**<br>Farmer B |
|  | **High** | **III**<br>Farmer F | **IV**<br>Farmers A, C, E |



Diagram 2   Model of external control of the farm

## 6.    Possible farmer reactions regarding this growing dependence

Given this context, in order to ensure both functioning and viability of their farms, farmers have to 'react' with respect to this environment. In other words, they can direct to a certain extent the external control to which they are subjected. Autonomy is retained through vigilance with respect to this external control, through using these external constraints positively (seizing opportunities) and lastly through collective action.

### 6.1   Vigilance and record keeping

One way of managing external control is to adopt an attitude of permanent vigilance. It is in the farmers' interest to organise their information system. The farm is currently the target of a large amount of information, but this in-

formation is not always used and developed to the full. We propose the definition of a certain number of criteria to the farmer, which can be used as indicators in external control situations and on which he can exert vigilance. This is a sort of strategic record which is kept and updated by the farmer himself. This record covers two aspects of analysis: static analysis of the farm using the year N, and dynamic analysis of the farm's performance together with its relations with MWC. The latter incorporates analysis of past performance and forecast of medium-term change (table 3).

Table 3   Model of control sheet used for on-going vigilance

| Type of control | Indicators | Year | | | | | Threshold/ Objective |
|---|---|---|---|---|---|---|---|
| | | N-2 | N-1 | N | N+1 | N+2 | |
| Land ownership | MWC land / SAU (%) | 17.7 | 74 | 74 | 74 | 74 | 74 |
| | Tenant farmed land / SAU (%) | 30.2 | 1 | 1 | 1 | 1 | 1 |
| Work supply | AV work supply/Seasonal work supply (%) | 10 | 20 | 28 | 30 | 25 | 25 |
| | Number of AV visits per month | 1 | 3.5 | 4.2 | 4.5 | 4 | 4 |
| | Available revenue ('000 FF) | 330 | 280 | 450 | 500 | 550 | 600 |
| | Monetary surplus ('000 FF) | 285 | 220 | 390 | 440 | 450 | 550 |
| Revenue | Annuities / AR (%) | 13.6 | 21.4 | 13.3 | 12 | 9 | 8.3 |
| | MWC subsidy / AR (%) | 16.36 | 19.3 | 25.8 | 32 | 29 | 29 |
| | MWC subsidy / MS (%) | 19 | 24.5 | 29.7 | 36.4 | 35.5 | 35.5 |
| | Development of MWC subsidies | E | E | I | I | E | CP |
| Functioning connected with TS | Dysfunctioning due to AV | 0 | 1 | 2 | 2 | 2 | 2 |
| | Involvement in technical processes | 2 | 2 | 2 | 3 | 3 | 3 |
| | MWC recommendations | 3 | 2 | 1 | 1 | 1 | 1 |
| Functioning non-connected with TS | AV unauthorised visits | 0 | 2 | 4 | 5 | 5 | 5 |
| | MWC limitations | 0 | 1 | 2 | 2 | 1 | 0 |
| | MWC recommendations | 1 | 1 | 2 | 2 | 1 | 0 |

AR = Available revenue, MS = Monetary surplus, S = Savings, I = Investments, PC = Production cycle, TS = Technical specifications

**Explanatory note** : This table has been filled out using real data from one farm as an example. However, the figures in italics are hypothetical. The last column gives the threshold set by the farmer for each indicator, used as an alert signal if and when the indicator goes over the threshold creating a critical situation. For certain indicators (Gross product, Available revenue, etc) this column is rather an indicator of the objectives to achieve. This example can be interpreted as follows: at the beginning (year N-2 and year N-1) MWC did not intervene much nor make many recommendations to the farmer, in order to encourage farm changes and to avoid discouraging other farmers who had not yet signed the contract. The hypothesis can be made that, once changes are irreversible, the number of recommendations (for example to put more straw in the stables, change the type of stable, give less concentrated feed to animals, etc) or limitations (no fertilizer, no chemical treatment of field disease, grow less cereals, do not plough a plot, etcetera) will increase.

## 6.2 Dependence taken as an opportunity

Dependence of farms with respect to their environment does not necessarily mean vulnerability or weakness. Ways must be found and developed in order to turn this situation to their advantage. The farmers are led to find strategies for managing this dependence, and two can be given here (Saporta, 1989). The first is 'knowing how to make oneself indispensable', and consists of absorbing the objectives of the requesting party, in this case MWC, and imposing oneself through techno-economic efficiency as a privileged partner. In order to succeed, one must be irreplacable. The second strategy is 'knowing how to negotiate with more important people than oneself'. In the farm's case, this means knowing that it is in quite a good position with regard to powerful local actor-groups, in this case MWC. This strategy pays in counteracting indirect external control (pressure).

When MWC expressed its request that agriculture should be more environment-friendly, several farmers on the plateau realised that an opportunity was being offered to set up, with MWC support, new systems that would have sooner or later been imposed by the European Union anyway (agro-environmental measures, excedent, etcetera). The opportunity to be front runners was attractive to those farmers, such as Farmer A, who were already sensitive to these issues.

## 6.3 Interface and collective action

One way of confronting the external constraints coming from powerful actor-groups is to create an interface system, which will back the farm up in its negotiations with external groups in its environment and protect it against the process of external control. It is a question of seeking out allies in order to create coalitions between the actor-groups concerned by a particular situation.

It is true that in the case study presented here, there were few collective actions and it was difficult to encourage any had we so wished. The economic interest group involving MWC and the farmers for the purpose of product development did not function. The development subsidiary, AV, could have included the farmers on its administrative board but this was not the case. Lastly, collective projects concerning equipment and manufacturing, such as lucerne dehydration, which could have brought the plateau farmers together did not take off and individual projects took their place. The reasons for these failures can be put down to the individualistic and wait-and-see attitude of the farmers and also to MWC lack of willpower when action was required. However, one collective action must be underlined: Farmers A and E of our sample were members of a reflection group of six farmers on the nature of the contract proposed to them by MWC. They succeeded in modifying certain clauses and legal terms of the contract.

## 7.    Conclusion

The research underway shows the apparition of new development models which closely associate several actor-groups, certain of which are newcomers in the agricultural field, such as water companies, water boards, local collectivities. These organisations can be added to the farmers' usual economic partners (upstream and downstream industries). The behaviour of these new actor-groups has fundamentally altered this question of external control because they are often more dynamic than the traditional actor-groups.

The farmer is now confronted with various forms of contract: production contracts (especially regarding vegetables), service contracts (for example land upkeep), commercial contracts between the farm and its clients, etcetera. This new situation modifies the farming profession and brings with it increased openness for the farm regarding its close environment.

The model for external farm control can be used to analyse the relationships between farms and local actor-groups. The control sheet given above is an efficient means for exerting on-going vigilance in order to counteract external control.

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# CHANGING ORIENTATION STYLES OF AGRICULTURAL ENTREPRENEURS: A CASE STUDY AMONG NURSERYMEN (BOOMKWEKERS) IN BOSKOOP

Bareld van der Ploeg 1)

## Abstract

*The paper reports about a case study on the changing orientation style of nurserymen in the old centre of arboriculture and trade Boskoop. The life-worlds of these nurserymen (with regard to orientation) are compared with presumptions about the orientation of professional entrepreneurs. It appears that there exists a world of difference between these life-worlds and the model-world of professional entrepreneurs. The paper includes a qualitative description of direction and context of changes in the orientation style of real entrepreneurs.*

## 1. Introduction

### 1.1 Background

The case study about 'changing orientation styles' takes part in a research project (DOBI) of Agricultural Economics Research Institute (The Hague) and LUW University Wageningen. The main aim of this project is to bring to the front stage the farmer as an active user of information. This aim implies in particular that we want to get a more clear picture of the way in which real farmers deal with information. The result should be useful for professionals in Agricultural Knowledge Systems who want to realise a 'demand-driven or interaction-based supply of information'.

### 1.2 Research theme and aim

A specific way in which a particular farmer deals with information is labelled here as 'orientation style'. The style concept will be explained later in this paper (2.3). It appears that there are several orientation styles. Orientation styles represent a relative stable set of attitudes and patterns of behaviour in the area of information search and processing. When conditions of farming

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alter radically, farmers however may show a switch from one orientation style to an other one. F.i. this can happen when a farmer realises that his farm will be 'winding-down' because he is at middle-age and his son decided to choose a non-farming occupation. This kind of rapid changing conditions - correlated with demographic or business cycli - come to different farmers at different times. Other radical alternations esp. in technological or market conditions may occur to all farmers in a regional area or in a certain branch of agricultural production, in the same period. In our case study (changing) orientation styles are studied in a context of accelerated sectoral changes.

Aim of these study (for the DOBI-project) is:
- to try methods of case study research;
- in order to estimate;
- which orientation styles among farmers are present and
- which switches in these styles actually occur or may be expected in the near future.


## 2. Research approach

### 2.1 Case study

A basic feature of case study research is theoretical and methodological triangulation. This means: An object (case) is studied from different points of view and with different methods of observation and data analyses.

A first form of triangulation in this case study is the use of two different conceptual models (see 2.3). Model A (Scheme 1) has been constructed in advance. Interviews with entrepreneurs were guided by this conceptual model. These interviews were analyzed in order to estimate the relative position (orientation style) of the entrepreneur. However the interviews were not guided by preconceptions completely. Entrepreneurs were stimulated to tell their story behind the answer. The preconceived model A was analyzed after each interview according to the problem of goodness of fit with face to face impressions with real entrepreneurs. Model B (Scheme 2) was constructed after analyses of all interviews. This model was based at dimensions which represent the main friction which was found between the preconceived model (A) and fresh impressions from the life-world of entrepreneurs.

Secondly, triangulation was present in the way in which information was collected and analyzed. In the preceding paragraph qualitative aspects were emphasized. Such aspects are: conceptual models, stories of entrepreneurs and estimated position (styles) of entrepreneurs. However also quantitative data and methods of analyzing were present. In most of the guided questions respondents could indicate their own position at an ordinal scale. The data were analyzed by two methods. Factor analyses reduced the complexity of information at a level of variables by looking for central dimensions. Cluster analyses lowered these complexity at a level of individual cases (entrepreneurs) by look-

ing for clusters containing entrepreneurs with about the same way of dealing with information.

A third form of triangulation was bound to the qualitative interpretation of information from the interviews. This triangulation consisted in different 'eyes of beholders'. The interpretation of interviews were discussed between the researcher (BvdP) and a professional interviewer of his institute who held 12 of 24 interviews. The results of a first analyses of all interviews in terms of (three) different styles were discussed with six local experts.

## 2.2    Case

A fourth form of triangulation in this study is multi-level analyses.

At a macro-level 'the case' consists of the nursery centre Boskoop-Hazerswoude in the western part of Holland. This centre has been chosen because of three reasons:
1)    It is a surveyable nursery centre (with arboriculture and trade) surrounded by quite different agricultural activities (meadows, arable land and greenhouse horticulture);
2)    Populated by entrepreneurs with a quite characteristic style, also compared with nurseryman in other parts of Holland;
3)    While market and technological changes (f.i. a shift toward pot nursery) represent conforming forces for entrepreneurs with a specific style.

Intermezzo: Boskoop holdings

The average Boskoop holding has about one hectare cultivated land. The differences in area-size of the holdings are relatively small. Only some of the nurseryman have a holding with more then 2 ha cultivated land. However holdings of the same area-size often are quite different regarding economic size. The economic intensity of landuse shows a positive correlation with the presence of greenhouses (supporting glass, f.i. for multiplying by cutting) and the shift away from cultivation in natural (peat) soils to container grown nursery stock. These most intensive holdings are less diversified compared with the less intensive holdings. Yet these 'specialised holdings' often have hundred or more different 'homogeneous product quantities' (species, cultivars, production stages). These small quantities are delivered to the nearby Boskoop nursery trading companies, but also to other agro-business delivery institutions in the Randstad area (Flower Auctions, Forwarding Houses in the Bulb District). Even the most specialised holding in Boskoop-Hazerswoude are highly diversified when compared with most nursery holdings in other parts of Holland. The less intensive holdings which often are diversified to an extreme extent, still are relative intensive when compared with nursery holdings elsewhere. The production costs are mainly labour costs.

Especially in discussions with local experts attention was payed at phenomena at the macro-level. One of the topics was whether entrepreneurs with a particular style have a leading or a marginal position in the production cen-

tre. Also comparisons of Boskoop with emergent centres of nursery production and trade in other parts of the country (f.i. Zundert) were discussed.

At a micro-level the number of cases was 24. These were entrepreneurs unto 64 years old, who had been chosen ad random from the area Boskoop-Hazerswoude.

At a meso-level the number of cases (three) is equal to the number of orientation styles found. These case are analyzed in discussions with local experts.

## 2.3    Conceptual frame en qualitative impressions

The central concept in this study is 'orientation style'. Familiar concepts are 'farming style' (Van der Ploeg 1991) and 'life style' (Bourdieu 1990). These concepts embody the notions of 'actors' and 'resources'. The relation between actors and resources has two sides.

At the one hand actors are the owners, users and developers of resources. At these side actors invest energy (including money) in the further development of their resources. Meanwhile these resources are used for strategic purposes. In the life style concept the ultimate reason is the gain of 'social status'. In the farming style approach these ultimate reasons are intrinsic or extrinsic 'job satisfaction'.

At the other hand actors are prisoners of the resources which they inherited, bought or developed in a earlier stage. Resources and accustomed ways of using them, represent constraints and limitations to the actor. In this sense a resource can be compared with jumping-pole. The distance which can be reached are depending not only at skills of the jumper but also at properties of the pole.

The concept of 'orientation style' is an abstraction from the broader concept of 'farming style'. Not all authors would approve about such an abstraction, because of the interconnectedness of orientation (words) and practices (things). Our abstraction can be illustrated by scheme-1 (model A). This scheme has a vertical and a horizontal entrance.

The orientation style concept focuses at the vertical entrance: The occupational orientation of the farmer. From this vertical perspective we are interested in perceptions of 'good farmers' and actions taken to improve one-self in this direction.

The 'farming style' concept refers to the horizontal entrance: The business orientation of the farm. Now we are interested in ideas of farmers about 'good farming' and actions for farm improvement. Farmers with a certain farming style will consistently give priority to a particular kind of farm improvement. In scheme-1 this priority can be attached to a particular sub-system. For instance the farming style of 'koeieboeren' or 'cattle farmers' (Spaan 1992) is marked

by a positive bias of the farmer to improvements in the 'biological sub-system'. Other farming styles are marked by the fact that the farmer has a strong preference for a certain relationship with the surrounding of his firm (see the lower part of the scheme-1). F.i. the farming style of the 'zuinige boer' or 'thrifty farmer' (Roep 1991) strives for minimum outside relations while the so called 'fanatieke boer' or 'fanatic farmer (Roep 1991) and 'topper' (Spaan 1992) are tuned at high-input/ high-output production.

In our study not these farm improvements but farmers personal improvements, represent the central question. Three human resources were used as sensitizing concepts in the investigation. These are:
1) Vakmanschap (Ability of a Craftsman);
2) Management Capaciteit (Ability of a Manager) and
3) Ondernemerschap (Ability of an Entrepreneur).
A fourth one 'Inzet/ IJver' (Motivation/ Diligence) appeared from the interviews as being important to the nursery-men. In the scheme this is left aside because at Inzet (in pure form) the information aspect is absent. The other three 'human resources' refer to personal domains of 'information + know-how (skills)' of the farmer.

Interviews with nurseryman were guide by scheme-1 (model A) in which the personal resources mentioned above, were related to sub-systems of farms. The scheme indicates nine potential areas of attention for the farmer. In the lower part of the scheme the farm surroundings is added as an extra area which is asking for attention too. The complexity of the scheme is reduced by the printing in bold of three 'areas of attention' at main cross-roads. It was presumed that dominance of orientation as a craftsman would show 'Wahlverwantschaft' (loose connection) with working with living material (biological sub-system). Domination of orientation as a manager would most easily go hand in hand with a preference for organisational activities. Dominance of orientation as an entrepreneur was presumed to be related especially at economic or financial matters. The interviews however were open to the possible existence of only loose connections. With other words: For instance, entrepreneurial capabilities can be applied also at non-financial matters such as the 'biological sub-system'.
Being a craftsman is associated by respondents with non-rational aspects of behaviour. A real craftsman is passionate -he is a nurseryman by heart- and he has intuition. An expression which is mentioned very often, is that a real craftsman has 'green fingers'. In financial matters a real craftsman is somebody who has a good nose for where the money in the market is.
Entrepreneurial capacities appear in the first place to be associated with accumulation. A real entrepreneur wants to expand his business. But in relation to the 'biological sub-system', these nurseryman is 'een verzamelaar' (a collector of valuable cultivars).
Management capacities are associated at first with 'formal rationality'. A real manager is somebody who measures his holding (in figures) and who puts a high weight at planning.

| orientation at the enterprise (sub-systems) | occupational orientation (resources) | | |
|---|---|---|---|
| | being a craftsman | being a manager | being an entrepreneur |
| biological (crops, cattle) sub-system | **1 to be a real nurseryman; to have 'green fingers'** | 4 to be somebody who registrates everything (fertilizers, etc.) in nursery | 7 to be a 'collector' of new cultivars |
| social (labour) sub-system | 2 to be a nurseryman who can handle a broad assortment | **5 to be an organiser who always works according a plan** | 8 to be somebody who always tries to do things better |
| economic (financial) sub-system | 3 to 'smell money' in the market, or knowing how to 'play with' traders | 6 to be a real book-keeper | **9 to be a real entrepreneur who wants to expand his business** |

| external sub-systems | nature | technology (supply) | markets (demand) |
|---|---|---|---|

In the interviews the affinity of the respondent with each of these cells (1 to 9) was estimated. At the end of the interview the nurseryman was asked how well he could recognize himself in nine short portraits of nurserymen.

To be a 'nurseryman with green fingers' represents without any doubt, the most popular capacity of Boskoop entrepreneurs. Feelings of occupational proud almost always were connected with skills in the handling of living material. A minority has a focus of interest in the first column (Craftsman), connected with the play of trading. The skills how to organise these complex holding (cell 2) remained remarkable implicit in the interviews. This is connected to the steady pattern of farm development. The current complex holding crystallised in a step by step process over a period of many years. An expression often used was: 'You must experience if something goes' (Je moet merken of iets loopt'.

Quite the opposite counts for the options 4,5 and 6. Many nurserymen showed a lack of affinity or even aversion, to management aspects. This will be illustrated quantitatively (see 2.4).

The third column (Capacity of being an Entrepreneur) provokes mixed impressions. At first glance few respondent show themselves as real entrepreneurs. Later in the interviews many nurserymen told about improvements

which they had in mind for their holding. This low profile is connected with a predominant pattern of steady farm development. An other cause of these low profile might be the impression that most respondents to a high degree are absorbed by 'internal affairs'. They are unlike 'real entrepreneurs with a broad horizon' (see also 2.4).

## 2.4 Some quantitative illustrations

### 2.4.1 Knowledge Model

Respondents are asked about their opinions with regard to the best way to improve as a nurseryman. According to the approach of 'agricultural paradigm' by Beus and Dunlap (1991) respondents are confronted with several sets of opposite views.

The Boskoop nurseryman were invited for each of the sets to indicate - at a five point scale - their own position to the two views.

This table holds a selection of four sets (with each two views) out of a larger number of such sets in the interviews.

The first two sets opposes informal rationality (perception in practice, craftsman skills) to formal rationality (scientific research, planning before doing). Most respondents have hardly no affinity with formal rationality. The quantitative data fit very well with qualitative impressions. Respondents see themselves in the first place as craftsmen and they are proud about this. In regard to actual behaviour there is a strong impression that most of the attention and mental energy of Boskoop entrepreneurs go towards matters of informal rationality (see also 3.4.2).

The last two sets in table 1 compare an individualistic-isolated approach (to concentrate at own holding) with an interactive approach (to compare with colleagues). These questions provoked different reactions (fourth set) or showed a preference for an interactive entrepreneurial approach (third set). This is not in line with the qualitative impressions that in many cases the world of these nurserymen is largely limited to their own holding. Yet the reactions of respondents in general look quite meaningful. There is a general awareness of a social norm which says that as an entrepreneur you should look beyond your own holding. Nurserymen often seem to know how well compared with others in their neighbourhood, they themselves apply to these norm. And of course, the qualitative impressions are influenced by the eye of the beholder. The perceived small world of Boskoop nurserymen is based at a comparison by the researcher with greenhouse gardeners in the nearby centres of Westland and Aalsmeer.

*Table 1    Number of respondents according to self perceived affinity with portraits of nursery-men*

| | | Number of respondents (n = 24) | |
|---|---|---|---|
| The best thing a nurseryman can do is to rely at ...: | | | |
| I | His own experience and perception in practice | 18 | (12 !) |
| | (Undecided between I and II) | 6 | |
| II | Results of scientific research and experimental stations | - | |
| As a nurseryman you should be at the first place ...: | | | |
| I | A craftsman with nursery acumen | 11 | (4 !) |
| | (Undecided between I and II) | 9 | |
| II | A manager who organises and figures out plans | 4 | (1 !) |
| As a nurseryman.....: | | | |
| I | It does not help you a lot to look at what colleagues do because every holding is different | 4 | (1 !) |
| | (Undecided between I and II) | 5 | |
| II | You see examples in your neighbourhood to pull up yourself | 15 | (16 !) |
| As a nurseryman.....: | | | |
| I | You have to earn it at your own holding | 9 | (4 !) |
| | (Undecided between I and II) | 7 | |
| II | Your earn most by visiting other holding and to talk with colleagues | 8 | |

! = strongly ('volledig' in Dutch) agrees with the view.

It appears that the most important sources of information are connected to informal social contacts (colleagues and their holdings) or to business contacts (suppliers, traders). Also own experience in practice is ranking high. Information sources which belong to the official (formal, specialised) knowledge network are evaluated relatively low. This low estimation applies also to institutions which have there location in the nursery centre Boskoop-Hazerswoude, such as the Experimental Station (Proefstation).

## 2.4.2   Sources of information

| Sources of information (in 7 categories derived from 'factor analyses') *) | number of respondents (n = 24) | | | |
|---|---|---|---|---|
| | unimpor-tant | not unimportant | | all |
| | | not 1th or 2th source | 1th or 2th source **) | |
| **Category 1** | | | | |
| -Professional meetings | 4 | 20 | - | 24 |
| -Extension prof. unions | 6 | 15 | 3 | 24 |
| -Exhibitions | 2 | 19 | 3 | 24 |
| -Study circles | 9 | 13 | 2 | 24 |
| -Courses | 8 | 16 | - | 24 |
| -Excursions, demonstrations | 6 | 18 | - | 24 |
| **Category 2** | | | | |
| -Colleagues and their holdings | - | 4 | 20 | 24 |
| -Traders and bourse | 2 | 12 | 10 | 24 |
| -Own bookkeeping (neg. cor.) | 3 | 21 | - | 24 |
| **Category 3** | | | | |
| -Own experience in practice | - | 5 | 19 | 24 |
| -Bookkeeper (neg. cor.) | 2 | 17 | 5 | 24 |
| **Category 4** | | | | |
| -Radio | 14 | 10 | - | 24 |
| -Experimental Station (local) | 6 | 16 | 2 | 24 |
| -Employees (neg. cor.) | 10 | 12 | 2 | 24 |
| **Category 5** | | | | |
| -Professional papers | 1 | 18 | 5 | 24 |
| -Laboratory analyses | 6 | 16 | 2 | 24 |
| -Supplier, f.i. soil | 2 | 8 | 14 | 24 |
| **Category 6** | | | | |
| -Teleservice, PC | 18 | 6 | - | 24 |
| **Category 7** | | | | |
| -Family at holding (neg.cor.) | 3 | 17 | 4 | 24 |
| -Extension Service, Advice Bureau | 12 | 7 | 5 | 24 |

*) Neg. cor. = Negative correlation with other variables (sources of information) in same category (factor); **) Mentioned as 1th or 2th source of information in one of the following situations: 1) Cultivation problems; 2) Product Choice; 3) Large investments and 4) Succession and occupational choice children.


## 2.5   Three styles

Cluster analyses was applied at 24 cases (all respondents) with 17 variables (reactions related to orientation). The method brings respondents together in

(relatively) homogeneous sub-groups (clusters). The 17 variables which are taken into account represent reactions of respondents at:
1) Knowledge Model (see 2.4.1);
2) Evaluation of information sources (see 2.4.2) and
3) Identification with 9 portraits of nurserymen which correspondent with positions in scheme 1 (see 2.3).

The result of the cluster analyses reads as follows:
Cluster (Style) A            8   respondents
Cluster (Style) B           10   respondents
Cluster (Style) C            5   respondents
Lonesome case                1   respondent
                          ------
All                         24   respondents

    The scheme below gives an impression of what makes these clusters (styles) different. The horizontal dimension in this scheme is individualistic (isolated) versus interactive orientations. The vertical dimension is informal versus formal rationality.
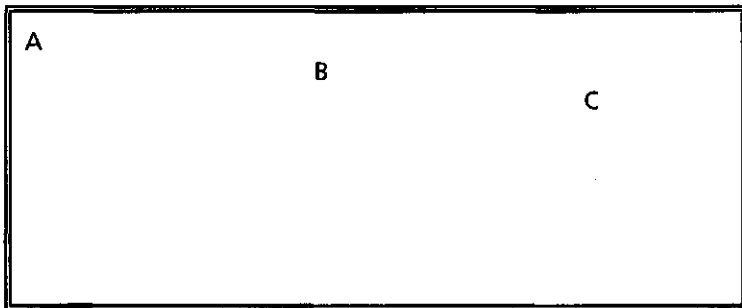
Scheme-2  (Model B): Estimated position of orientation styles A,B and C.
          Vertical dimension     = Informal vs formal rationality
          Horizontal dimension = Solitary vs interactive orientation

solitary, informal                          interactive, informal
(isolated craftsman                         (social comparison
model)                                      model)



solitary, formal                            interactive,
(calculating                                formal (study
decision maker model)                       circle model)

Style A is found in the scheme in the left-above corner (non-interactive, informal rationality). These nurserymen appear from the interviews as being mentally absorbed by hard work.

Style C is the opposite of style A. However even in these style formal rationality in general is valued rather low. The interactions with colleagues are relatively intensive. These interactions are not embedded in organised networks such as study circles. The interactions of this style may be called semi-organised. Their is a close connection between informal (personal) contacts and interactive (business) interactions. However the impression was got that most of the times informal contacts are a side-effect of interactive orientation. With other words: Contacts with colleagues tends to be selective and in the beginning inspired by professional orientation.

Style B is located halfway between style A and C. This style appears as the typical Boskoop style, from which both other styles originated. These respondents appear as the real craftsmen. Compared with style C they are less tuned at high-productivity but (at least) to same high degree at high-quality. They are proud of having specialities in their assortment. This accounts especially for species which are to difficult to produce by most of their colleagues. Compared with style A these nurserymen have much more contacts with colleagues. The impression is that interactive orientation is a side effect of informal social contacts in the production centre. A handicap for interactive orientation is that the holdings are so extremely diversified and different.

## 2.6    Dynamic aspects

Style A interacts with winding-down or stand-still processes in holding development. Many of these entrepreneurs say that their holdings probably will be terminated when they themselves retire. Their holdings in general are extremely diversified and labour intensive. The entrepreneurs of style A might be characterised as 'thrifty hard working nursery man'.

Style C interacts with processes of relative specialisation and capital intensification. These few entrepreneurs made relatively large investments, especially in 'supporting glass' and shifting to container grown nursery stock. Local expert see in this group a rising leading group in the nursery centre Boskoop-Hazerswoude. The entrepreneurs of style C try to combine craftsmanship and quality with management and productivity. This style might be called 'high productivity nursery man'.

Style B ('the real Boskoop nurseryman') is tuned at mixed and gradual holding development. Peat soil grown nursery stock is central in their holding. Local experts see a future for such a typical Boskoop way of development. However after there opinion there is a lack of leading holdings and co-operation between innovative entrepreneurs.

The three style were quite recognizable for local experts. A central theme which appeared from the discussions was:
1) How to realise a higher level of professionalisation;
   (to stimulate nurserymen leaving the left-above corner of Model B)
2) Without loosing the current high level of craftman's qualities.

This applies especially for style B. Local experts did not see an autonomous development which could make this central group of Boskoop entrepreneurs 'ready for the future'. They were depressed by the failing of a recent initiative to establish a network (circle) which intended to study niches in the market. Some local experts reported that the 'raison 'd' être' of Boskoop was incorporated in style B and its specific utilisation of peat soils.

Regarding style C local experts saw an autonomous development which they consider as growing professionalisation. As a result of shifting to container grown nursery stock this small group will grow in number. These entrepreneurs maybe will dominate local organisations. However there is also a tendency to hitch on at national based nursery organisations or at institutions in the nearby greenhouse centres.

## 3. Discussion

*IT and real entrepreneurs*

There is a gap between at the one hand the concept of Information Technology and at the other side the life-world of Boskoop nursery-man. In these life-world information is not a product which can be isolated from practice. In other sectors or regional areas this gap probably is not as big as it is in Boskoop. In that sectors and regions however 'informal rationality' and 'self-supply with information' may play a much larger role than outsiders may be inclined to think.

*Embeddedness in many ways*

The orientation of entrepreneurs is not a matter of 'Freischwebende Inteligenz'. To the contrary, this orientation is embedded in different ways. The orientation Boskoop nursery-men appears to be embedded in:
1) Holding structure and development;
2) Local culture and informal networks;
3) Commercial networks.

As a possible key factor can be mentioned the small scale of the production. Most holdings are small family firms each with a large number of very small product groups. This make every holding a unique case. This makes it a difficult target for suppliers of information by formal IT-networks. Informal networks are important but often at a generalized level. Entrepreneurs f.i. can

discus new techniques of reproduction of plants by cuttings but they don't have the same context of appliance.

*Substitution of informal by formal rationality ??*

According to local experts style B only will have 'a future' if a development to a higher level of professionalisation takes place. In this regard some theoretical remarks about scheme-2 seems to be relevant. It may be doubtful if 'moving towards formal rationality' always means 'moving away from informal rationality'. The opposite can be the case. A typical instrument of formal rationality as a registration system for minerals can be used by the entrepreneur as a tool to look in the field with a sharpened eye at his holding. The same can be true for 'moving to interactive orientation'. An entrepreneur who takes part in study-circles f.i. may be motivated to have an intensified observation of his own holding.

This may have implications in many regards, f.i. for the thinking about the so called centre function in horticulture (Reinhard 1995). The increased mobility of entrepreneurs and the growing possibilities of telecommunication do not automatically mean that the significance of local contacts decreases.
Interactive orientation can be a key factor which decides about the future of typical Boskoop cultivation. Information Technology for these specific cultures can be developed only in interaction processes between practice and specialised knowledge institutions. A current bottle-neck is the lack local farmers (participation in) networks. There is also a lack of nurserymen who operate at interfaces between farmers networks and networks of specialised knowledge systems.

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# FARMERS' MACHINERY INVESTMENTS

by Senior Researcher Brian H. Jacobsen 1)

## Abstract

*In examining the econometric models used to explain variations in demand for tractors, this paper concludes that the explanatory power of the models is low when dealing with net investments. The models seem to be better at explaining variation in gross investments, but neither the neo-classical, the accelerator nor the ad-hoc models, can claim to be superior to the others. The previous year's income seems to be the most important variable. There are few variables with a high general explanatory power and the studies have therefore to be supported by descriptive analyses. The paper then discusses findings of a more descriptive nature concerning farmers ability to forecast machinery investment and how the decision is made. Findings suggest that the decision process can be divided into two parts, with a long phase of considerations and a short phase were the action is taken. Machinery investments are often underestimated and it is crucial that the farmer is able to make the necessary calculations as few outside the farm are involved in the process. It is concluded that greater knowledge of the decision process would enable better advice and better forecasts concerning farmers' machinery investments.*

**Key-words** : Machinery, Investments, Farmers, Decision.

## 1. Introduction

Explaining farmers decisions, especially investment decisions, is not easy. The decision process is complex and not always based on systematic economic calculations. Previous research in Denmark has shown that Danish farmers underestimate both future machinery investments and future costs related to these investments (Jacobsen, 1994a). Although much research has been carried out concerning farmers' investments, researchers' understanding of the investment behaviour, both theoretical and empirical, is still unsatisfactory (Elhorst, 1993).

A new Danish research project looking specifically at farmers investment decisions has therefore been undertaken. The main purpose of the project is to gain insight into the farmers' investment decision making process based on interviews and previous findings.

The purpose of this paper is to give an insight into previous work on machinery investments. The first section of the paper reviews different economet-

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ric models used to estimate farmers' capital demand. In the subsequent section, the results concerning demand for tractors, primarily in the UK and the USA, are presented and conclusions related to the model approach and the variables, are made. The purpose is to find variables which have proved to have a high general explanatory power. Descriptive findings are discussed in section four looking at the decision process and farmers ability to forecast machinery investments. The paper finishes with remarks on the findings and an outline for the future work.

## 2.    Econometric models of agricultural investments

Econometric models have often been used to analyse farmers' investments. Jorgensen (1967) emphasises the importance of testing the explanations found in the economic theory by econometric models. Econometric models are good at finding general explanations over a number years, using time series data. Although typically not very good at explaining decisions made on the individual farm, they can give explanations which are more reliable than case studies. After an introduction to different models of capital investments, the results from these models are analysed to find general conditions which influence farm investments.

2.1    Introduction to models of capital investments

One of the major problems when analysing capital investments, is that the statistical information normally presents the total or gross investments per year. The gross investment is equal to net investment plus replacement investment (1), where the net investment can be defined as the difference in capital stock ($K_t$) from one year (t) to the next (t+1).

(1)    $I_{gross\,(t)} = I_{net} + I_{replace}$ , where
(2)    $I_{net} = K_t - K_{t-1}$ ,

Often the net investment ($I_{net}$) is the focus of attention, which means that assumptions concerning the replacement investments has to be made. The general assumption is that the replacement investments are a fixed proportion (δ) of the level of capital (Jorgensen, 1967):

(3)    $I_{replace\,(t)} = \delta * K_{t-1}$

The replacement investment over a period is often assumed to be equal to the depreciation. Instead of a fixed level, some models use different depreciation patterns (geometric decay or engineering data patterns, Penson, et al., 1981). The choice of model for replacement investments is important as, in general, they are larger than the net investments. Net investments in agricultural assets are often less than 1/4 of the replacement investments taken as the annual depreciation (SJI, 1994).

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The level of capital (**K**) can be measured in value, horsepower or numbers. With technological progress, an old and a new tractor are very different in efficiency and a decrease in numbers might not necessarily imply lower total value or horsepower. The technological development has been accounted for in different ways by calculating a quality index, based on horsepower, four wheel-drive etc. (e.g. Cooper, 1994).

A very central variable in calculations of capital investments, is the optimal level of capital (**K***). It is assumed that there is an optimal level of capital that all farmers try to reach. The present level of capital moves towards the optimal level with a given percentage ($\lambda$), which is assumed constant over time. The net investment is hence the difference between the present and optimal capital level multiplied by the speed of adjustment, where the average adjustment time is: **$\lambda/(1-\lambda)$**.

(4)    $\mathbf{I_{net}} = \lambda * (\mathbf{K_t^* - K_{t-1}})$

In the following, we will look more closely at how the optimal level of capital is determined.

## 2.2    Choice of model

The most commonly used models when estimating the optimal level of capital is:
1.    Accelerator models
2.    Neo-classical models
3.    Ad Hoc models

*Accelerator models*

The accelerator models assume that the ratio between the optimal level of capital and output is fixed.

(5)    $\mathbf{k_t} = \mathbf{K_t^* / Q_t}$, where

$Q_t$  =  the total output (amount)
k    =  the constant ratio between output and capital

In its simple form the accelerator model assumes a progression towards the optimal level of capital, which based on (4) looks like:

(6)    $\mathbf{I_{net(t)}} = \lambda \, (\mathbf{k \, Q_t - K_{t-1}})$

The level of net investments is therefore a function of change in output of e.g. all agricultural products. The models are also called Clay-Clay models, because of the fixed (clay) relationship between the factors. The model has been criticised for its symmetrical nature and the assumption that the adjustment to the optimal capital level is constant over time and depends only on

output. Models which try to overcome these drawbacks are called flexible accelerator models. In the flexible accelerator model, the level of capital is a weighted average of previous optimal levels of capital (Hegrenes, 1991).

## Neo-classical models

The optimal level of capital is estimated from the relationship between earnings (**Q\*p**) and the price of capital (**c**). The basic idea is that the investment function can be derived from the neoclassical production function, which assumes that companies maximise profit (Jorgensen, 1967).

The profit maximizing theory postulates that the firm should adjust its stock towards an optimal stock level. The optimal stock level is determined by the income and the costs from running a machine. These costs are found by calculating the implicit rental on capital services at each point in time.

The optimal level of capital is:

(7) $K^*_t = \alpha * (Q_t * p_t) / c_t$, where

$K^*_t$ = optimal level of capital
$Q_t$ = Output
$p_t$ = Product price
$c_t$ = Price of capital
$\alpha$ = Elasticity

The models are called 'putty-putty', because the relationship between the variables is flexible. The net investment using (4) then becomes:

(8) $I_{net\ (t)} = \lambda\ (\alpha * Q_t * p_t / c_t) - \lambda\ K_{t-1}$

According to the neoclassical theory, higher profitability will lead to more investments, while the accelerator model will respond to higher output. In between the Clay-Clay and the Putty-Putty models, are the so-called Putty-Clay models, where the factors are fixed after the investment has been made (Cooper, 1994).

## Ad Hoc models

In these models, the optimal level of capital is determined from a range of variables like the previous year's income, land prices, level of liquidity etc. They are not limited to the variables mentioned before, but are limited by the model maker and the data. Hence a simple model can look like:

(9) $K^* = f(x) * P_{t-1}$, where

**P** is the previous year's profit (t-1) and **f(x)** the functional relationship between profit and optimal capital. The total model becomes:

(10)  $I_{net\,(t)} = \lambda * ( f(x)*P_{t-1} - K_{t-1})$

All three model approaches described in this section, try to estimate the optimal level of capital. We will now see how they have performed and which parameters are the most important.

## 3.    Results from models of farmers' demand for tractors

One of the difficult factors in estimating tractor investments is the quality of data. How many tractors are, in fact, still in use and what is the value of these ? There are different ways of dealing with these problems as well as differences from one country to another. This has to be remembered when comparing results from different analyses.

Analyses have been carried out since the 50'ties mainly in the USA and the UK. The results presented in this paper are the results which have given the best explanation of the dependent variable chosen. Only significant variables (5% level) are generally included. The discussion here focuses mainly on the $R^2$ -value, but this value should not be taken uncritically as there might be problems with multicolinearity, however this is seldom mentioned in the papers presented. A summary of the results are given in appendix 1. It can be noted that the price of tractors used are often the real price, either per tractor or per horsepower (Brase, and Ladue, 1989).

Looking at the results, it is clear that the first analyses made after the Second World War were good at explaining the variation in demand (e.g. Griliches, 1957 and Heady and Tweeten, 1963 op. cite Rayner and Cowling, 1968). With $R^2$ -values of more than 90%, they performed well. The important parameters here were the price relationships between tractors and output (crop prices). The interest rate was also significant and so was the previous year's stock. It seems reasonable that the relative price in terms of tractor price and interest is important in deciding whether to buy a new tractor. In the study by Heady & Tweeten (1963) it was found that the amount of acres were important in explaining investments. Farms with high acres invested less per acre than small farms indicating higher productivity on larger farms.

In a later study of the demand for tractors in the USA, covering some of the same years, Rayner & Cowling, (1968) found similar results in trying to explain the demand for tractors. Their models were much better at explaining the number of tractors than the number of horsepower purchased.

Rayner & Cowling had in 1967 examined the UK market using the same approach as in the USA-study. The results were different as they found tractor prices in relation to labour earnings to be important. This can be explained through the fact that labour earnings (wages) are probably higher in the UK and hence are more important in deciding when to replace labour with machines. Investment allowances was also significant and can be explained by a higher tax-rate in the UK than in the USA. Rayner & Cowling, (1967) found, in general, that UK farmers adjust quickly and have a more highly developed

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profit seeking behaviour than management in industry, looking at the significant variables.

Where the previous models were based on ad hoc models, Penson et al. (1981) looked at the depreciation pattern using a neo-classical model. The replacement investments were found from the depreciation pattern chosen. Penson et al. (1981) found that the engineering data pattern gives the best explanation. This pattern assumes a much lower fall in the level of service over the years than most other depreciation patterns e.g. the geometric decay pattern. The analysis found agricultural output over implicit rental price to be significant, as well as the stock of capital and the previous year's net investment.

In an analysis from the UK, looking at net investments in agriculture, Dawson & Dawson (1984) did not find any significant variables at the 5% level, although their equation has a high explanatory power. They used 5 different models, but none preformed very well. In one of the most recent articles on net investment in tractors in the UK (Cooper (1994), neither the neo-classical, nor the ad hoc models were very good at explaining net investments. One of the few significant variables is investment allowance, but the model can only explain less than 50% of the variation in demand.

In other countries, like Australia (Vanzetti & Quiggin, 1985) and Norway (Hegrenes et al., 1991) attempts have been made to explain farmers' investment decisions using econometric models. The approach in Norway using ad hoc models was not too successful, but results from Australia show that the gross return on sheep and beef are the most important variables. An analysis of investments in the Dutch Dairy sector based on individuel farm data conclude that the predictive power of the estimated model is disappointing (Elhorst, 1993). He concludes that a lot of important variables are still missing in the investment equations.

In Denmark, few have tried to model future investments. Andersen & Stryg (1985) based their forecast on a regional LP-model and forecasts of earnings over the following 5 years. The model forecasted the right development in investments (falling), but the development progressed quicker than the forecasters thought. The model is not used anymore.

The Danish Institute of Agricultural and Fisheries Economics also makes forecasts of future investments. Previous forecasts have not been based on econometric calculations, but on a sample of the farm accounts concerning the forecast period (one year), which is why the estimates have been fairly successful. In 1995, estimates of future investments are going to be made based on the farmers forecasts, which is discussed in the next section. This model seems so far to be able to produce fairly good results.

*Conclusion of model and results*

The conclusion is that the models have difficulty in explaining farmers' investments decisions, which is a general problem with investments not only in agriculture. All in all, the following conclusions can be drawn:
1.  Newer attempts at modelling farm demand for tractors are not as good at explaining variations in demand as the old ones.

2.	It is easier to estimate the gross investments than net investments.
3.	The ad hoc models seem to produce just as good results as the neo-classi-
cal ones.
4.	There is no standard way of dealing with technical change, but it is im-
portant that it is included.
5.	Liquidity has not been significant in any of the studies, but the previous
year's income is, in some cases.
6.	Tax allowance is significant in UK models.

The models do not offer general explanations which cover both the USA
and the UK over a long period of time. These analyses therefore can not stand
on their own, but have to be supported with more descriptive analysis.


## 4.	Descriptive analysis of machinery investments

After having discussed econometric models, this section deals with more
descriptive findings primarily from Denmark, discussed in Jacobsen, (1994a &
1994b), based on a survey of 25 farmers. The main focus here is how well farm-
ers plan their machinery investments (gross investments) and how the decision
process can be described.

*Farmers planning of machinery investments*

Previous analyses have found that farmers underestimate future invest-
ments (Christensen et al., 1990). In interviews with farmers, they claim that they
have a long phase of 6-12 months where they consider future investments and
a short action phase of up to 2 weeks where the choice of brand is made
(Jacobsen, 1994). The interesting point is that farmers in the first period do not
disclose their ideas to their bank, their advisor or their spouse. When the deci-
sion is made, it is seen by people around the farmer as a very sudden decision,
whereas the farmer thinks it has been well planned.
	This is supported by analyses carried out by the Danish Farmers' Union
(DFU, 1995). Here farmers are asked what they expect to invest in machinery
in the period 3 to 9 months from the time they are interviewed. At the same
time, they are asked what they, in fact, have invested in the past 6 months
(DFU, 1995). It can be seen from figure 1, that farmers constantly underesti-
mate future machinery investments. The machinery investment is fairly con-
stant, around twice the expected level in all the years from 1979 to 1994. One
would think that the expectations in some years were much closer or even
higher than the actual level, but that is not the case, although investments
have been fluctuating over time. Also the level of income does not seem to
influence how good the forecast is. It should be noted, that that building in-
vestments are much closer to the expected level over a number of years.
	In all years, farmers expect to invest less the following 6 month than they
did during the 6 months before. On average 17% of all farmers expect to make
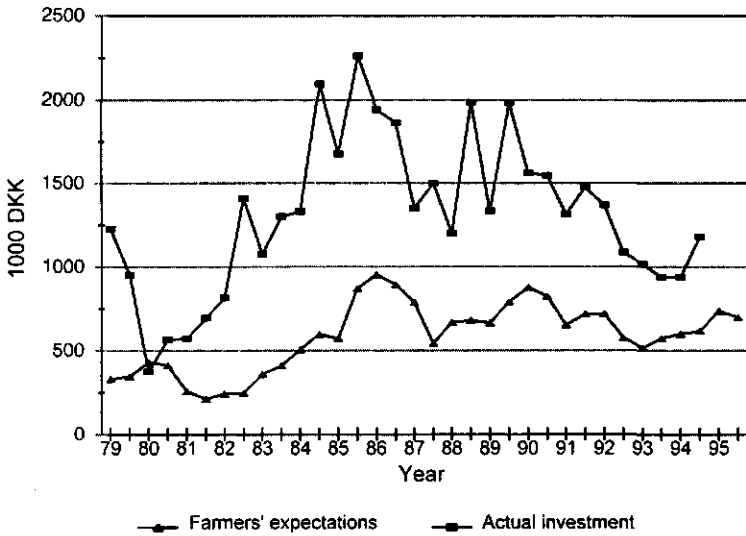machinery investments and 25% actually made machinery investments. A more

*Figure 1    Danish Farmers expected and actual machinery investment*
Source: Danish Farmers Union, 1995

detailed analysis of their expectations, reveal that in 12 out of 17 years there have been larger investments in the second half of the year. This is supported by statistics saying that more then 35% of all tractors and more than 50% of all combine harvesters are sold in October-December (LIB, 1995). In most, years the forecast for the first half of the year is slightly better than for the second half (DFU, 1995).

The findings seems to show that when farmers are asked by outsiders about future investments, they disclose only the ones already decided upon. Only 50% of all machinery investments are planned 3-9 month before. A lot of farmers indicate that their investments are based on the situation here and now, whereupon a frame is set for the actual investment (Jacobsen, 1994). It seems crucial that the farmer, before these quick decisions are made, has the necessary information and is able to calculate the 'true' cost, as no 'sparring'-partner is involved in the process.

### Information gathering

Experience from Denmark seems to indicate that farmers are well in-formed about dealers and price levels etcetera (Jacobsen, 1994a). They are not however very good at calculating the costs, neither the tractor cost per year nor

the machinery cost per year. The analysis showed that the costs were generally underestimated by 25-30% (Jacobsen, 1994a).

Findings from the UK, concerning a survey of 55 farmers, show that many farmers got their initial source of information about a particular tractor through previous experience, with 'previous ownership' being the most dominant factor (Foxall, 1979). Agricultural shows were ranked very low, but sales representatives came second. Asked about the influential factors in the purchase decision making, they said that technical performance and price are the most important factors. The survey found, in line with the previous discussion, that two-third of all the farmers did not discuss the decision with anyone before it was made. The ones that discussed their decision, discussed it primarily with local farmers. It is interesting that farmers do not get their initial source of information from other farmers and only 1/3 discuss it with other farmers, and yet they claim that approximately 70% of their neighbours had purchased a similar model.

Using experience as a guide, means that farmers might not look for available alternatives due to brand loyalty and a very limited search behaviour. The author concludes that farmers' behaviour when buying a tractor to a large extent is parallel to the behaviour of professional buyers in manufacturing and service industries (Foxall, 1979). In both cases, a 'human element' and experience, is the strongest determinant in the decision process. Farmers' purchase of tractors are similar to most industrial purchase decisions in that they are strongly influenced by both behavioural factors and purely economic forces.

Concerning the price, it should be noted that a typical Danish farmer gets reductions of 20-30% of the official price (Jacobsen, 1994). It is unclear how the prices are determined, but farmers seem to buy more when they get a high price for their secondhand machine. It is however unfortunate if this situation is used by the dealers to increase the price in years with a high demand. It is therefore also in the farmers' interest to level out machinery investments over the years (Petersen, 1994).

*Reasons for investments*

Findings from Jacobsen (1994) seem to indicate that fear of repairs or even breakdowns were ranked highest as a reason for investments, followed by price, technology and as a fifth working conditions. It seems like farmers over a period of time become more aware of the problems with their present machinery. Problems with e.g. the gearbox, gradually become unbearable and the decision to buy is made. Alongside the decision of whether to buy, the decision of which brand to buy is analysed. The farmer looks at tractors when he is at the dealers for 'other reasons'. He finds 'room' in the budget, and if he sees a good offer he buys the tractor immediately.

Often, however, the fear of future breakdowns is overrated. The fact that a new tractor is better and more comfortable is often hidden in this excuse. The maintenence costs do not seem to increase dramatically over years and the the total cost seems to fall over the life time of a tractor when no technological

development is assumed (Laursen, 1993). Better working conditions etcetera often give higher utility, but not necessarily higher income.

Many investments in tractors in recent years have been made due to new methods in cultivating and sowing, requiring fewer, but larger tractors. Findings by Foxall (1979), show that technical performance and price were the most influential factors when deciding which tractor to choose.

High income and tax allowances are not stated by farmers as the prime reason for machinery investments, but it is mentioned as a reason for the time of year. Farmers themselves say that higher income does lead to higher investments, but they do not regret the decisions made afterwards (Jacobsen, 1994a). The high income is more a fact that triggers investments that have already considered. Other findings on the decision making process indicates that soil quality, value of machinery inventory, the operator's age and education, influence how the decision is made (Johnson, et al., 1985). Comparing their findings to statements made by farm machinery dealers on what they perceive to be important, it was found that dealers underestimate the importance of machinery wearing out and overestimate the importance of improved technology and investment allowance. The conclusion is that dealers should learn more about their customers decision making process.

## 5.    Final remarks

The conclusion of this paper, looking both at econometric and descriptive analysis of machinery investments, is that the farmers' decision process is not easy to describe. It is difficult to find variables that explain variations in demand for tractors. The econometric analyses have not been able to find one model which is superior to the others as shown by Brase & Ladue, (1989). Both the econometric and the qualitative analysis seem, however, to show that previous year's incomeis important.

Farmers have a short planning procedure, which means that future machinery investments are underestimated. It seems crucial that the farmer collects the relevant information and is able to make the necessary calculations, as no-one outside the farm questions the basis on which the decision is made. It is not easy to see how farmers know when or how much they can invest in machinery. For farmers who are not able to evaluate the costs of investments, this can lead to economic problems, especially on farms with a high debt rate like the Danish ones.

The planning procedure, the decision process and the reason for investments as well as the cost evaluation is analysed in a Danish research program. During a three year period (1995-98), a number of farms will be followed closely to get a better understanding of these problems. The information will then be used to make a model which tries to 'mimic' farmers' machinery investments. The purpose is to get an insight into the decision process and reach conclusions which can help advisors in their job. The findings here suggest that there is no easy way of describing farmers' machinery investments. Farmers' lack of theoretical calculations seem to be helped by 'rules of thumb', which

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allow farmers to make acceptable decisions. The project has therefore an interesting, but not a very easy task ahead.


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Table 1 Results from studies of investment in farm tractors

| Author | Data | Model | Dependent variable | Significant variables | $\bar{R}^2$ | $R^2$ |
|---|---|---|---|---|---|---|
| Griliches, 1957 | USA 1920-57. | Ad hoc | Gross investment in tractors | Tractor price / Crop price (t-1)<br>Interest<br>Lagged stock | | 0,91 |
| Heady & Tweeten, 1963 | USA 1935-60 | Ad hoc | Gross investment and Stock change | Acres per farm<br>Tractor price / Output price<br>Net real farm income (t-1) | | 0,91<br>0,92 |
| Rayner & Cowling, 1967 | UK 1948-65 | Ad hoc | Gross Investment | Tractor price / Labour earnings (t-1)<br>Investment allowance<br>Lagged Stock | 0,94 | |
| | | | Stock | Tractorprice / Labour earnings (t-1)<br>Lagged stock<br>Tractor price / Crop price<br>Investment allowance | 0,998 | |
| Rayner & Cowling, 1968 | USA 1947-62 | Ad hoc | Purchase of number of tractors | Acres per farm<br>Age<br>Lagged stock of tractors<br>Number of farms<br>Stock of horsepower | 0,93 | |
| | | | Purchase of tractor horse-power in total | Age<br>Crop production | 0,64 | |
| Penson et al., 1981 | USA 1950-78 | Neo-classical | Net investment in tractors ($) | Output*price/cost<br>Real stock of farm tractors<br>Net investment (t-1) | | 0,67<br>0,86 |
| Dawson & Dawson, 1984 | UK 1950-79 | Accelerator<br>Neo classical<br>Ad hoc | Net investment in agricultural machinery, buildings etc. | (none are significant)<br>(none are significant)<br>Land prices (at 10% level) | 0,90<br>0,90<br>0,91 | |

*Tabel 1 Results from studies of investment in farm tractors (continued)*

| Author | Data | Model | Dependent variable | Significant variables (5%) | $\bar{R}^2$ | $R^2$ |
|--------|------|-------|--------------------|-----------------------------|-------------|-------|
| Vanzetti & Quiggin, 1985 | Australia 1957-83 | Neo-classical Putty-Putty | Net investments | Gross return from sheep and beef Income from cereals (t-1) Income from cereals (t-2) | | 0,58 |
| | | Clay-Clay | | Stock of tractors / acres Income from sheep and beef | | 0,56 |
| Hegrenes et al., 1991 | Norway 1978-87 | Ad hoc | Gross investment in equipment | Income - depreciation (10% level) Debt rate (10% level) | 0,10 | |
| Cooper, 1994 | UK 1964-90 | Neo-classical Ad hoc | Net investment in tractors | Output * Price Investment allowance | 0,19 0,41 | |

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# COMPUTER-BASED MANAGEMENT DIAGNOSIS ON THE AGRICULTURAL CONCERN: ADVANTAGES, LIMITS AND PERSPECTIVES

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## Abstract

*This paper describes the experiment of modelizing and computerizing the management diagnosis of a farm carried out by 9 advisory centers with the Ecole Nationale d'Ingénieurs en Techniques Agricoles de Bordeaux. The tool chosen for computerizing the reasoning process was an expert system based on production rules, on a micro-computer. The authors first describe the aims of the expert system and the methodology used. Then, they draw the following conclusions. Fine-tuning the expert system to bring it up to a professional level requires a specific method of work and a homogenous information system. Moreover, the quality of diagnosis depends on the one hand on the transcription of human reasoning and on the other hand on information used to evaluate references, that is to say standard references and normative references. The authors define these two terms before showing that the relevance of the diagnosis depends on these references. Finally, they try to show that it is possible to improve the definition of a reference as well as the way of using it in order to provide the farmer with a more evolved Information System.*

**Key-words** : expert system, standards, references.


## 1.    Introduction

Faced with increasing uncertainty as to the future, many farmers now apprehend their role in the world as real bussinessmen; these are the « agri-managers » or « innovating-farmers ». They need, in order to make optimum choices, a regular evaluation of their farm's performances. Of course, an analysis of economic indicators does not lessen the risks stemming from the choice of a production system or from the weather pattern. Nevertheless, the perfor-

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mance of the farm is improved when an economic diagnosis is regularly set up to provide the farmer with a more evolved Information System. Based upon this vision of farming, research was carried out by a team at the E.N.I.T.A. in order to systematize the economic diagnosis in agriculture.

This diagnosis, which is, in fact, an evaluation of the farm's situation, requires the collection and treatment of several kinds of economic data. The analysis relies, indeed, on technical data as well as on financial data. Based on existing information, the goal of the analysis is to provide the farmer with results which can help him to take his decisions. This diagnosis presents indicators which, in fact, can be broken down into three parts: value, semantic content and decisional content.

In France, the fonctionning of the Information System (IS) in agriculture is such that all management information is collected and treated by external experts: the advisory centers. This is quite different from industry and results from the specific situation of the agricultural world. Contrary to other diagnoses on a farm, the management diagnosis can, therefore, be easily formalized and systematized.

Even if the use of computers has become usual in agricultural management, classic software in agriculture is not adapted to systematizing human reasoning. It is necessary to apply new methodology: the use of artificial intelligence, and more particularly, the expert system. Though the expert system, it is possible to automatize the management diagnosis on a farm and, therefore, to provide the farmer with a more evolved Information System.

In the first part of our presentation we will define the aims of the expert system, then describe the methodology used in setting up the automatized diagnosis. In the second part, we will examine the role of the information system in the expert system to show how the relevance of the diagnosis depends on information.

## 2. Automatizing the management diagnosis of a farm by means of an expert system

### 2.1 Aims

#### 2.1.1 Meeting the demand of farmers

As early as the the beginning of the nighteen eighties, farmers were under pressure to take management decisions in the context of the agricultural crisis. This remains the situation today. French national production has, indeed, reached the excess level and, now, seeking of maximum production no longer means maximum profits. From 1984, the Common Agriculture Policy has gradually imposed quotas in order to reduce the level of production. The development has forced farmers to adapt their management policy: improving productivity and production through technical mastery is no longer sufficient. Nowadays, uncertainty prevails: in order to manage a farm successfully, the farmer must be able to adapt very quickly to changes in the economic environment.

He must continually modify his choices concerning: investments, production, personal expenses ... In short, to cope with a more and more uncertain environment, the farmer needs to evaluate the economic situation of his farm regularly, i.e. set up an economic diagnosis, so that he can take the best decisions at the best moment.

In France, in most cases, this diagnosis (Bonnet, 1984) is not carried out by farmers but by advisory centers. This means an extra cost that the farmer is not always ready to pay, in so far as the value of this information is rarely evident.

This explains why it seemed useful to our team at the E.N.I.T.A. to automatize this diagnosis through an expert system.

### 2.1.2    Offering new advantages thanks to automized methods of diagnosis

As stated earlier, farmers need a comprehensive diagnosis which can be regularly used and whose cost remains low. However, in order to define such a diagnosis, it is necessary to set up, to systematize, then to automatize a comprehensive diagnosis method.

This task was carried out by a team at the E.N.I.T.A. with the help of nine advisory centers in the north of France, which represent more than 7,000 farmers who wanted to automatize their economic diagnosis. The goal targeted by the team was to systematize a diagnosis suitable to all kinds of farms. The data used was mainly accounting data, completemented with technical information and references from outside the farm.

Therefore, compared with other methods, the automatization of the diagnosis by means of the expert system was found to be a time saver. In addition, it reduced costs, while remaining easy to understand.

### 2.1.3    Exploiting the possibilities of artificial intelligence by means of an expert system

Another aim identified by the team was to use the assets of artificial intelligence in setting up the automatization of the management diagnosis.

In the field of artificial intelligence, three areas can be distinguished (Bonnet, 1984): automation, treatment of natural language, and expert systems. The latter is the most relevant for our method. An expert system is, indeed, 'software which automatizes the knowledge of an expert on a topic for a well-fixed aim'. However, the simulation of human thinking by means of an expert system implies two pre-requisites. First of all, human thinking in the research domaine must not be too structured so as to be formalized by an algorithm. Secondly, the human expertise must be updated according to accumulated experience.

These two conditions are present in the case of the automatization of farm management diagnosis. This is why artificial intelligence harnassed by the expert system is used in our method.

## 2.2 Methodology

### 2.2.1 Formalization of the diagnosis by an expert team

To set up the diagnosis, we used a method designed to take into consideration all possible cases for a specific problem. To utilize this method, which requires a global vision of the problem, the expert team (one person in each center) referred back to its own concrete experience. In order to identify all the information necessary for the diagnosis, they studied technical as well as economic and financial areas. The diagnosis was split in six parts. Utilizing the same methodology, each part was independently analysed and included three steps: presentation, explanation, and commentary.

### 2.2.2 Automatization with a specific tool

To formalize the diagnosis, the experts met two days per month for one year. During these meetings, they compared their own experience and points of view. After each meeting, two people of our team at the E.N.I.T.A. worked for four to six days to set up a preliminary formalized version by the means of a generator with production rules. This version was then sent to all advisory centers. The latter utilized this version on concrete cases with a view to noting all problems or errors in the analysis. There was a feed back to the expert team: the team corrected the first version which was re-tested. In other words, there was a constant exchange between the experts and the advisory centers in setting up the final version.

## 2.3 First results and conclusions

### 2.3.1 Advantages in using the 'expert system' tool

Three actors can be identified in the implementation of the expert system: advisory centers which set up the system, advisors who use it and farmers who read the final commentary. Each actor obtains specific advantages but the main idea which emerges is that of diagnosis cohesion.

First of all, the formalized diagnosis (which always uses the same logic) brings to the farmer a homogenized view of the management policy which should be implemented on the farm. Moreover, this tool allows for the comparison of diagnoses over time and, therefore, gives a good representation of the evolution of farm indicators.

Secondly, the expert system offers advisors three advantages in comparison with their previous methodology.

The first one is a gain in time. A 'manual' diagnosis requires about three hours of work while the expert system produces the same report in eight minutes, including the printing. The advisor can, therefore, produce more reports.

The second advantage is the harmonisation of the advisors commentary style. The diagnosis framework is the same for all advisors. The reasoning logic

and references are always the same: a common base of analysis underlies each commentary.

The last advantage lies in the personalization of the commentary. Each advisor has the possibility of correcting the text of the commentary produced by the expert system. Should a commentary seem incomplete or poorly adapted to the situation, the advisor only needs a word processor to directly adjust the comments. The gain in time offered by the expert system makes this stage of control and personalization easier.

Finally, the expert system is a very good teaching tool for advisory centers. It shows new advisors how a diagnosis is built and which criteria are studied in setting up the commentary. Additionally, the system is flexible and can be easily adapted. It makes the conception of the diagnosis and the updating of information easier and allows the advisory center to personalize its commentary.

## 2.3.2    Evaluation of the automatized diagnosis

According to advisory centers the automatized diagnosis is reliable, fast and impartial.

In the centers' view, there is no major difference between the commentary of a 'manual' diagnosis and that of the automatized one. Results are quite similar in so far as the reasoning and the presentation of the commentary are nearly the same. One of our stated aims is, therefore, achieved: conclusions show that the artificial diagnosis is as reliable as the 'manual' one.

Moreover, as described earlier, the automatized commentary offers advisors a substantial gain in time. It also includes graphs or tables that the advisor would not have the time to do.

Another positive aspect of the artificial diagnosis is its impartiality. It is very difficult to be objective when writing a commentary. Even experts do not always use the same indicators to analyse a problem. Therefore, the method of analysis may vary from one study to another: criteria and references can change. With the expert system, these differences are overcomed because the system implies the formalization of the analytical approach.

According to farmers' responses, three advantages can be identified in the automatized commentary.

Firstly, the commentary is quite short: five or six pages. Like businessmen, farmers want and need to have condensed information: the length of the commentary seems, therefore, well adapted to their needs.

Secondly, the graphs add extra value to the commentary. Even if they are merely a presentation of the results, they are easily comprehended by the farmer. They are all the more appreciated in that they often do not exist in the 'manual' commentary.

Thirdly, the farmer is interested in the link between technical and economic results because the farmer is above all a technician: the approach used by the expert system is, therefore, suited to his way of thinking.

### 2.3.3    Limits and perspectives

Even if the expert system is appreciated, it is still incomplete in transcribing human reasoning. It has two main limits: the modelization of the reasoning and the information used. The consequence of these limits is the simplification of human reasoning.

First of all, to automatize the diagnosis with an expert system, it is necessary to make a model of that diagnosis. That means to describe and to formalize it in order to create a model. Unfortunately, the formalization of the diagnosis unavoidably simplifies human reasoning. The structure of the diagnosis, and its automatization method (If... then...) have, indeed, simplifying effects.

Moreover, formalization is not always possible. It is sometimes too difficult to transcribe the great complexity of human reasoning. Indeed, it does not exist at the moment a method which can transcribe the intuition of the expert: the expert himself is often unable to explain his own diagnosis. His reasoning is the result of a combination of several factors which can not all be identified. That leads to a global judgement which is difficult to transcribe.

The second limit concerns information used in the expert system. As all the information cannot be introduced, the system is necessarily somewhat imprecise. To achieve a common basis used in the diagnosis, it is impossible to consider all information existing in reality. Therefore, the more we limit the field of information, the poorer the transcription of human reasoning.

Currently, most studies are carried out to improve the modelization of reasoning but only a few of them are based on information. People are rather inclined to focus their work on the modelization of reasoning to provide the farmer with 'the' proper decision. We think that the expert system must be used in another way: it must complement the the farmer's information system. The expert system depends above all on the IS which it is built upon. That is why we have chosen an 'information approach'.

In our opinion, the relevance of an expert system depends as much on the reasoning transcribed by the computer as on the information used in this reasoning. Instead of criticising the expert system's low level of intelligence, and attributing its weakness to an imprecise modelization, we think it would be better to work on information in order to add extra value to the system.


## 3.    The relevance of a diagnosis depends on information

### 3.1    Information necessary in setting up the diagnosis

### 3.1.1    Definition of information

As previously mentioned, the expert system uses technical, economic and financial information (essentially from accounting) and some references. It is now interesting to describe more precisely what information is. In fact, the term, which is ambigous, can be broken down into two aspects (Peaucelle, 1988):

-   a material part, the « signifier », which is the 'visible' and transferable part of information (words, codes, symbols...).
-   a conceptual part, the « signified », which represents what we understand from the information (we use the terms of sense, semantic content, idea...).

According to G. Bateson, 'une information est une différence qui crée une différence' ('information is a difference which creates a difference'). That means information can be defined as the difference brought about by a message which changes the receptor's behaviour, which is adapted to his new state of knowledge. J.C. Courbon (1993) shortens this definition of information by the following:

Information = Data (sign + code) + Interpretation model.

We can therefore say that information is different from data in so far as it isn't neutral.

### 3.1.2     The modelization of information

The commentary of the expert system utilizes above all accounting information concerning the farm. However, to perfect the diagnosis, it is necessary to collect, in addition, technical information on the farm and its environment: the legal status of the property, land distribution, the annual weather pattern ... To treat all this information, the expert system requires, as does any software, a standardised presentation to automatize the process. To achieve this aim we were obliged to solve two central problems:

*    the homogenisation of the conceptual part of information

The analysis determines which kind of information must be used but a selection of information is nevertheless necessary. Indeed, several types of information of the same nature can be used to present or explain a result. For example, the current profit can be used to explain the performance of a farm for one accounting period as can the net profit or the global margin. Moreover, one term can have several significations. So a choice must be made and this depends on three factors: the unanimity of experts' opinions, the availability of information, and its immediate utility.

A set of homogenised information which has the same signification for all users is also determined. However, this does not mean that this information has the same value.

*    the standardisation of the material part of information

The necessary information in the expert system is either numerical (value, ratio...) or symbolic (a string such as the name of the farm, the production system ...). This information must be defined in a determined order and format so that the expert system can read them. Thereafter, once its signification has been defined (the homogenisation) the information must be standardised in its presentation.

All advisory centers had their own IS: this was, therefore, incompatible with our aims of homogenisation and standardisation. That is why we built a new IS, specific to the expert system. We named it the 'unique grid' because of its presentation. The unique grid is represented by a file or ordered tables.

### 3.1.3 The use of references

Finally, in setting up our diagnosis, we used some specific information which we referred to as 'references'.

References have the same characteristics as information: they have a material and a conceptual part but they also play a special role in so far as they allow for an explanation and an interpretation of the results. Two main characteristics of references should be noted. Firstly, as opposed to 'internal information' (technical, accountable or financial data), stemming from the farm itself, references are 'external information'. Secondly, the use of a reference depends not only on its semantic content but also on its value.

Therefore, references are technical, economic or financial information whose value is used as a measure of comparison in order to explain the results. To interpret a result, most of the commentary comes from a comparison with references. This phase is often wrongly compared with intelligence because the software appears to be quite similar to human reasoning, that is to say nuances are introduced. In fact, the commentary includes expressions such as quite good, rather bad ... In the commentary, references are essential because they are used to assess the results: they are the basis of the evaluation produced.

Two kinds of references can be distinguished:
* standard references: they represent indicators from the average of a set of farms. For example, the average profit margin for all corn farms whose turnover is more than 1 million. To build these standards, we use the same indicators as those on the farm. A statistical average of all individual indicators is taken.
* normative references: they are the result of the reasoning and the experience of the experts and are not necessarily the result of a sample average. These references can, moreover, be produced from new indicators which are not used at the farm level. For example, to assess the current profits of a farm, the average of all current profits is not used but rather two new ratios: current profits / gross profits and production / gross profits which represent the material part of the reference. Thereafter, each ratio is attributed a specific value which is the conceptual part of the reference and, at that point, it is possible to say whether the current profits figure is good, quite good, quite bad or bad. To obtain such an evaluation, it is necessary to establish a certain number of thresholds. They correspond to values chosen by the experts to determine the level at which the commentary must change. For example, in the E.N.I.T.A. software, for current profits, one of the thresholds is fixed at 15% and 15,000 F. This means that the result is judged good if the current profits increase by more than 15% and more than 15,000 F.

## 3.2 References determine diagnosis relevance

### 3.2.1 Relevance of diagnosis depends on the definition of references

As is true with the other information, references used in the expert system require a common definition of their material part. But this is not sufficient: references imply a specific problem relating to the choice of their value (their conceptual part). The use of references is based on the comparison between their value and farm indicators. The relevance of the commentary depends on this comparison: this explains why the conceptual part of references is essential.

For normative references, the conceptual part is defined by the experts. It is a result of human reasoning divisible into two parts:

The first is the objective part. The value is determined by the experts relying on their experience and their knowledge of the problem. Even if this value does not precislely correspond to a statistical calculation, the result is quite similar.

The second part is the subjective reasoning. The expert actually gives his opinion about the value of the normative reference. Having an idea of the performance the farm should achieve, he consequently assesses the optimal value of the reference. Therefore, the expert establishes the value more on a feeling (based on his own IS) than on a calculation.

Normative references are therefore a compromise between observations (objective reasoning) and the aim to be achieved (subjective reasoning). In most cases, the fixing of the thresholds depends more on subjective rather than objective reasoning. Threshold fixing therefore requires a consensus among all experts who must accept the fixed definition of the references in order to give a normative aspect to the commentary.

For standard references, the value is the result of a calculation: it is determined by means of a statistical tool which provides the average of an indicator for comparable farms. Contrary to normative references, standards can vary from one farm to another. For example, the wheat yields standard comes from an average of data collected in wheat-cultivating farms. But this average is different for each geographic area, so this disparity reappears in the values of standards.

A standard can be universal concerning its material part but its value can not be definitely fixed. Standard references are 'external information' but they are linked to the farm in so far as the specific geographic and economic situation of the farm determines the value of the standard. Therefore, each advisory center must determine its own standard values to set up its diagnosis.

As they are the results of calculations, standard references appear to be more reliable than normative references, which are partially subjective. However, the representativity of the calculated average may itself pose a problem. The representativity of standard references determines the relevance of the comparison with the farm indicator. In our example, the yield standard must be representative of the yields obtained on comparable farms for the comparison to make any sense. Representativity is a major problem which has, as yet,

rarely been treated in agriculture (Sebillotte, 1991). In most cases, not taking this into account is harmful to the comparison because the sample is often taken from heterogeneous situations. The larger the sample, the more it is representative but the less it is relevant.

Therefore, the choice and the setting up of references is not indifferent to the relevance of the diagnosis. The use of references is based on comparisons. From the comparison between the value of the reference and the value of the farm indicator there results an explanation (increase or decrease) or an assessment (good, quit good, quite bad...). That is why the value of the reference determines the relevance of the commentary.

Nevertheless, a relevant value obtained for a reference does not necessarily mean a relevant diagnosis: the use of references also plays a great role.

### 3.2.3 Relevance of diagnosis depends on the comparison between farm indicators and references

Once the problem of the reference value is solved, there still remains two further problems with the comparison between this value and the value of the farm indicator.

The first one concerns the fixing of boundaries which mark the intervals between expressions of evaluation, creating variations in the commentary when these values appear. For example, if we fix a threshold of 15% to assess the rise of current profits, a rise of 16% will be considered as an increase whereas a rise of 14% will be considered as stable. Moreover, a profit of 50,000 F will be considered as an increase only if it rises by 7,501 F. So the changes appearing in the commentary when the threshold is crossed are often unsatisfying and somewhat arbitrary. Two techniques are used in the expert system to reduce this problem:
-     the combination of two boundaries. A percentage boundary and a calculated one were crossed to set up a more relevant commentary. For example, the rise in the profits is identified by an increase of more than 15% and more than 15,000 F or by an increase of more than 50,000 F.
-     the fixing of several thresholds. Instead of changing the commentary as soon as a boundary is crossed, the software was written with several intervals defined with their own commentary. To kinds of treshold can be distinguished: level and variation thresholds A variation threshold describes the evolution of farm indicators, using 'internal information'. For example, a variation threshold of 5% in expenses means a rise if expenses increased by more than 5%, a stagnation if expenses varied between - 5% and + 5%, and a decrease if expenses varied by more than - 5%. A level threshold describes the comparison of a farm indicator with the standard. For example, if the wheat yield is 105% higher than the standard, it will be considered good. If it is between 95 and 105%, the yield will be considered to be at the same level ...

The second problem is the fixing of specific thresholds for each advisory center. It is, indeed, necessary to reduce the heterogeneity among samples. It is possible to obtain different commentaries with similar references values. For

example, if an advisory center fixes its threshold at 10% whereas an other one fixes it at 5%, a profit of 7% higher than the standard will be considered as good in the first case and as normal in the second case.

Therefore, heterogeneity of the commentary depends not only on the fixing of reference values but also on the method of comparison of individual indicators with these values of references.

## 4. Conclusion

Even if the automatized diagnosis of agricultural farms already produces quite good results, two ways of improving the diagnosis remain possible. The first one concerns the modelization of human reasoning and the second, the definition of a more relevant IS.

We chose the second in defining our research. Information in an expert system is essential: a large part of the commentary depends on the comparison of farm indicators with references. This is why it is necessary to define precisely what a reference is. The two parts (material and conceptual parts) of the reference must be clearly distinguished. The definition of the conceptual part must include not only the semantic content but also the value of the reference. This value depends on two factors: the calculation mode and the sampling method.

In the commentary, two kinds of references are distinguished: standards references, which are a representation of a phenomenon (they result from a statistical calculation) and normative references, which include an extra value. The difference between these two kinds of references is rarely made: people often use averages, which they call either standards or references. But contrary to a standard reference, a normative reference is not neutral: it includes the point of view of the experts and is therefore more effective than a standard reference in comparing farm indicators with references.

Unfortunately, a universal reference is impossible. The heterogeneity of the agricultural world requires differentiating references area to area, size to size etcetera. Therefore, to work at a collective level, it is first necessary to normalize the definition (the material part) of the reference and then to define specific values (the conceptual part). The material part of a reference can be applied to several areas but the value of this reference is dependent on the context in which it is used. We cannot compare a farm indicator with a reference which has not been defined for a comparable situation. Hence, the first step is to define all kinds of situations before fixing a specific reference value for each of them. This means that the sample choice is essential to the relevance of the diagnosis. If the sample is not representative, the use of a reference for this sample is meaningless. To our mind, it has no sense to us a reference if the representativity of the sample is not known.

Finally, determining the value is not sufficient to enable a comparison with the farm indicator. A single value is not enough to situate the performance of a farm. To avoid this binary method (good or bad), specific boundaries and thresholds must be fixed for each reference value. With this method, we lessen the problems of commentary breaks around the value of references.

Therefore, the creation of a more evolved IS is essential for improving the relevance of the automatized diagnosis. In order to do this, it is first of all necessary to standardize and improve the definition of references before upgrading the methods which compare farm indicators and references. New methods like mathematical flow should, indeed, be tested.

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# A LANGUAGE FOR (DISPUTED) LEARNING: THE USE OF COMPUTER GENERATED MINERAL BALANCES BY DAIRY FARMERS AND EXTENSION WORKERS IN THE NETHERLANDS

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**Abstract**

*This article reports on a study which set out to investigate the prospects of a particular set of qualitative research methods for acquiring insight in 'the information needs' of farmers. At the same time the study intended to assess the added value of (computer-generated) environmental parameters in processes of decision-making, learning and extension. It is hypothesized that knowledge and information related practices (or patterns of behaviour) could form a much more meaningful entrypoint for orienting information services than specific information needs. In order to explore this hypothesis, learning and decision-making practices in relation to mineral management were studied with the help of participatory observation followed by qualitative interviews. With the help of these methodological tools various insights are generated in relation to learning, decision-making, and the (added) value of mineral parameters in different learning settings. On the basis of these insights, it appears possible to formulate a number of recommendations for improving the technical and/or socio-organisational design of computer-based communication technologies. It is concluded that studying learning practices by means of participatory observation followed by qualitative interviews does indeed have a potential for orienting communication technology development. Eventually, suggestions are made on how to integrate such research tools in procedures for (participatory) communication technology development.*

## 1. Introduction

On the eve of yet another hype about new electronic media in Western society, agro-informaticians have already learned their lessons. Some 15 years experience has taught many of them that it is far from easy to develop

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computer-based communication technologies 2) that really invoke a lasting enthusiasm from farmers and extension workers. Although some have taken a normative turn and resorted to 'user-blame' explanations for this phenomenon by arguing that the available technologies are quite adequate but that there are problems and shortcomings at the 'demand side' (e.g. Klink, 1991), several studies suggest that there is plenty of space to improve computer-based communication technologies (Hofstede, 1992; Van Dijk et al., 1991; NRLO, 1991; Leeuwis, 1993). At the risk of being equally normative, we take 'improvement' to mean that communication technologies become better geared towards the existing needs and practices of prospective users, rather than that prospective users become increasingly moulded towards the requirements of new technologies. From this position, there is an imperative to gain better insight in what is often labelled 'the information needs' of farmers. This article reports on a study which set out to investigate the prospects of a particular set of research methods for acquiring insight in 'the information needs' of farmers. At the same time the study intended to assess the added value of (computer-generated) environmental parameters in processes of decision-making, learning and extension.

## 2. Towards a research methodology

*The pitfalls of the 'information needs' concept*

Even if a variety of strategies for identifying 'information needs' are available (Davis & Olson, 1985:480ff; Bots et al., 1990:156ff; Brittain, 1982) many agro-informaticians are still faced with the burning question of what the information needs of farmers might be 2). Apparently, something must be wrong with either the methods available or the concept of 'information needs' itself. A previous study in the domain of horticulture indicated that both may be the case (see also Leeuwis, 1993).

First, evidence in the horticultural study suggests that - especially in problematic situations - specific information requirements are often extremely

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1)     Elsewhere (Leeuwis, 1993), it has been argued extensively that management supporting computer facilities (e.g. 'management information systems', 'decision support systems', 'expert systems') can -for analytical and explanatory purposes- best be regarded as (computer-based) *communication technologies* since they inherently imply a communication process between various actors (e.g. the researchers or extension workers who develop them and the farmers who use them). Computer software and hardware, then, can be considered media for communication (next to more conventional media).

2)     This, of course, did not prevent them from developing computer-based communication technologies. In the face of the lack of clarity about user requirements agro-informaticians frequently resorted to deducing needs from formal decision-making models and/or available scientific knowledge. Hence, the needs were often attributed (if not prescribed) to prospective users.

short-lived, and succeeded by new and/or reformulated needs. In contrast, the notion of information needs is imbued with static connotations in the sense that it is linked to the idea that we must first identify the needs, and then develop technologies and messages which cater for them. This implies that such needs are assumed to be relatively static over a certain period of time (at least the time necessary to develop messages and/or technologies).

A second tension arises from the observation that horticulturists find it very difficult to analyze their own needs, whereby it seemed even more difficult for them to simultaneously evaluate the potential added value of an unknown technology in meeting such needs. More in general, it emerges that prospective users are often not discursively aware of the needs that are already fulfilled (precisely because they are already catered for, and therefore no longer 'a need'), and have no need for information of which they are not even aware (precisely because they do not know about its existence). In a way it seems that an information need only emerges temporarily when it is about to be fulfilled; that is, when particular information is already offered and within reach. And only when one has access to particular information does it becomes possible to evaluate whether or not there was a real need for the information. Nevertheless, both the concept of information needs itself and many of the research strategies used to identify them build on the assumption that needs are tangible and can be made discursive prospectively by those who supposedly have them. In short, it emerges from these two points that the whole idea of assessing specific information needs before developing an offer (either computer mediated or not) is rather paradoxical.

Third, in accordance with earlier studies (e.g. Bolhuis & Van der Ploeg, 1985; Leeuwis, 1989; Roep et al., 1991) the horticultural study shows that - even among at first sight rather homogeneous groups of farmers - there is significant diversity in terms of the strategies and rationalities that farmers adhere to, which is reflected in both differential participation in knowledge networks and divergent interests in specific (types of) knowledge and information. Despite this significant diversity, agro-informaticians - in searching for 'the information needs of farmers' - seem to assume a certain degree of uniformity across particular categories of farmers.

Finally, the concept of information needs seems to be associated with the idea that such needs arise at a discrete point in time, which is often thought of as a moment in which a particular decision has to be taken. The idea, then, is that - in order to ensure that adequate decisions (regarded by many as 'formally rational' decisions) are taken - specific information is necessary. However, the study conducted in the horticultural sector revealed that many 'decisions' have a rather long 'incubation period'. In everyday practice, it seems, decisions do not arise out of a discrete moment of decision-making, but rather from a long-lasting, often routine-like, and only partially conscious process of learning.

From above observations it was concluded that the concept of 'information need' is of limited use for the purpose of orienting information services (either computer mediated or not). In inspired by social theory (e.g. Giddens, 1984) and our previous research findings, the hypothesis was formulated that knowledge and information related practices (or patterns of behaviour) and

associated *types of information needs* (rather than specific information needs) could form a much more meaningful entrypoint for orienting information services (Leeuwis, 1993:413). After all, as part of their everyday routines and actions, farmers deal continuously with knowledge and information in a manner which shows regularities. It is such *practices* which may or may not be fruitfully supported or facilitated by computer-based communication technologies. Hence, we decided to look for methodological tools for studying knowledge and information related *practices* as the main object of study.

*A methodological approach for studying learning practices around the mineral balance*

In this study, we considered knowledge and information related practices to be the key component of both learning and decision-making. As indicated earlier, we consider learning and decision-making to be so closely intertwined that it is unhelpful to make a strict separation between the two. Hence, we will speak simply of *learning practices*. As a basic methodological tool for studying learning practices we have selected observation followed by qualitative interviews in connection with the observations made. For the evaluation of the prospects of this methodological approach at least two criteria seem relevant: (a) the extent to which it has helped to get an insight in learning and decision-making processes at farm level; and (b) the extent to which the insights gained help to direct the (further) development of appropriate communication technologies. Below, we will first present an outline of the research setting which was chosen, and then provide further details on the operational methodology adopted.

For getting a better insight in both learning practices and the potential role of communication technologies therein, we decided to focus on learning practices concerning environmental issues. This because environmental issues are a relatively new concern for farmers, in relation to which they - confronted with all sorts of new laws and regulations - could be expected to feel an immediate urge to learn. As environmental parameters often play a role in environmental laws & regulations, we decided to narrow the scope by looking especially at the role of computer-generated parameters in environmental learning practices. This choice was also based on our experience that such parameters have the potential to provide feedback (Leeuwis, 1993), whilst feedback is an important mechanism for learning (Röling, 1994; Heymann, 1994).

While looking for a adequate research opportunity we came across the Mineral Supervision project of the Service for Agricultural Extension (Dienst Landbouw Voorlichting, DLV). The project is aimed at dairy farmers, and consists of the following four phases which are jointly followed through by a farmer and extension worker during two or three subsequent farm-visits:
1.    *calculation - by means of a computer programme - of a mineral balance* (i.e. a balance of incoming and outgoing minerals on the farm) on the basis of a variety of figures and farm accounts;

2.   analysis of the mineral balance in order to identify areas for improvement and/or potential changes in the farm set up;
3.   technical advice on selected areas for improvement;
4.   recalculation of the mineral balance on the basis of the proposed inter-ventions 1).

Nationwide, some 2,000 farmers participated in this project in 1993. For farmers the costs involved were about $f$ 500,-. In this context, the following methodological set up was chosen.

-    *Observations*
In the beginning of 1994, observations were conducted of 15 farm-visits in the context of the Mineral Supervision project. In the selection of the visits it was attempted to maximize diversity in terms of the project-phase involved (see above) and the mineral surplus (as expected by the extension worker). This in order to ensure that observations would cover different 'stages' of learning, as well as differential problem situations. Also, logistic considerations played a role in the selection of respondents. The observations took place in one ex-tension district and involved four extension workers (3 male, 1 female) and 17 farmers (15 male, 2 female). The farm-visits were observed and conversations were tape-recorded, and later written out and coded. Observation were made on the basis of the pre-tested list of attention points. Attention points were inspired by detailed research questions, deriving from theoretical consider-ations, previous research experiences, pre-tests and extension worker feedback.

-    *Commentaries and qualitative interviews*
Immediately after the farm-visits, the occasion was evaluated with the extension worker involved on the basis of a list of attention points. With farm-ers such evaluations were combined with an semi-structured in-depth interview which covered various additional themes as well. These evaluations/interviews were held on the farms between 2 and 3 weeks after the farm-visit. Most ques-tion were open or in nature, and in case of closed questions respondents were always invited to provide their interpretation of the answer given. During the interviews, both the interviewer and the researcher could raise additional ques-tions and issues.
In order to maximize diversity in terms of the project-phase involved, simi-lar interviews were held with four respondents who did not participate in the project, but had access to a mineral balance through another route.

-    *Network analysis*
Simple forms of network analysis were carried out in order to identify the sources of information that farmers and extension workers can and/or do avail

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1)   A recalculation of the mineral balance some time after the actual implemen-tation of the improvements was not included in the DLV project, at least not in the district where we carried out our study.

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of in relation to environmental parameters. This network analysis was integrated fully with the observations and interviews.

- *Feedback sessions*
In order to cross-check the interpretations and conclusions of the researchers, several group-meetings were held with extension workers. In case of doubts, farmers were consulted as well (by telephone) in order to check the validity of particular interpretations.

As will be clear from the above, the study was highly exploratory, in depth and qualitative in nature. Given the infancy of research in this field of study, we thought it wise to adopt an exploratory strategy, and follow suggestions by Elias & Scotson (1976) to let 'sociological significance' prevail over statistical significance.

## 3. Insights obtained on learning processes and the (added) value of environmental parameters

An first indicator for assessing the value of the research methodology is the extent to which insight is gained in learning and decision-making processes at farm level, in this case concerning mineral management issues. Below, different sets of conclusions which were (expectedly and unexpectedly) arrived at are reported. In the context of this paper we must be necessarily brief. For qualitative and quantitative details, see Stolzenbach & Leeuwis, forthcoming.

*The specific nature of learning on mineral management*

First, it became clear that learning on mineral management is a precarious activity. The need to learn has - in the view of farmers - been imposed on them from the outside (i.e. environmental legislation), whereby farmers feel that have to make disproportionate sacrifices when compared to other citizens. Hence, learning on the mineral balance is politically and emotionally laden. Some of the insights we gained relate to this. It appears, for example, that 'protecting the environment' is by far the least important motivation to learn. Farmers appear rather pragmatic, and are eager to minimize the consequences of environmental policies. In relation to this most farmers develop only limited insight in mineral processes; they want to understand roughly what they can do to minimize consequences, and show little interest in further detail 1). In pointing out directions for change, they make themselves highly dependent on extension workers, whose advise they tend to take remarkably serious. In all,

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1) This attitude may of course be a momentary phenomenon. At the time the fieldwork was conducted emotions were high, due to speculations about extremely high fines for those with mineral surplusses. This may have resulted in a bias with respect to their motivation to learn.

it seems that although the participating farmers accept the need to learn and intervene as a political reality, they do not support the policies that they are subject to (see also Aarts & Van Woerkum, 1994). This ambivalence characterizes their learning practices.

*General insights about learning*

It emerges that learning practices are inherently connected with action and intervention. Farmers appear to be involved in a continuous process of learning and decision-making, in which reflection and action alternate constantly, albeit with a fluctuating rhythm. In some cases reflection precedes action, whereas in others action precedes reflection. A pervasive conclusion is that learning constitutes a *process of switching* between different levels of learning, i.e. 'the farm in its environment', 'the farm as a whole', and 'parts of the farm'. Within each level, a number of knowledge and action domains (see also Van der Ploeg, 1991) can be distinguished. It seems that learning processes may commence at any level or domain, and is then followed by switching and translating between various levels and domains. In such processes of switching, *searching for direction* is an important mechanism. At a particular point of entry alternative solutions are identified and selected. Subsequently, projections are made of the implications of selected solutions on neighbouring levels and domains. This sequence is usually repeated a number of times, and may involve different degrees of action, experimentation and reflection. The complexity of learning processes is further enhanced by the observation that they are shaped by contextual, historical and personal factors (see also later on), and that they seem to be only partially conscious. Moreover, learning cycles (Kolb, 1984), 'phases of decision-making' and switching processes seem to be passed through in a highly iterative and non-linear (Engel, 1989) fashion, whereby (explicit or implicit) questions, problems and motivations are subject to continuous change. Furthermore, a number of learning processes (with respect to different levels, domains, questions, etcetera) take place simultaneously. Finally, learning takes place in different learning settings (e.g. while working, during extension visits, in studyclubs, at the kitchen-table, etcetera), and involves a number of sources of knowledge and information (own experience, extension workers, colleagues, magazines, mass media, etcetera) 1).

Another conclusion at the general level is that - while learning - farmers do not only switch between the different levels and domains of their own

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1)    In relation to mineral management, the study revealed that DLV extension workers, professional magazines and the feed-supplier's extension workers are the most valued and most frequently consulted sources by the participants in the DLV project. Colleagues were evaluated as being relatively unimportant by the respondents. There are indications that these evaluations are not representative for Dutch dairy farmers (see Stolzenbach & Leeuwis, forthcoming). This indicates that the participants in the project constitute a specific (self-selected) category.

farms, but also between farms. Such farm comparison practices appeared to be a rather powerful mechanism and stimulant for learning, which take place either in direct interaction between farmers (e.g. in studyclubs), or with the intermediation of third parties, such as extension workers. Looking beyond the boundaries of one's own farm can provide farmers with credible feedback on their own functioning, and can at times enhance (but also diminish) their self-efficacy.

*The (added) value of mineral parameters in an extension context*

Below we will draw several conclusions in relation to the value and added value of mineral parameters in the 'extension visits' learning setting.

First and foremost, mineral parameters seem to constitute a (numerical) language for speaking about certain aspects of farming. During extension visits, this language played an important role in setting the agenda, and in the analysis and formulation of problems and solutions. Hence, the mineral parameters played a significant role in structuring the learning process. Thereby, the numerical language was found to be associated with various strong and weak points. Strong points were:

- the compatibility of the language with the language of policy-makers; hence, dealing with the language is crucial for farm-survival;
- the language provided a new frame of reference which contributed to making things visible which previously remained invisible;
- the capacity of the language to facilitate simple and quick (be it rough) comparisons between farms;
- the language seems suitable for the identification of trends (even if this could not yet be established);
- the language helps to generate an agenda for further qualitative discussion.

Weak points were:

- the partial incompatibility of the language with the current 'information-household' on farms created frequent translation problems;
- the way in which 'facts' are produced with the help of the language is at times untransparent (i.e. the various computer manipulations have a black box character);
- the validity of generated facts is at times rather dubious;
- the relevance and meaning of the language in relation to environmental policies remains uncertain (due to uncertainties at the level of policy);
- the language is emotionally and politically laden; hence, to a degree people 'resist' to speak the language;
- in view of the foregoing it appeared difficult to contextualize the information provided, and to make translations towards practical interventions; it was only rarely that unambiguous conclusions with respect to intervention were drawn.

During extension visits the weaker aspects of the language can be partially compensated as the different backgrounds of farmers and extension

workers allow them to overcome translation and interpretation problems. This requires considerable effort. At times this goes along with irritations and unproductive loss of time. On the other hand, these efforts can also lead to improved insight in mineral management, and an increasing awareness that the 'information-household' needs change (e.g. requires better registration).

Second, it appears that mineral parameters offer the opportunity to give an *summarized description* and overview of the farm in terms of mineral processes. These descriptions help to clarify *what* the results of the farm are. Also, the parameters give some diagnostic insight into the *way in which* - via particular processes - results come into being (e.g. where the main mineral losses can be found). However, mineral parameters do not provide insight in *why* certain results are produced. For identifying the detailed practices (and their rationale) through which results are produced, the input from farmers and extension workers remains crucial.

Third, to the extent that mineral parameters provide insight in where mineral losses are created they also help to direct the search for solutions and intervention strategies. However, opportunities to make projections and simulations by means of computer programmes play a limited role in the eventual identification of specific measures. Simple logic and simple calculations ('on the back of a box of matches') play a much more significant role. Computer calculations are mainly used as an illustration or double check.

Fourth, the interplay between farmers, extension workers and mineral parameters contributes to the farmers' willingness to take measures. On average farmers express intentions to implement 4 concrete measures 1). Farmers attribute about two thirds of these measures to altered and/or sharpened problem perceptions and arguments which have emerged during the extension-visits. There seems to be little or no relation between the number of intended measures and (a) the phase of the Mineral Supervision project that people are in, and (b) the actual understanding of mineral processes. In relation to the former, however, there are indications that the nature of the measures changes as farmers proceed in the project (i.e. from impinging on external mineral streams to influencing internal streams). In general, it appears that farmers do not relate the measures they intend to take to precisely defined goals; objectives are rather stated in terms of directions, e.g. 'higher', 'lower', etcetera.

Fifth, within studyclubs mineral parameters have the potential to become part and parcel of new social norms for 'competent performance' and craftsmanship, thereby reducing the importance of 'productivist' parameters.

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1)    Available time and resources did not allow us to check whether these measures were actually implemented after some time.

We can conclude that mineral parameters can have a significant value in extension situations. Most importantly, they function as an *extra language* for analyzing mineral processes. The language can play an important role in getting an overview of the farm, in formulating problems, making diagnoses, identifying solutions and signalling trends. In short, they help to structure learning processes. The added value lies especially in the fact that mineral parameters provide an *new and additional* language. If this language were to replace all other languages for learning, its contribution would probably be far less. The same would probably be true if the language would not develop further; if the parameters would stay the same farmers would in due course become bored with them (as has happened in other instances, see e.g. Blokker, 1984; Roep et al., 1991). Although the Mineral Supervision project contributes to some understanding of mineral processes, it cannot be concluded that participants take more and/or different measures than non-participants. Therefore we must be careful not to over-exaggerate the meaning of the project or even the meaning of mineral parameters 1).

## The (added) value of mineral parameters in 'individual' learning settings

In principle, the strong points of the numerical language can be valid outside extension situations as well. So far, however, the opportunities to compensate for the weaker aspects of the language are much less outside such situations. Hence, the benefits of mineral parameters can be expected to be less for 'individual' learning settings. This also emerges from our (rather limited) empirical material. Although in general the actual understanding of mineral processes remained low, even among participants of the Mineral Supervision project, it emerged that understanding was even less among those farmers who had access to mineral parameters, but did not participate in the Mineral Supervision project. Moreover, the latter tend to have less confidence in the validity of the mineral parameters (and - given the problems discussed earlier on - probably rightly so). Furthermore, even participants seemed to have done little with the mineral parameters in the weeks in-between the observations and the interview. In part, the limitations of the mineral parameters in individual learning settings can be attributed to their relatively alien character. In time, the benefits can be expected to rise in the near future.

## Relevant diversity

Both farmers and extension workers can be classified and categorized in a variety of ways. In relation to learning practices concerning mineral management several segmentations seem relevant. First, it seems relevant to distinguish between those who just commence to learn and those who have already some history in this respect. As mentioned earlier, we see that in due course the

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1) No farmers were interviewed who did not have access to a mineral balance of their own enterprise.

interests often shifts from influencing external mineral streams to internal efficiency. In this process, the interest in particular parameters changes as well. Second, in line with Kolb's (1984) findings, there indications that farmers are characterized by differential learning styles. Some farmers find it relatively easy (and even fun) to deal with abstract parameters (like mineral parameters), while others prefer to learn on the basis of more concrete experiences. Third, it has emerged quite strongly that younger farmers have both a higher understanding of mineral parameters than older ones, and a more positive attitude towards the environmental policies which more or less prescribe the use of these. Probably, cultural meanings, educational history, and future prospects play a role here. Fourth, is seems that in the present set up, mineral parameters are geared to specialised farms, and are less geared towards mixed farms. Clearly, all these segmentations have an explanatory value if it comes to understanding why (specific) mineral parameters play a particular role in farmers' learning practices.

Also among extension workers there seem to exist relevant differences. Apart from the fact that extension workers from different origins (feed-suppliers, accountancy bureaus, DLV) seem to operate differently in relation to mineral parameters, it emerges that even among DLV personnel there are difference in 'extension styles'. Extension workers seem to have a clear preference for working either from theory to practice ('the teachers') or from practice to theory ('the advisors'). Both types can fruitfully use mineral parameters, albeit in different 'stages' of the extension process.

## Conclusion

From the above it can be included that the research methodology adopted can indeed be fruitfully applied for gaining in-depth insight in learning practices, in this case against the background of specific questions concerning mineral management.

## 4. Recommendations for communication technology development

On the basis of the insights generated about learning and the (added) value of mineral parameters in different learning settings, we were able to derive a number of concrete recommendations for improving DLV's Mineral Supervision project. Tentatively, several more general conclusions were drawn in relation to the criteria that appropriate communication technologies may have to meet. Some of the recommendations refer directly to the technical design of communication technologies (i.e. their 'internal design'), whereas others refer to the socio-organisational environment in which they are embedded (i.e. the 'external' design of the technology) (see Leeuwis, 1993). In many cases recommendations allude to both design aspects, which shows once more that the social and technical dimensions of a technology are closely intertwined.

At the more general level, an important conclusion is that - given the complexity and capriciousness of learning processes in everyday practice - it is neither feasible nor useful to develop communication technologies which aim at restructuring learning and decision-making practices in a *comprehensive and procedural* manner. Rather, such technologies could be designed as tools which support existing learning practices (see Stolzenbach, 1994; Leeuwis, 1993). For example, communication technologies could support farm-*comparison practices* by offering easy access to other farmers' data and addresses whilst at the same time providing opportunities for selection and/or data manipulation and presentation. More in general, communication technologies may facilitate *switching practices* between and within farms, and support searching for directions.

Another more general recommendations is that the (external and/or internal) design of communication technologies should anticipate relevant diversity among prospective users. Moreover, communication technologies should be reasonably compatible with the existing 'information-household' on farms, and have a high degree of transparency. For securing continued support of learning practices, it is important that the contents of communication technologies can be flexibly adapted. If communication technologies are insufficiently tailored, compatible and/or transparent these shortcomings may be partly compensated by the provision of supervision activities (e.g. in the form of extension-visits or group-meetings). In any case, providing platforms for debate is an important condition for contextualizing information provided by communication technologies.

Associated with these more general recommendations are a number of concrete recommendations for improving DLV's Mineral Supervision project (see for details Stolzenbach & Leeuwis, forthcoming). In all, we can conclude that the methodological approach adopted may indeed have a practical relevance in relation to communication technology development.

## 5.    The value and place of the methodological approach in communication technology development

Earlier on we have identified two criteria for evaluating the prospects of our methodological approach: (a) the extent to which it has helped to get an insight in learning and decision-making processes at farm level; and (b) the extent to which the insights gained help to direct the (further) development of appropriate communication technologies. In our view, the preceding sections have made plausible that a methodology which combines observation followed by qualitative interviews in connection with the observations made has - in principle - a reasonable potential in relation to both criteria. The main question, then, is how these qualitative research methods (and the social scientists who apply them) should be built in into procedures for communication technology development. In order to answer this question, I will first reflect briefly on current methods for communication technology development, and then proceed to identify some important criteria that an alternative approach

will have to meet, whereby special attention is paid to the role of social scientists and qualitative research methods as the ones explored in this paper (see also Leeuwis, 1993) 1).

Many conventional methods for communication technology development make use of well described procedures 2). In many cases, the procedure starts with a feasibility study, which is followed by the making of a 'functional design'; that is, a plan which outlines which functions the technology must be able to perform. Then, a 'technical design' is made, which indicates how the required functions will be technically realized. Subsequently, the technicians build the technology and test whether or not it works in a technically adequate fashion. Finally, the communication technology is considered ready for introduction.

Even if users have participated extensively in drawing up a functional design, such procedures pose certain problems. Due to the difficulties that are inherent to the identification of information-needs (see earlier on), it is only *after* users are confronted with an eventual that technology that they become aware of their true wishes and needs. An adaptation of the design on the basis of the users' learning experiences in this respect, however, is often prevented or delayed because of the fact that considerable investments and important decisions have already been made at this stage. Hence, mainstream methods for communication technology development tend to obstruct learning, and do not help much to prevent and/or correct for 'anticipatory misfits'; that is, they help little to ensure that such technologies anticipate everyday learning practices of - in this case - farmers. Moreover, such methods tend to represent technology development as a well-directed, and rationally organised collective decision-making process, which results in predictable outcomes. Empirical studies, however, suggest that - in everyday practice - development processes constitute a continuous process of struggle and negotiation, of which the outcomes are inherently unpredictable (Long & Van der Ploeg, 1989; Crehan & Von Oppen, 1988; Leeuwis, 1993).

Below, we will outline some criteria that an alternative approach may have to meet. The key assumption underlying these criteria is that, if processes of communication technology development indeed constitute simultaneously a process of learning and a process of negotiation, it makes sense to *organise* them as such. This has the following implications:

First, in order to ensure adequate anticipation on the users' needs and social context, the development process should be participatory in nature. That

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1) Elsewhere, the author has outlined in detail the characteristics of a so-called 'learning-oriented' method of communication technology development (Leeuwis, 1993).

2) Such procedures can be either 'process-oriented', 'data-oriented', 'object-oriented', 'project-oriented' and/or 'socio-technical' in nature (see Bots et al., 1990).

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is, the various (categories of) prospective users should be involved as many stages of the development process as possible.

Second, the development process should have a highly iterative nature, so that the learning experiences of users can be rapidly integrated into both the internal (technical) and the external (socio-organisational) design. For the internal design, this means that - on the basis of a rather rough analysis and specification of requirements - developers start to build almost immediately an equally rough working model of the communication technology. The prospective users, then, are asked to test and evaluate this working model. On the basis of their comments and discussions, the developers can create a new working model; a procedure which repeats itself until a 'final' and satisfactory version is obtained. Such a method is labelled by Vonk as 'prototyping'; that is:

> 'an approach for establishing a systems requirements definition which is characterized by a high degree of iteration, by a very high degree of user participation in the development process and by an extensive use of prototypes' (Vonk, 1990:22).

A prototype, then, is: 'a working model of (parts of) an information system, which emphasizes specific aspects of that system' (Vonk, 1990:20).
For the development of an adequate external design, such prototyping efforts will have to be supplemented by field testing.

Third, the prototyping process will have to preceded and accompanied by the type of qualitative sociological/anthropological research that we have explored in this paper. These research efforts serve several purposes: (1) Research is needed to identify relevant diversity among (different types of) users. In order to do so, such studies must focus on diversity in (knowledge and information-related) practices, and explore the socially negotiated character of this diversity. (2) In relation to this diversity, socio-anthropological research can help to identify initial criteria which the prospective communication technology might have to meet in order to have added value, and support adequately the practices in which various categories of users engage. Such criteria, in turn, can be used to give initial direction to the prototyping process. (3) Also, such studies can serve to determine for which cross-sections and/or coalitions of actors it may be realistic to develop an overarching communication technology. Different types and/or segments of actors may very well pose demands on the technology which are contradictory and/or mutually exclusive. In order to maximize the chances for the prototyping process to result in a productive consensus, compromise, and/or conflict, it is necessary to make a deliberate selection of target-categories and participants. (4) Social studies can be carried out to monitor the process of prototyping and field testing, and provide adequate feedback to the participants on the social nature of the choices made, and the consequences that might ensue. (5) Finally, socio-anthropological may help to assess the overall feasibility and desirability of the would-be technology.

In all, we see that social scientists (e.g. sociologists and extension scientists) can fruitfully play a variety of roles in processes of communication technology development. They can act as researchers, facilitators, participants, intermediaries, negotiators and/or as political activists.

Clearly, neither the type of method proposed nor the involvement of social scientists therein provides a guarantee for successful communication technology development. Due to the social nature of technology development processes, the outcomes thereof will always be characterized by a considerable degree of unpredictability. In order to maximize the chances for success, such a method can be applied most fruitfully in an organisational setting in which: (a) communication lines are short; (b) decisions can be taken rapidly; (c) actors are prepared to work quickly and cheaply; (d) access exists to sufficient software and hardware resources and experiences; (e) the organizations involved are willing to delegate decision-making responsibilities, and (f) the development process can be - at least temporarily - shielded from external conditions, interventions and/or formal planning.

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# OPTIONS FOR GREENHOUSE PRODUCTION SYSTEM MANAGEMENT: ANALYSIS & SIMULATION

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**Abstract**

*Model-based investigations of greenhouse production systems can help growers to improve management. In the present study, operational decision-making in pot plant production under uncertainty with respect to crop growth and price formation is analyzed by means of simulation. Five strategies of operational management are formulated and subsequently evaluated in combination with three tactical production plans. Simulation results show adaptive operational decision-making improves profitability, particularly in case of poor tactical planning. Furthermore, the application of the present methodology in greenhouse horticultural practice is discussed. From this discussion it is concluded that computerized experiments with greenhouse production system models can be instructive for both growers as policy-makers to investigate problems subject to uncertainty and multiple criteria.*

**Key-words** : Greenhouse System Management.


## 1. Introduction

Greenhouse managers dispose of advanced options to control the production process. Nevertheless, greenhouse production system management can be rather problematic due to the complexity of the system and the dynamic character of its environment (Challa et al., 1994). Complexity relates to a high number of temporal and spatial state variables in combination with a high number

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of non-linear relations and many options for management. Moreover, exogenous conditions, such as weather and selling prices, are generally unstable.

In recent years, the margins for greenhouse production have been narrowed due to (1) increasing international competition, (2) increasing consumer demands on product quality, and (3) government efforts to improve sustainability. As a result, growers search for new options for greenhouse production both for the short and the long term. Due to the complexity of the greenhouse production system and the dynamics of its environment, however, it is rather difficult to find a satisfactory balance between inputs and outputs for a new or modified system. Moreover, because of the small margins in greenhouse production nowadays the implementation of new options for greenhouse production is rather risky. Thus, there is a need to explore the opportunities of new options for greenhouse production system management in an experimental way.

Various approaches can be applied to investigate new options for strategic, tactical and operational management of (greenhouse) production systems. Of course, experimental production system designs can be investigated empirically, but this is rather expensive. Moreover, the empirical investigation of isolated subsystems bears the risk of creating new problems in other parts of the whole system, while solving the problem in the investigated subsystem.

Controlled experiments with enterprises, as for example Jofre-Giraudo et al. (1990) conducted, are often impracticable. It is hardly possible to assure consistent practice of management strategies in separate groups of nurseries. Moreover, it would be difficult (if not unethical) to persuade growers to apply strategies of management that are regarded improper or rather risky beforehand. Finally, such experiments are generally complicated by the limited control over intervening variables, which often leads to nonrandom sampling and distorted results.

Ex post experiments can be conducted based on the availability of cross-section data over time of individual nurseries. Verstegen et al. (1993), for example, examined farm results before and after implementation of computerized management information systems. In many cases, however, this approach can not be applied, because management strategies do not change demonstrably and abruptly at some point in time.

With rapid developments in computer technology, system analysis and modelling have become a widely applied approach to investigate production system management strategies (Pidd, 1992; Spedding, 1990). Despite the common concern for validity, both optimization models and simulation models enable efficient experimentation with virtual production systems under various conditions.

Finally, a fourth option is the so-called laboratory experiment, where real growers solve virtual management problems (Cats-Baril & Huber, 1987). Although setting variables, such as available time, undivided attention and motivation, can invalidate the results of such an approach, it opens opportunities to conduct rather controlled experiments with real growers involved.

## 2.    Objective

The present paper is directed to the formulation and evaluation of various strategies of operational management in pot plant production (Leutscher, 1995) as an example of model-based greenhouse production system investigation. Since operational management was regarded as adaptive decision-making during the implementation of the tactical production plan, strategies of operational management had to be evaluated in combination with various tactical production plans.

Because the objective was to study the dynamic process of adaptive decision-making, the use of laboratory experiments was rejected. Moreover, because both controlled experiments and analysis of an experimental greenhouse production system were impracticable and no appropriate data for ex post experiments was available, system analysis and modelling was the only suitable approach to achieve this objective. Simulation was applied for modelling, as in similar studies like Papy et al. (1988) and Stafford Smith & Foran (1992). Optimization techniques were not applied, because the purpose of the study was to analyze the expected transient effect of adaptive operational decision-making, rather than to optimize individual decisions.

Production management on pot plant nurseries is particularly focused on greenhouse area allocation, because of the ability to displace plants during cultivation (Annevelink, 1989; Basham & Hanan, 1983; Buchwald, 1987; Krafka et al., 1989; Leutscher & Vogelezang, 1990). Moreover, the allocation of labour is important, because labour requirements are also discontinuous since they mainly relate to potting, spacing and delivery. Because of the dynamic greenhouse area and labour requirements during cultivation, pot plants are produced in batches, which have individual cultivation-schedules. In the greenhouse various batches in different developmental stages are cultivated simultaneously. Thus, the main problem of pot plant production management is the allocation of greenhouse area and labour to multiple batches throughout the year.

The allocation problem can not be solved satisfactorily by only tactical planning because of uncertainty. Therefore, adaptive decision-making (i.e. operational management) is investigated, where crop growth and price formation are the most important processes subject to uncertainty. Adaptations of cultivation-schedules of individual batches should be submitted to the condition that further implementation of the tactical production plan is not prohibited. Of course, the grower may also consider new tactical production planning every time adaptation of cultivation-schedules seems necessary. In the present study, however, frequent reconsideration of the tactical production plan as a whole is regarded to be inconsistent with its medium term guideline function.


## 3.    The model

The pot plant nursery model simulated the implementation of a tactical production plan over a period of one year under uncertain exogenous condi-

tions. Hence, it enabled the analysis of sequential decision-making and its consequences in response to variable exogenous conditions. The structure of this whole-system model described the relations between individual subsystems: crop growth, price formation, and operational decision-making. Moreover, it calculated the economic and organizational consequences of the simulated events. Thus, the model provided an integrated view on the consequences of production actions triggered by the original tactical production plan or by operational decision-making.

Crop growth was modelled based on a quantitative approach of dry matter accumulation (Leutscher & Vogelezang, 1990). In addition, product quality (in terms of plant length) and heterogeneity among plants in a batch were modelled. Crop growth deviations (leading to non-standard product attributes) were caused by random starting conditions for each batch and a random level of outside radiation. The crop growth model was specified for Schefflera arboricola 'Compacta' based on available experimental data.

Price formation was modelled under the assumption of perfect competition on the pot plant market. Because of the limited information about the behaviour of the pot plant market, the price formation model was rather straightforward and consisted of a seasonal pattern with random long-term and short-term deviations (Makridakis & Wheelwright, 1978). Moreover, the price formation model simulated price reduction in case of deliveries with non-standard product attributes. The model was specified based on statistical data and after consultation of growers.

The operational decision-making model simulated monitoring of crop growth and price formation at the end of the cultivation and, in case of rejection of pre-declared thresholds, adjustment of the tactical production plan. A set of IF-THEN rules was specified for each strategy of operational management and applied to determine if the tactical production plan should to be adapted. Furthermore, a heuristic search procedure was applied to make such adaptations. The objective of the adaptation procedure was specified for each strategy of operational management.

Empirical validation of the whole model was impossible, because it represented a virtual enterprise with newly formulated and consistently applied management principles. Instead, the behaviour of the specific models for crop growth and price formation was compared with available data. Moreover, individual decisions were compared to the intentions of the applied strategies of operational management.

## 4.    System variants and experimental design

Each system variant consisted of a combination of a tactical production plan and a strategy of operational management. Every simulation with the pot plant nursery model was influenced by a given course of exogenous conditions. These exogenous conditions were simulated randomly prior to any simulation-experiment and affected the simulation of either crop growth or price formation. A set of 25 scenarios of exogenous conditions (common random numbers)

was applied to replicate individual system variants under various uncertain conditions. All replications were executed parallel to each other with identical initial system states.

Three tactical production plans were formulated, based on the same description of the imaginary nursery and on average exogenous conditions with regard to crop growth and price formation. The reference plan ($P_1$) was developed by applying standard technological coefficients and a profitability objective function in a linear programming model. In addition, the extra slack plan ($P_2$), was based on the same linear programming model, except for the length of the standard cultivation-schedules. In fact, for every optional batch the standard cultivation-schedule was extended with one week in order to avoid operational problems due to delayed crop growth. The cash flow plan ($P_3$), was based on the standard linear programming model except for the interest rate on operating capital. Although the financial situation of the modelled nursery was disregarded, operational management was believed to be affected by the cash flow situation. Hence, in the cash flow plan ($P_3$) liquidity problems were assumed to lead to higher interest rates as a consequence of a negative cash account.

Five strategies of operational management were formulated (table 1). These strategies varied with respect to the processes monitored, whether short term profitability was considered as an objective, and with respect to the time interval between deliveries. The *passive* strategy ($S_1$) involved no operational adaptation whatsoever. Thus, under this strategy all cultivation-schedules were implemented exactly according to the initial tactical production plan. Consequently, the delivery of batches with advanced or delayed crop growth lead to price reductions due to non-standard product attributes. Under the *product quality* strategy ($S_2$), price reductions were tried to be avoided by adapting cultivation-schedules. Hence, under this strategy the objective of operational management was to deliver pot plants with standard product attributes as much as possible regardless of short term profitability. Conversely, under the

*Table 1    Specification of the applied strategies of operational management*

| Strategy | Monitored processes | Short term profitability as objective | Fixed delivery moments per week |
|---|---|---|---|
| *Passive* ($S_1$) | none | no | yes |
| *Product quality* ($S_2$) | crop growth | no | yes |
| *Profitability* ($S_3$) | crop growth | yes | yes |
| *Flexible delivery* ($S_4$) | crop growth | yes | no |
| *Active marketing* ($S_5$) | crop growth & price formation | yes | no |

*profitability* strategy (S₃) cultivation-schedules were only adapted to crop growth deviations if such adaptations were expected to be profitable on the short term.

Under strategies $S_2$ and $S_3$ pot plants were assumed to be monitored, treated and delivered at fixed moments during every week based on the premises of the tactical production plan. Under the *flexible delivery* strategy (S₄) this assumption of fixed moments of delivery in each week was dropped. Besides, this strategy was identical to $S_3$. The *active marketing* strategy (S₅) involved the adaptation in response to crop growth deviations as well as due to price deviations.

## 5. Simulation results

Stochastic patterns of crop growth and price formation lead to considerable variation in net farm income. Figure 1 shows, for example, simulated net farm income for each of the 25 replications of system variants $P_1S_1$, $P_2S_1$ and $P_3S_1$. Due to the use of common random numbers system variants tend to have strong covariation.

Net farm income (DFL. m²)
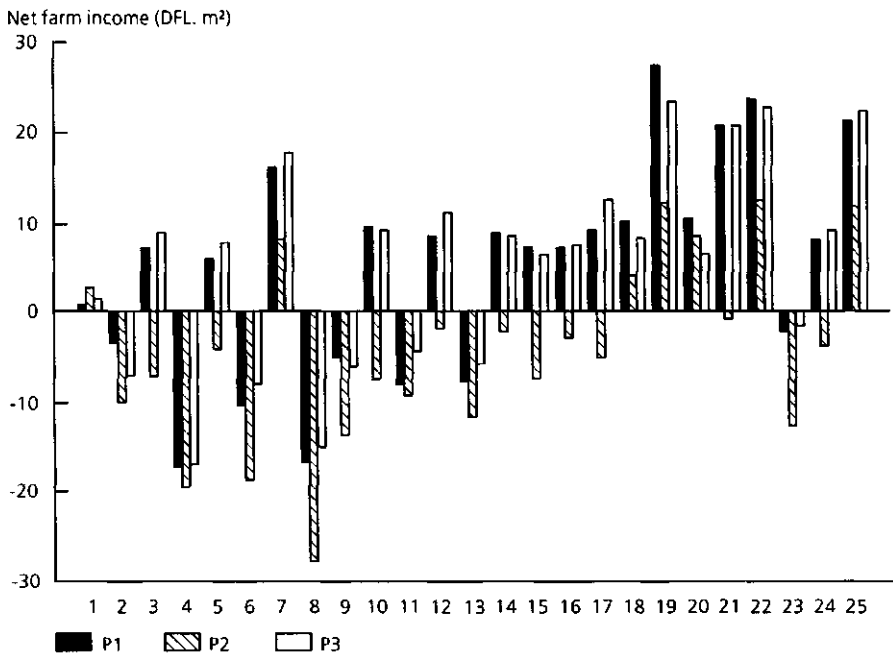


*Figure 1    Simulated net farm incomes under system variants $P_1S_1$, $P_2S_1$ and $P_3S_1$ in 25 replications*

The 25 replications per system variant were used to analyze and compare distributions, variances and means. The assumption of a normal distribution per

system variant as well as the assumption of common variance seemed reasonable. Subsequently, average net farm incomes (figure 2) were analyzed by means of regression metamodelling (Kleijnen, 1992). This technique enabled the simultaneous analysis of both tactical production plans and strategies of operational management with system variant $P_1S_1$ as a reference. Thus, besides the main effects also interactions could be investigated. Furthermore, regression metamodelling compensated for statistical dependency due to common random numbers by taken the covariance matrix into account.

Compared to the *reference* plan ($P_1$), the *extra slack* plan ($P_2$) lead to a significant reduction of the net farm income ($P<0.05$), whereas the *cash flow* plan ($P_3$) had no significant effect ($P>0.05$). There was no significant effect of the replacement of the *passive* strategy ($S_1$) by the *product quality* strategy ($S_2$) on net farm income ($P>0.05$). Replacement of the *passive* strategy ($S_1$) by either the *profitability* strategy ($S_3$), the *flexibility* strategy ($S_4$), or the *active marketing* strategy ($S_5$), however, did lead to a significant improvement of net farm income ($P<0.05$). Except for system variants $P_2S_2$ and $P_3S_5$ significant interactions between strategy of operational management and tactical production plan were found for all system variants ($P<0.05$). This indicates a strong interdependence between the effect of operational management on net farm income and the applied tactical production plan. In fact, figure 2 shows operational management partially compensated poor tactical production planning (the *extra slack* plan ($P_2$)).
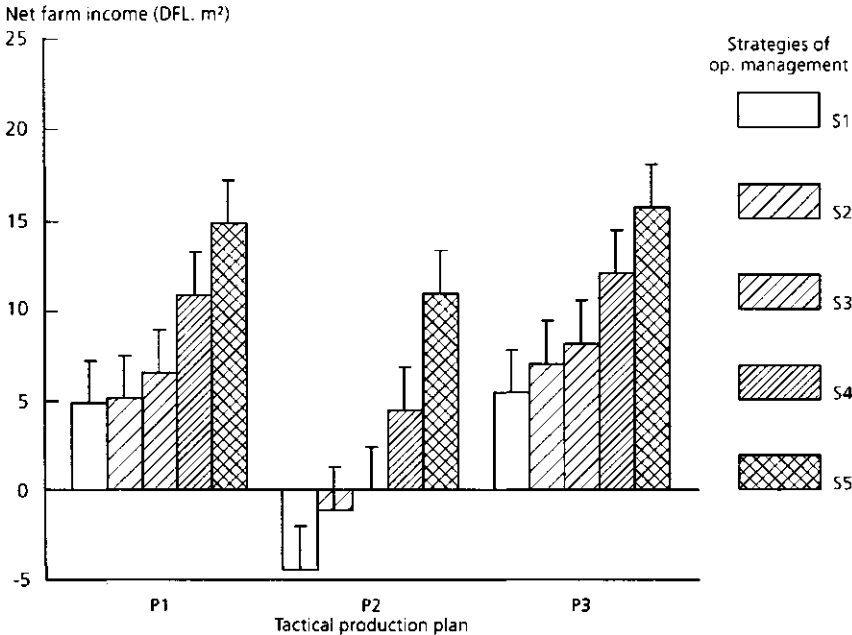


*Figure 2    Average simulated net farm incomes with corresponding standard errors of mean for all system variants*
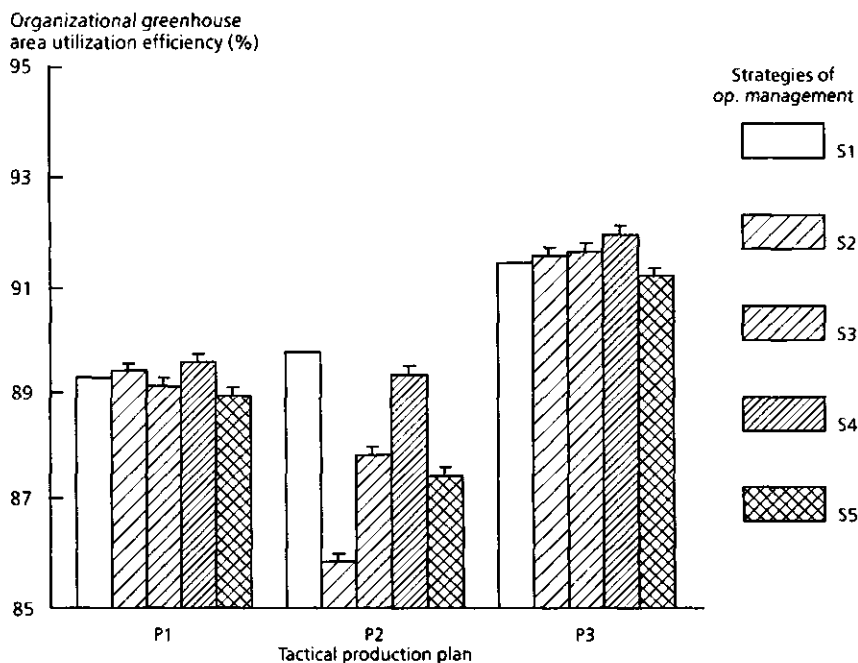
Figure 3  *Average simulated organizational greenhouse area utilization efficiency with corresponding standard errors of mean for all system variants*

Although net farm income was considered the most important criterion for comparing system variants, other simulation results were also taken into consideration. Growers, for instance, usually strive for a high rate of occupation of greenhouses, indicated by a high organizational greenhouse area utilization efficiency (figure 3). Without discussing these results in detail here, figures 2 and 3 demonstrate multiple criteria may lead to inconclusive comparisons, which may only be solved by indicating the grower's preferences in one way or an other.

## 6.    Discussion

The present study on operational decision-making contributes to the understanding of options to manage the pot plant production system. In general, model-based investigations of greenhouse production systems may help growers to improve their management skills with respect to the design and the control of the system. The presented methodology supports the grower to deal with available information about individual processes within the system as well as to explore options for greenhouse production management under various conditions.

Ideally, greenhouse production models are programmed in such a way, that growers can change parameters and analyse their own nursery by means of simulation. Moreover, execution of such analyses in groups under the supervision of an expert could be even more instructive. Hence, greenhouse production system models could be applied to improve decision-making and management indirectly by supporting the learning process of the grower. Moreover, model-based investigations of greenhouse production systems may provide general principles for direct computerized support of decision-making on individual nurseries.

Besides application by growers, greenhouse production system models can also be applied by policy-makers. In this respect, sustainability will become an important subject. The presented methodology could be used to predict the response to particular exogenous conditions (i.e. stimuli & restrictions by government or the market). For this type of application, however, the behaviour of the grower (as part of the system) should also be modelled. This would include social-psychological aspects of decision-making. Moreover, in order to predict the behaviour of the complete enterprise non-production processes, like purchase of assets and resources, financing, labour management and marketing of products, should also be considered.

The present paper shows the simulation research methodology can be successful in integrating theory from various scientific disciplines if based on a rather normative approach. Hence, greenhouse production system models may be useful to find new options for production in case of changing constraints imposed by government and society, and to satisfy multiple objectives under uncertainty.

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# THE FARMERS IN-SERVICE TRAINING IN RELATION TO MANAGE THE FARM

Per Chr. Springborg, M.Sc. 1)

## Abstract

*Today the Danish farmer manage his farm as a modern cooperation where in-service training is one of the means of improving the farmmanagement. However, in Denmark the supply of cources have been great and confusing. Therefore it has been very difficult for the farmer to select which course he should participate in and when he should do it, but also to plan his in-service training in a long view.*

*For that reason there has been developed a new type of subjectcources, which is attended to the professional farmer and manager. The new sujectcources discuss a certain subject with more care than usually. At the same time the demand for the courses is that they dont overlap. This gives the farmer a guarantee that he doesn't waste time on irrelevant courses. Instead he is having his knowledge on the certain subject enlarged.*

*The subjectcourses makes it now possible for the farmer to plan his in-service training more systematically. With this types of courses the in-service training will here by in the future go on at a higher level than usually. The teachers will typically be consultative advisers and scientists mainly from the agricultural centers.*

*The results of a systematical in-service training can be a better interplay with the the farmers adviser. The relations between the farmer and the adviser can change from one way communication, from the adviser to the farmer, to be a both way communication. The farmer and the adviser will in the future be sparringspartners.*

**Key-words** : In-service training, management, strategic planning, decision making.

## 1.     In-service training courses for farmers in Denmark

The demand for in-service training courses for farmers in Denmark is met by an extremely wide range of different courses.

The development of a systematic in-service training course system for farmers was initiated in the beginning of the 1980s, triggered off by the increasing specialisation and the resulting demand for increased professional and

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management skills. Furthermore, new demands were made on the farmers from the surrounding community in the form of environmental measures to reduce nitrate leaching from farmland as well as increased attention on the use of pesticides, feedstuffs etc. This makes demands on the farmer both in his capacity as a 'professional' and as a farm manager which are not necessarily covered by the training he has obtained so far.

This is one of the reasons for developing a comprehensive and varied supply of in-service training courses which are supported both legally and financially by the Danish Government.

Figure 1 shows the number of Danish farmers who participated in subsidized courses in the period 1983-1994, converted to participants in week-long courses. The present description is based solely on courses approved by the Structural Directorate under the Danish Ministry of Agriculture.

No. of participants in week-long courses
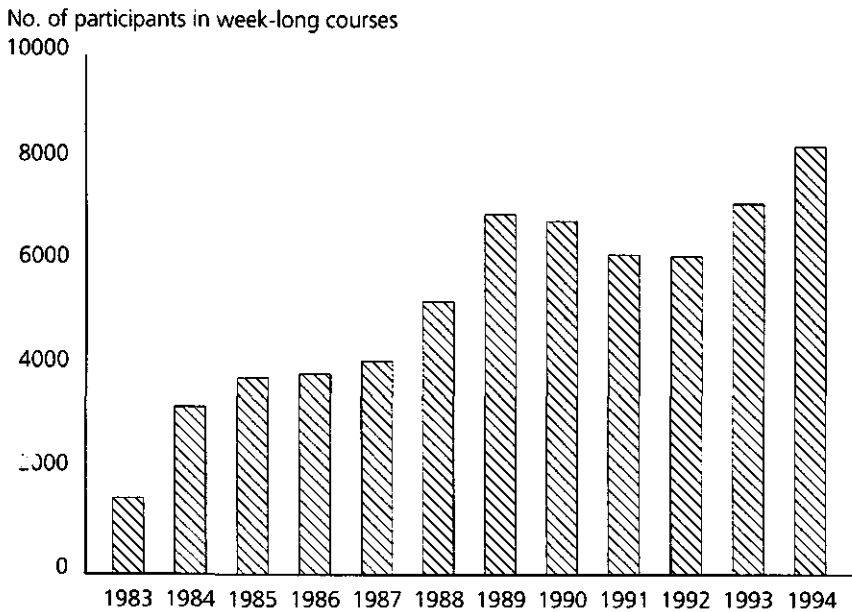


Figure 1   Overview of Danish farmers' participation in subsidized courses
Source: The Ministry of Agriculture and The Institute for Agricultural Information.

## 2.   Position of theme-oriented in-service training courses

This presentation describes a number of factors which are essential to the in-service training of established farmers in Denmark. The purpose is to show how the implementation of theme-oriented courses, including the organisation and development of structured courses may effect both the receivers and the suppliers of agricultural courses.

The theme-oriented courses are developed to comply with a wish expressed by the agricultural in-service training centres - and a legitimate demand on the part of the agricultural industry - to develop a clear and professionally adequate range of courses addressing the professional farmer. The supply is thus intended to provide the farmer with the possibility of combining a number of modules into his own educational plan meeting his special requirements in terms of educational level and contents.

One of the main demands is that the theme-oriented courses must be supplied nationwide, calling for extensive cooperation between the suppliers of courses in terms of both development and planning.

In this connection it should be stressed that the main idea itself and the extremely broad supply of courses have been such a great challenge that nationwide cooperation has been a must to accomplish the task.

Therefore, the courses are developed by the in-service training centres in cooperation with the Institute for Agricultural Information and the relevant national departments of the Danish Agricultural Advisory Centre.

The theme-oriented courses are offered only as residential courses by the in-service training centres, thus forming a special element of the total supply of in-service training courses for farmers.

## 3.   Structure and contents of theme-oriented courses

The modular theme-oriented courses are directed towards the professional farmer and the farm manager who want to get a more profound knowledge of a specific topic or a number of specialist topics.

The theme-oriented courses are 3-day residential courses which consist of a number of main themes within a production area and typically containing 4 - 5 single modules. Each module concentrates on very specific, well-defined topics which are treated in detail both professionally and in terms of contents.

The theme-oriented courses are offered in the following 3 production areas: cattle husbandry, plant production and pig production. The themes and modules of the individual production areas are characterized by the following factors:
*       A theme consists of one or more modules, i.e. theme-oriented courses.
*       The courses are 3-day residential courses.
*       Each individual course is professionally well-defined so that overlapping between the modules does not occur.
*       Each module is an integrated whole and must be capable of standing alone.
*       For each module a description of subject matter is worked out containing the sub-items, aims and guiding number of lessons.

Every theme-oriented course makes up a well-defined module with professional contents differentiating it from all other modules, irrespective of theme and production area.

Figure 2a shows the structure of the theme-oriented courses within cattle husbandry. Later in the supplement in figure 2b and 2c the structure of the

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theme-oriented courses within pig production and crop production are presented.
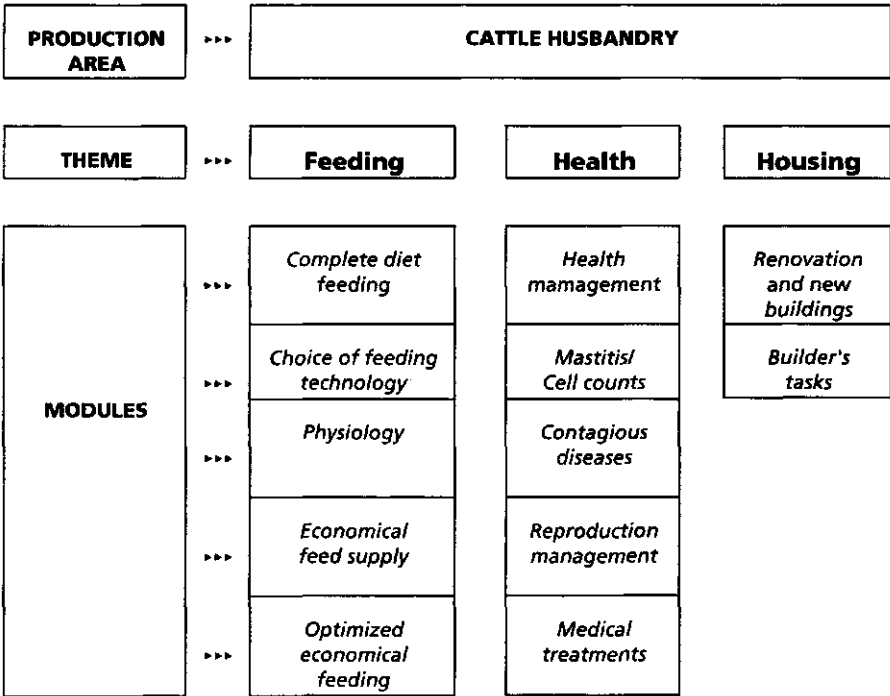
| PRODUCTION AREA | ►►► | CATTLE HUSBANDRY | | |
|---|---|---|---|---|

| THEME | ►►► | Feeding | Health | Housing |
|---|---|---|---|---|

| MODULES | | Feeding | Health | Housing |
|---|---|---|---|---|
| | ►►► | Complete diet feeding | Health mamagement | Renovation and new buildings |
| | ►►► | Choice of feeding technology | Mastitis/ Cell counts | Builder's tasks |
| | ►►► | Physiology | Contagious diseases | |
| | ►►► | Economical feed supply | Reproduction management | |
| | ►►► | Optimized economical feeding | Medical treatments | |

*Figure 2a.  Theme-oriented courses within cattle husbandry*

Within the production area of **CATTLE HUSBANDRY** the following 3 themes:

**feeding**
**health**
**housing**

form the framework of the complete modular contents.

The above structure ensures that all details within one production area are dealt with in order to cover all the needs of the professional farmer. At the same time a well-defined delimitation ensures professional depth.

The modules are organized so that they supplement each other and all together they cover the theme in question completely.

In the same way the 5 modules of:

*health management*
*mastitis/cell count*
*contagious diseases*
*reproduction management*
*medical treatments*

cover the **'Health'** topic.

The modules are organized as separate courses - they supplement each other like squares in a chessboard - and each farmer can make his own decision according to interests and needs. There are thus no built-in preconditions that any module depends on the participation in the preceding ones. The farmer can make his own choice and combine the modules he wants into a genuine educational plan that may spread over several years.

## 4.    Development and planning of courses

*Cooperative relations*

Due to the professional contents, the nationwide cooperation and the possibility of continuous evaluation and adjustment it has been necessary to involve different partners to help develop and further develop the theme-oriented courses. These partners are invited to provide knowhow, nationwide service, educational innovation work and to ensure both regional and national coordination in relation to other in-service training courses.

The following parties are involved in the development of the theme-oriented courses:
*    farmers;
*    agricultural in-service training centres;
*    Institute for Agricultural Information;
*    regional in-service training advisers;
*    senior advisers;
*    local specialist advisers, vets etc.

*Course planning*

Right from the start it was decided that the theme-oriented courses should include the 3 main production areas: CROP PRODUCTION, CATTLE HUSBANDRY and PIG PRODUCTION. No independent courses were to be offered within farm accounting and economy as economy and economic evaluations form natural elements of the already planned theme-oriented courses within the picked production areas. The reason for this is that the farmer is evaluating the whole farm as one economic whole.

For the sake of development and the chance of studying the effect of the first courses it was decided to start with one production area and then later on extend the range of courses by the two remaining areas.

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In 1994 the first theme-oriented courses were started within CATTLE HUS-BANDRY. 4 courses were organized in the season of 1994/95, one of them being a pilot project. In 1995 courses were offered within the two other areas, CROP PRODUCTION and PIG PRODUCTION.

*How to ensure course contents*

The parties involved in the planning of the courses for the 3 areas have followed the same principles in order to comply with the requirements formulated, including:
*       involvement of farmers in both a demand analysis and an evaluation of the professional relevance and the implementation of the courses;
*       professional expertise, using both the national departments and the local specialist advisers;
*       educational expertise, including i.a. the Institute for Agricultural Information, in-service training centres and specialized in-service training advisers;
*       utilization of the experience that the in-service training centres have gained from residential courses already held at the in-service training centres.

*Planning procedure*

The modular theme-oriented courses are planned by picked farmers, local specialist advisers, national departments, vets and other advisers in cooperation with the in-service training centres, the advisers specialized in in-service training and the Institute for Agricultural Information.

At the opening meetings the persons involved discuss the idea, aim and structure of the theme-oriented courses. A common ground for further activities and suggestions as to topics and modules are worked out for the individual areas.

Later on the contents of the individual themes is described more precisely. In this connection the contents of the individual modules are coordinated and determined.

As a matter of principle the detailed planning of the individual theme-oriented course is taking place at the particular school where the first course is to be held. Also in this phase farmers and specialist advisers are involved as knowhow providers. In order to ensure proper coordination and some uniformity in the development of the courses the Institute for Agricultural Information contributes to the detailed planning as well.

## 6.    Perspectives

The range of structured courses offered meets the wishes of the professional farmer to acquire detailed knowledge on specific topics. At the same time these courses consider a number of general and personal wishes and de-

mands as regards harmony and continuity for the development of the farm and the in-service training of the farm manager:
* The structured well-arranged courses facilitate the farmer's choice of exactly the topics that are most interesting to him.
* At the same time the farmer gets a good basis on which to select the courses he wants to attend and then to attend them in the order and at the speed that suit him best.
* Due to the structuring of the courses a farmer who chooses to attend a particular course can be certain that the course will be the same irrespective of training centre and point of time.
* The well-defined contents of the theme-oriented courses secure the participant against overlapping and at the same time he will work with new topics at every course.
* Due to the structured contents of the theme-oriented courses the participants can utilize the skills acquired directly on the farm.

In the future it will be possible to compound a number of coherent subjectcourses. It is the thought that a progress over 2 to 3 years where the farmer previously has compound a number of subjectcources in relation to his farm and interest. In the periods between the courses the farmers will work with some 'homework' that has to be approved by experts. The farmer will after participating in theese subjectcources, doing 'homeworks' and finally have work out a strategyrapport for his farm, get a diploma. I believe that this diploma can be a very important document in relation to buy a farm, to get a loan, to get a job and so on. The tought is that the farmer will be qualified as 'bachelor' in for example milkproduction.

The vision with the subjectcources is that the farmer quicker realize specific problems and more eaily solve it. The purpose is also that when the farmer have finished a number of cources with a strategy rapport for his farm, he will be better qualified to use his agricultural adviser. It will give the farmer a more clear view on his factory and he will be better to solve his problems in a professional way and in a strategycal perspective.

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## 8. Supplement

Figure 2b and 2c show the structure of the theme-oriented courses within pig production and crop production.
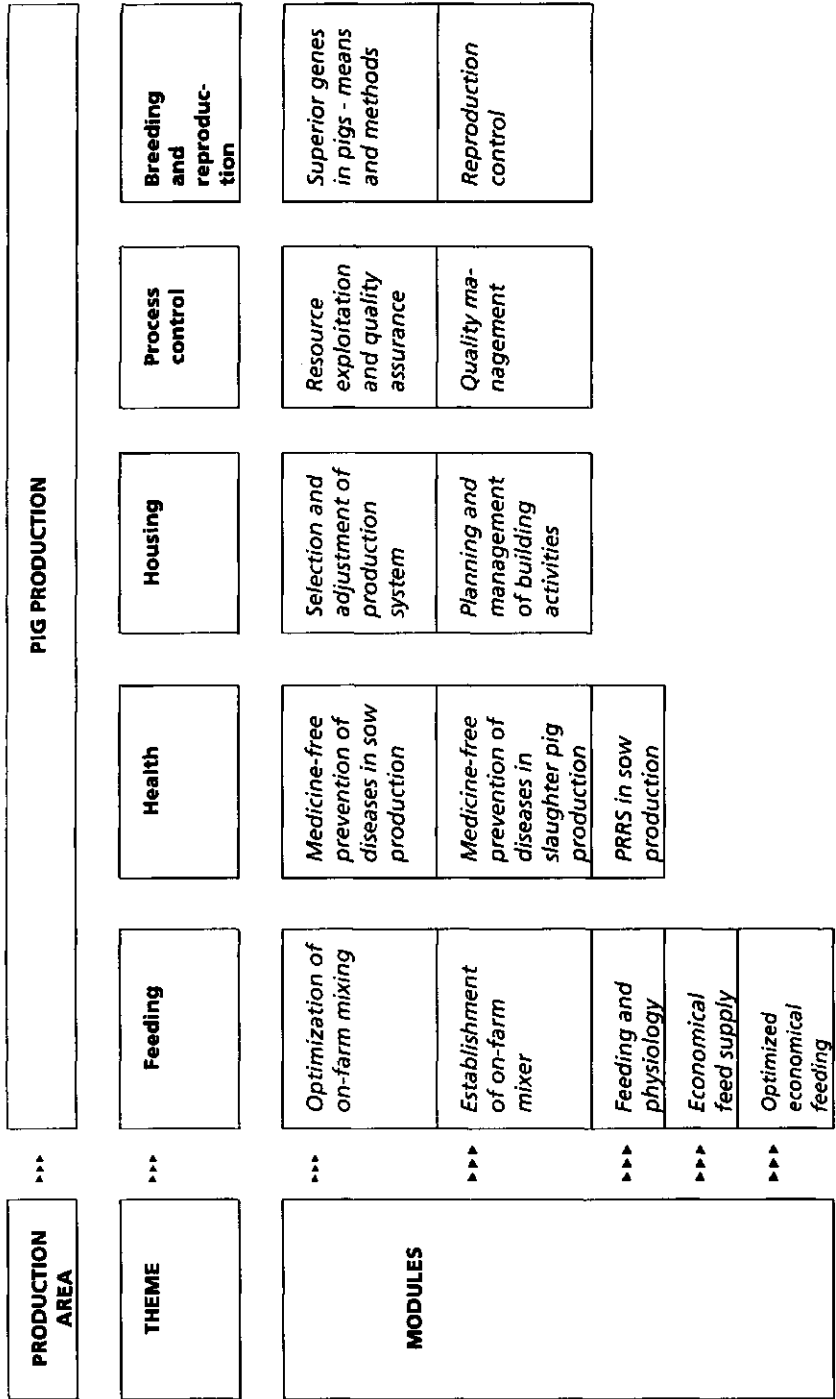
**PRODUCTION AREA**

PIG PRODUCTION

**THEME**

| Feeding | Health | Housing | Process control | Breeding and reproduction |
|---|---|---|---|---|

**MODULES**

| Feeding | Health | Housing | Process control | Breeding and reproduction |
|---|---|---|---|---|
| Optimization of on-farm mixing | Medicine-free prevention of diseases in sow production | Selection and adjustment of production system | Resource exploitation and quality assurance | Superior genes in pigs - means and methods |
| Establishment of on-farm mixer | Medicine-free prevention of diseases in slaughter pig production | Planning and management of building activities | Quality management | Reproduction control |
| Feeding and physiology | PRRS in sow production | | | |
| Economical feed supply | | | | |
| Optimized economical feeding | | | | |

*Figure 2b   Theme-oriented courses within pig production*

**CROP PRODUCTION**

| PRODUCTION AREA | THEME | MODULES |
|---|---|---|

**Management**
- Quality management and integrated production
- Contract purchase and sale
- Working environment and safety
- Economical feed supply
- Optimized economical feeding

**Planning**
- Computerized production control - INTERGRATED FARM MANAGEMNENT SYSTEM
- Field mechanization
- Optimized crop rotation
- Soil management

**Growth conditions**
- Fertilization
- Soil chemistry and biology
- Crop protection and weed control

**Cropping**
- Potatoes
- Rapeseed and peas
- Cereals
- Other crops

Figure 2c   Theme-oriented courses within crop production

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# EVALUATING MANAGEMENT AND MANAGEMENT INFORMATION SYSTEMS USING EXPERIMENTAL ECONOMICS

Verstegen, Jos A.A.M. 1); Sonnemans, Joep 2); Huirne, Ruud B.M. 3) and Dijkhuizen, Aalt A. 3)

## Abstract

*In 1992, a survey study revealed that, after adjustments for farm, learning, and trend effects, sow farmers using management information systems (MIS) produced 0.56 piglets per sow per year more than they did before MIS use, resulting in a return on investment of 220 to 348% (Verstegen et al., 1995a). The purpose of the present study was to learn if experimental-economic methods can be used as an alternative approach to determine the profitability of MIS in sow farming. An individual decision-making experiment was executed using a quasi-experimental, nonequivalent control, pretest-posttest design. In an MIS group, MIS estimates were derived by within-subjects comparisons of decision quality with and without MIS features. A baseline group was included to adjust for learning effects during an experimental session. Decision quality of subjects in the MIS group significantly improved when offered MIS features (p=0.064). However, after adjustment for learning during the experimental session, this effect was no longer significant (p=0.182). In a linear regression model, nineteen within-farm comparisons could be made between MIS estimates from the survey and those derived in the experiment. The regression model explained very little of the variation (≈8%) and none of the coefficients were found significant. The paper concludes with suggestions for further research.*

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## 1. Introduction

The scale of production in pig farming has increased considerably during the last two decades. However, due to narrowing margins per unit of output, farmers' income did not increase accordingly and became increasingly sensitive to changes in productive farm performance (Huirne, 1990). In pig farming, risks and pay-offs per decision are usually low. Nevertheless, decision quality significantly affects farm performance because of the large number of decisions to be made. Pig farming is mainly a routine-like activity which means that farmers rely on certain rules of thumb unless they become aware of (negative) deviations in performance: management by exception (Anthony, 1970). During the last decade, a strong development in electronic data recording and processing systems has taken place to support farmers in their decision making to control and improve farm performance. A category of more advanced systems 'designed to provide daily production information on individual animal level that is of potential value in making management decisions' (Boehlje & Eidman, 1984) is denoted here as management information systems (MIS). MIS structure the bulk of individual animal data on a farm, calculate certain key figures and produce farm overviews, working and attention lists. These MIS attributes give farmers the opportunity to identify deviations in performance sooner than before and also to identify less obvious deviations. Moreover, calculation of key figures and specific analyses of farm data provide new types of information that can improve decision making. Therefore, MIS benefits result from (i) more timely decision making and (ii) a higher quality of decision making. Verstegen et al. (1995a) conducted a survey study on the profitability of MIS in sow farming. Using a quasi-experimental nonequivalent time-series design, they showed that after MIS adoption, farmers raised 0.56 piglets per sow per year more than before (adjusted for farm variation, learning and trend effects). Under normal Dutch price conditions and under the assumption of fixed labour costs, the estimated MIS profit (benefits minus costs) is dfl. 30.- to dfl. 35.- per sow per year which means a return on investment of 220 to 348% and an improvement in net returns to labour and management of 7.7 to 8.7% [1]. A lack of observations, however, obstructed analysis of the effect of intergenerational transfer, and of the relationship between MIS use and individual farm performance. A controlled *field experiment* would have provided more opportunities for in-depth analyses but could not be applied because the MIS under study were already in use, prohibiting pre-audit random assignment of farmers (Verstegen et al. 1995a).

The purpose of this study is to learn if experimental-economic methods can be used as an alternative approach to determine the profitability of MIS in sow farming. According to Hamilton & Chervany (1981), MIS effectiveness can also be evaluated directly by investigating changes in decision-making pro-

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[1]     Return on investment of MIS = MIS profit divided by MIS investment costs; net return to labor and management = net farm profit plus compensation for labor and management.

cesses under influence of MIS features, rather than indirectly through farm performance. A basic assumption of experimental economics is that the results, obtained in a laboratory environment, carry over to the more complex natural environment, i.e., the external validity assumption (Davis & Holt, 1993). Most individual decision-making experiments focus on developing and testing of decision theories. Very little experimental-economic studies have tested external validity (Camerer, 1995). In this study, MIS estimates derived from pig farmers in the economics experiment are compared to (real-life) MIS estimates of the same farmers, determined in a survey study. The amount of information and experiences available to the subjects in the experiment is controlled by constructing an investment project selection problem as an abstract experimental-economic analogue of the sow replacement problem. The experiment is run with a computer program 1) and decision making is evaluated using Bayesian updating in a hierarchic markov processes (DP) model (Kristensen, 1988,1993; Houben et al., 1994). In an MIS group, MIS estimates are derived by within-subjects comparisons of decision-making quality with and without MIS attributes. A baseline group was included to adjust for learning effects.

This paper outlines the experimental-economic study and demonstrates the analogue between the abstract and the natural decision problem. Farmers' decision making quality and MIS estimates are presented, as well as suggestions for further research.


## 2.   The experimental-economic study

An investment project selection problem is constructed to be an abstract experimental-economic analogue of the sow replacement problem (App. 1). Instead of deciding on sows, subjects in the experiment have to choose between the decision to keep or to replace investment projects. Time available for decision making is limited (to resemble its opportunity costs in sow farming). An experimental year is defined in which subjects have to make decisions on each of fifteen projects in a group 2). After that, they have to do the same for a second group of fifteen projects. In the next experimental year, they again decide on the first fifteen projects, and so on.This procedure is repeated for several experimental years. Replaced projects are filled in by new projects to keep group sizes at fifteen. Each experimental year, more data of the (ageing) investment projects become available through their latest production results. The production potential of an investment project in the experiment consists of two properties, the number of production weeks per production year (PW), and the yield, i.e., the number of points that can be scored, per produc-

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1)    The computer software is developed for this experiment by Otto Perdeck at the Center for Research in Experimental Economics and Political Decision Making (CREED), University of Amsterdam.
2)    Parameters, such as the time for decision making and the group sizes were determined in pilot tests with (under)graduate students and staff members.

tion week (Y/PW) 1). For each project, the production data are sampled from a normal distribution around its production potential. Therefore, the production data provide subjects with imperfect information of the actual production potentials of the projects.

In our formulation of the decision problem, the property PW is constant over time and has two levels only, i.e., 'many' and 'few'. The difference between the values of these levels equals $1\sigma$ (App. 2: Fig. 1 and 2). Analogous to the (age-related) trend in litter sizes of sows, Y/PW expectations of projects change over time with a maximum value in the fourth and fifth production year. Again two levels, differing $1\sigma$, are used, i.e., 'high' and 'low' (App. 2: Fig. 3 and 4). With equal probabilities, a project has the property, i.e., potential, of producing many or few weeks per production year throughout its lifetime. Likewise, a project has fifty-fifty chance of having the potential to generate high or low yields per production week. Consequently, a project's total production potential has a 0.25 probability to be [many PW, high Y/PW], [many PW, low Y/PW], [few PW, high Y/PW], or [few PW, low Y/PW].

Subjects do not know the production potentials of the projects, but may be able to identify them by looking at their (sampled) production data and the figures in appendix 2. If a certain project has a relatively high yield per production week in many production years, it will likely have the property 'high Y/PW'. Else if this project repeatedly produces low yields per production week, it will likely have the property 'low Y/PW'. The same logic applies to the property PW. Once subjects have updated their beliefs on the production potential of a certain project, they may be able to form some expectations about the future profitability of this project relative to that of an unknown new project.

## 2.1  Experimental design

MIS effects are estimated in a quasi-experimental, nonequivalent control, pretest-posttest design (Weiss, 1972; Verstegen et al., 1995b), involving two experimental groups: an MIS group (A1,B1) and a Baseline group (A2,A3). In the MIS group, a selection of farmers first decide with limited data, paralleling decision making in sow farming without MIS (A-treatment). This provides the pretest values. Later on, the same farmers decide with more data, paralleling decision making when MIS attributes are present (B-treatment). This provides the posttest values. MIS estimates are formed by subtracting the pretest values from the posttest values (B1-A1).

The Baseline group (A2,A3) is included for controlling autonomous / exogenous changes in decision making over time, e.g., learning or exhaustion effects. These effects cannot be controlled by changing the order of the treatments (B1,A1) because the subjects who start with MIS information (B-treatment) may carry-over experiences to the A-treatment; they may have learned from the MIS features to which attributes they should pay attention. In the

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1)  Coefficients of variation of those properties match with their natural counterparts.

Baseline group, farmers continuously decide with limited information. Learning or exhaustion effects are estimated by (A3-A2). Instead of a random assignment, we purposely designated farmers to one of the experimental groups. Most of the farmers who participated in the survey study were included in the MIS group in order to derive an MIS estimate, which could then be compared to their MIS estimate in the survey.

Before the experiment, the production potential and production results of each investment project were sampled randomly. The production results were stored in input files of the stand-alone computer program that subjects were going to use in the experimental session. The A1 and A2 treatment got input file 1, and the A3 and B1 treatment got input file 2. Input file 1 and 2 contained different projects, and thus different production data, but because of pairwise sampling, the order of projects' production potentials was the same in both input files. Each subject in the experiment, independent of the group

*Table 1    Differences in data without MIS and with MIS for both the economics experiment and the natural situation*

| Economics experiment | Natural situation |
| --- | --- |
| **data without MIS (A-treatment)** | |

| Economics experiment | Natural situation |
| --- | --- |
| Project cards with | Sow cards with |
| 1)  starting and ending dates of the production period | 1)  insemination dates |
| | 2)  farrowing dates |
| 3)  yield per production week | 3)  litter sizes: no. of piglets born alive / dead |

| **data with MIS (B-treatment)** | |
| --- | --- |
| Project cards with | Sow cards with |
| | 1)  insemination dates |
| | 2)  farrowing dates |
| 3)  number of production weeks per year | 3)  sow-specific farrowing index figures |
| 4)  yield per production week | 4)  litter sizes: no. of piglets born alive / dead |
| | 5)  sow-specific number of piglets produced |
| 5)  total yield per year | per year |
| 6)  number of production years of the project | 6)  age of the sow |
| | 7)  boar data |
| | 8)  sow behavior |
| | 9)  vaccinations |
| | |
| Options to obtain | Options to obtain |
| 1)  overviews of projects sorted on the number of production years or the last total yield per year | 1)  standard overviews of sows |
| | 2)  user-defined overviews |
| | 3)  user-defined analyses |
| | 4)  working lists |
| | 5)  attention lists |
| | |
| Average values per project on project cards and overviews | Average values per sow on sow cards and overviews |

to which he or she was assigned, received the same set of input files and, thus, decided on the same projects. Each treatment was run for nine experimental years but, to avoid end-game behavior, this time horizon was not reported to the subjects.

Table 1 shows the differences in data between the two treatments and relates them to the natural situation.

## 2.2  Decision quality

Quality of decision making was assessed by comparing farmers' decision making to the theoretically optimal decision strategy. This optimal decision strategy was computed in a stochastic dynamic programming model (DP) using the hierarchic Markov process technique (Kristensen, 1988; Houben et al., 1994) with Bayesian updating (Kristensen, 1993). Although pay-off levels are good indicators of the overall decision-making quality of farmers, some good decisions may result in bad outcomes, and vice versa, due to the uncertainty in the decision problem. Furthermore, pay-off levels do not provide good insight into the decision-making strategy that farmers should have applied, and into the type of decision-making errors that were made.

For each project in the input files, the DP solution provided the optimal time of replacement and the losses of suboptimal replacement. The optimal time of replacement is defined as the moment where the expected marginal value of the current project is just dominated by the maximum average value of a new project (given that the average expected future values of the current project will never exceed the maximum average value of a new project) (Van Arendonk, 1984). Simulation of an experimental session using the optimal decision strategy results in a yield of 1,042,287 points in the A1 and A2 treatment and 1,040,761 points in the B1 and A3 treatment. Consequently, deciding according to the theoretically optimal strategy would result in a total yield of 2,083,048 points which equals a pay-off of dfl. 146.70 1). Losses denote the yield that is missed due to suboptimal replacement. If replacement is done too early, the loss is defined as the difference in expected future profitability between the replaced project (at the time of replacement) and a new project. If replacement is done too late, the loss equals the summation of differences in expected future profitability over the years after the optimal time of replacement, updated with the new production data in each year.

Differences in decision quality between posttest and pretest values in the MIS group are adjusted for differences in posttest and pretest values in the Baseline group. The resulting MIS estimates are compared with the MIS estimates from the survey study.

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1)    Pay-off is determined by subtracting from the total yield a fixed cost of 3450 for each project in each production year. Furthermore, a cost of 500 is subtracted for each replacement. The remaining yield was divided by 1500 to render the pay-off in Dutch guilders.

## 2.3    Procedure

Subjects received a summary of the decision problem, a hard copy of the figures in appendix 2, scrap paper, and a pencil. No communication was allowed between subjects. A session started with instructions of the decision problem, including the uncertainty in production potentials of investment projects 1). Part of the instructions were done by displaying some examples of investment projects using the same computer program that subjects would use later on. Further, information on the pay-off structure and on how to keep track of the pay-offs during the experimental session was provided.

After the instructions, subjects' understanding of the decision problem was tested with an exercise on paper. The subjects' task was to find out the most likely production potential of each of two projects given ten years of production data. After verification of the answers by the experimenter, the session proceeded with an A-treatment training period of four experimental years. This training period was identical to the subsequent A-treatment (but without monetary pay-offs), allowing subjects to learn (simple) keyboard handling and develop some rules of thumb for decision making. One computer screen displays the yearly production results of one investment project on a project card. Subjects can browse through the fifteen projects and mark individual projects for replacement. A decision to replace is visualized by a red cross through the project card. Subjects can alter this decision until a time limit of 120 seconds is exceeded (App. 1).

After the A-treatment and a coffee break of fifteen minutes, the session continued. The Baseline group of farmers continued with the second A-treatment (A3). The farmers in the MIS group got short instructions on the B-treatment and a three-year B-treatment training period. In the B-treatment, browsing through project cards is equal to the A-treatment. However, the project cards contain somewhat different data and subjects can request for overviews on the number of production years and on the last 'total yield per year' of the fifteen projects (table 1).

After the second treatment, the experimental session was concluded through cash payments of the subjects, which was done in private.

## 3.    Results

The total experiment consisted of eight separate experimental sessions which were conducted in a computer room at the Agricultural Education Center (AOC Boxtel). A session typically started at 7:00 p.m. and ended at 10:30 p.m. In total, 86 farmers participated. In the first four sessions, only members of the MIS group were included. Sometimes, more people (from the same farm) showed up then were invited. These extra people were also included in the experimental session, but only the farm member with the best performance

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1)    An English translation of the instructions is available on request.

was actually paid. In session 5 and 6, members of both the Baseline and MIS group were included. In the last two sessions, only members of the Baseline group were included. All of the participants learned the program rapidly and were very motivated to earn as much money as possible. Pay-off levels ranged between -dfl. 27.40 and +dfl. 145.63. The average pay-off was dfl. 104.79, which is 71% of the optimal strategy, derived from the DP solution. Surprisingly, one participant in the second session faced a negative pay-off, despite the fact that the outcomes in the pilot tests were highly positive. Fortunately, this farmer brought his son who did have a positive outcome and was paid accordingly.

## 3.1 MIS estimates

The MIS estimate in the experiment of participant i is calculated by (1).

$$MIS_i = B1_i - A1_i - \sum_{j=1}^{n_2} (A3_j - A2_j) / n_2 \qquad \textbf{(1)}$$

where
$\quad$ i=participant in the MIS group;
$\quad$ $B1_i$ = losses of participant i in treatment B;
$\quad$ $A1_i$ = losses of participant i in treatment A;
$\quad$ $\sum(A3-A2) / n_2$ = average change in losses of the $n_2$ participants in the Baseline group.

$\qquad$ Losses denote the yield that is missed due to suboptimal replacement (see also section 2.2.). MIS estimates represent the change in losses when subjects are provided with MIS features, corrected for the change due to autonomous / exogenous changes in decision making over time due to learning or exhaustion effects. The correction factor is derived from the Baseline group.
$\qquad$ Table 2 shows the losses in the baseline and MIS groups, and the MIS estimates for the 86 subjects in the experiment. Although the MIS estimates denote an average reduction of losses of 6,814 points, subjects did not significantly improve decision making when offered MIS attributes (p=0.243). This can be explained by the large variation in losses and MIS estimates. Some of the subjects did not fully understand the decision problem and repeatedly kept investment projects past their productive life time of ten years. As was emphasized in the instructions and clearly indicated on the project cards (on the computer screen), projects have zero yield after ten production years. However, the fixed costs of 3,450 points per project in each production year remain, meaning that keeping projects after ten years causes high losses. The loss of keeping one project for one year *after* ten production years equals the average expected yield of a new project, which is 3,898 points according to the DP solution. The loss of suboptimal replacement *within* the productive life time of ten years typically varies between 1 and 1,000 points. Therefore, the losses of keeping

projects after ten production years overshadow the losses of suboptimal replacement within the productive life time of projects.

Table 2    The losses for the 86 subjects in the experiment

|  |  | mean | s.d. | s.e. of mean | t-value | Pr > ⏐T⏐ |
|---|---|---|---|---|---|---|
| MIS group $(n_1=48)$ | A1 | 55,050 | 53,452 | 7,715 |  |  |
|  | B1 | 47,382 | 53,135 | 7,669 |  |  |
|  | B1-A1 | 7,668 | 39,926 | 5,763 | 1.33 | 0.190 |
| Baseline group $(n_2=38)$ | A2 | 51,784 | 36,342 | 5,895 |  |  |
|  | A3 | 50,930 | 43,923 | 7,125 |  |  |
|  | A3-A2 | 854 | 22,086 | 3,583 | 0.24 | 0.813 |
| MIS est. $(n_1=48)$ | B1-A1- $\sum(A3-A2)/n_2$ | 6,814 | 39,926 | 5,763 | 1.18 | 0.243 |

Table 3    The losses for the 63 selected subjects in the experiment

|  |  | mean | s.d. | s.e. of mean | t-value | Pr > ⏐T⏐ |
|---|---|---|---|---|---|---|
| MIS group $(n_1=35)$ | A1 | 27,465 | 11,111 | 1,878 |  |  |
|  | B1 | 24,132 | 12,010 | 2,030 |  |  |
|  | B1-A1 | 3,333 | 10,313 | 1,743 | 1.91 | 0.064 |
| Baseline group $(n_2=28)$ | A2 | 34,493 | 16,459 | 3,110 |  |  |
|  | A3 | 33,537 | 19,778 | 3,738 |  |  |
|  | A3-A2 | 956 | 12,908 | 2,439 | 0.39 | 0.698 |
| MIS est. $(n_1=35)$ | B1-A1- $\sum(A3-A2)/n_2$ | 2,377 | 10,313 | 1,743 | 1.36 | 0.182 |

To adjust for this effect, 63 subjects who made less than five errors in keeping projects after ten years were selected (1 project kept for 1 year after ten years = 1 error). The losses of these errors were substituted by the average loss that a subject experienced (apart from these errors).Table 3 shows the losses in the baseline and MIS groups, and the MIS estimates for the 63 selected subjects in the experiment. With the exclusion of farmers who did not properly

understand the decision problem, mean values, standard deviations, and standard errors of mean decreased substantially. Moreover, there is some evidence that subjects in the MIS group decided better in the B1 treatment than in the A1 treatment (p=0.064). However, part of this improvement probably is caused by learning over time. Adjustments for learning effects, as measured in the Baseline group, reveals a less significant MIS effect (p=0.182).

## 3.2 Comparison with the survey results

The purpose of this study was to learn if experimental-economic methods can be used as an alternative approach to determine the profitability of MIS in sow farming. Therefore, individual MIS estimates derived in the experiment were compared with individual MIS estimates of the survey study. From 19 of the 63 selected subjects, an MIS estimate from the survey study was available. Therefore, 19 comparisons could be made in a linear regression model (table 4).

Table 4    Comparing MIS estimates from the survey study and experiment in a linear regression model

| Source | DF | Sum of Squares | F Value | Pr > F |
|---|---|---|---|---|
| Regression | 1 | 3.02 | 1.49 | 0.2391 |
| Residual | 17 | 34.53 | | |
| Variable | B | SE B | T | Pr > |T| |
| MIS experiment | 3.20E-05 | 2.63E-05 | 1.22 | 0.2391 |
| intercept | 0.38 | 0.34 | 1.120 | 0.2781 |

Note: Dependent variable: MIS estimate from the survey study; Mean dependent variable = 0.51; R-square = 0.08; Adjusted R-square = 0.03.

Table 4 shows that the model explains only very little of the variation in the MIS survey estimates (R-square = 0.08), i.e., there is no obvious relationship between the MIS estimates in the experiment and those in the survey study.

## 4.    Conclusion

A basic assumption of experimental economics is that results, obtained in a laboratory environment, carry over to the more complex natural environment (Davis & Holt, 1993). This study tests this assumption. An investment project selection problem is constructed to be an abstract experimental-economic analogue of the sow replacement problem, and sow farmers were used as subjects in the experiment. Obviously, decision making of many farmers in the experiment differed from common practice in farm management. For instance, many farmers ignored marginal yields of the investment projects (in favour of average yields) whereas on their farm, they certainly put the highest weight on the

latest litters of a sow. Although the investment project selection problem was a simplified version of the natural sow replacement problem, and although the instructions were very carefully written and tested, many farmers did not fully understand the problem. Misunderstandings have caused for large variation in outcomes between subjects and have overshadowed variation between treatments.

Further experimental-economic research should concentrate on an alternative way of framing or explanation of the decision problem. Use of more natural decision problems (Dickson, 1970; Van Schaik, 1988; Van Bruggen, 1993) may avoid many misunderstandings. However, this also demonstrates the danger of using natural decision problems. The reasons for better understanding is that farmers can apply their usual decision-making rules on the problem. In this experiment, framing the problem as 'sow replacement' would certainly have 'triggered' many farmers to decide differently. However, is this because of a better understanding of the problem or because of some unknown rules of thumbs they have developed on their farms? Also, simplifying the abstract decision problem may avoid misunderstandings. However, this will cut down the analogy between the abstract and the natural decision problem and, consequently, lowers external validity. Therefore, a better explanation and framing of the investment selection problem used in this study, including more training elements and more visual tools (e.g., paper project cards) seems to be the best next step in testing external validity of experimental-economic methods.

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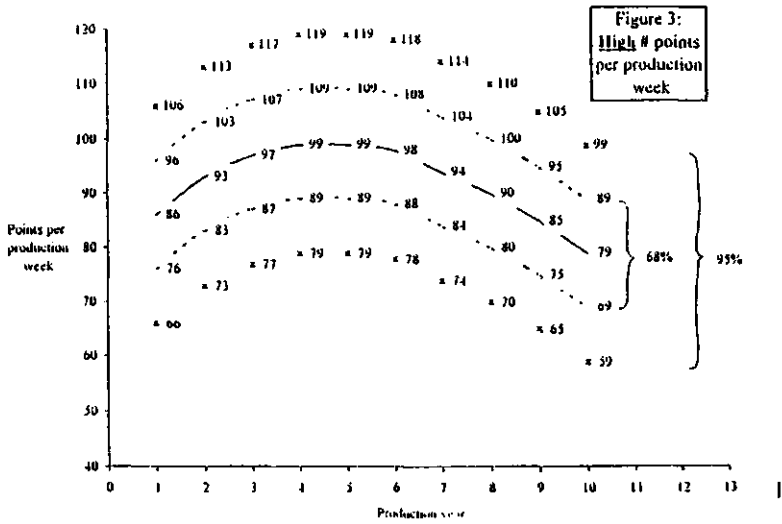
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# Appendix 1: Parallels between the natural sow replacement problem and the investment project selection problem

| Project selection | Sow replacement |
|---|---|
| Two decision alternatives: to keep or to replace a project | Two decision alternatives: to keep or to replace a sow |
| First one group of fifteen projects is evaluated (during 120 seconds). Afterwards, the same is done with a second group of fifteen projects. This procedure is repeated each experimental year. | Each week ten to fifteen sows are evaluated. After one production cycle the sows, that were kept before, are evaluated again |
| A project that has been replaced will never again return in the portfolio of projects | Once a sow has been replaced, the decision can never again be recalled |
| Replacement decisions become effective at the end of an experimental year. Marked projects are then immediately replaced by a new project | Sows who are removed from the herd are replaced by gilts to keep the herd size intact |
| A project's production history provides imperfect information about its potential to have a certain yield per experimental year | A sow's production history provides imperfect information about her potential to produce a certain amount of piglets per year |
| Each experimental year, new information on the production potential of a project becomes available | Each parity, new information on the production potential of a sow becomes available |
| The production potential of a project is fixed and consists of two properties, namely: | The production potential of a sow is fixed and consists of two properties, namely: |
| 1) the yield per production week, and<br>2) the number of production weeks per experimental year | 1) the number of piglets per litter, and<br>2) the number of litters per year |
| The yield per production week is at the maximum level in the fourth year of production | The litter size is at the maximum level in the fourth parity |
| The maximum productive lifetime of a project in the experiment is 10 experimental years | The maximum productive lifetime of a sow is 10 parities |

Appendix 2: Production figures that were explained to the subjects in the experiment; the bold lines provide the expected value of a certain property in a certain production year; the dashed and dotted lines provide the +/- 1σ intervals and +/- 2σ intervals lines, respectively

Figure 3:
High # points per production week



Figure 4:
Low # points per production week

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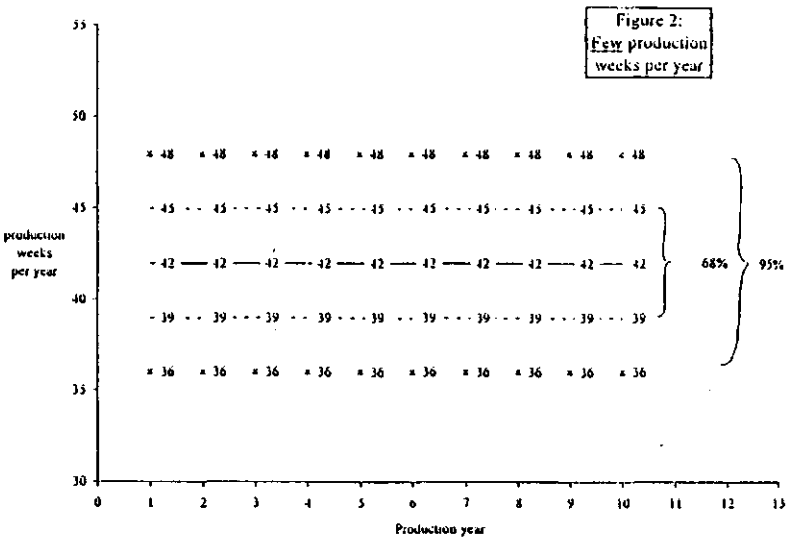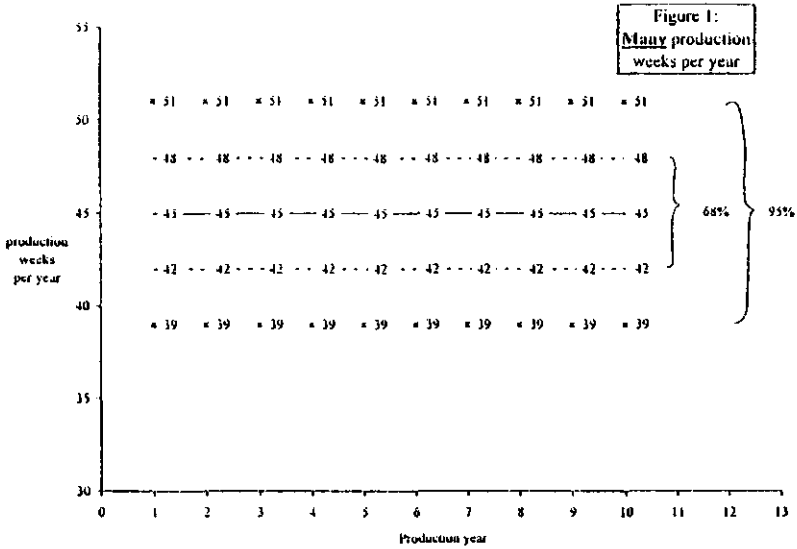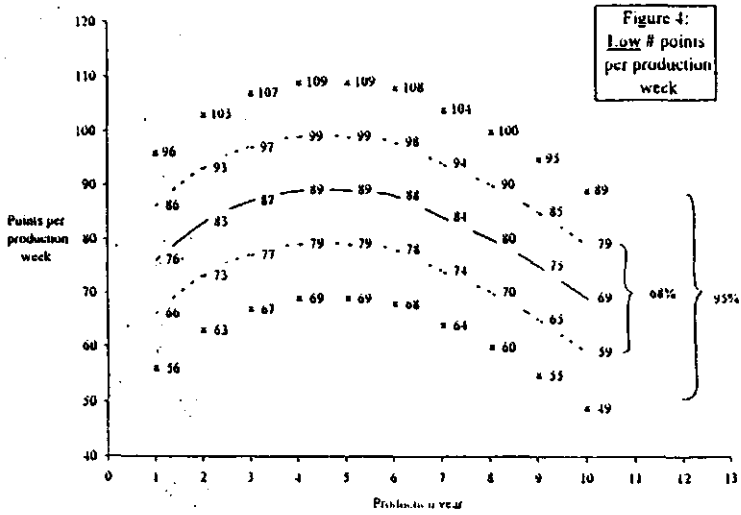
# EXECUTIVE INFORMATION SUPPORT FOR AGRIBUSINESS MANAGEMENT
# - PRINCIPLES AND EXPERIENCES -

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## Abstract

*Executive management deals with ill defined and unstructured decision problems which makes the identification of appropriate information for decision support and the organization of appropriate information systems a difficult task. It requires the linkage with executive management's mental decision models and the identification of support needs through interactive approaches. The paper analyses such approaches for their suitability in the development of executive information systems (EIS) for sector use and reports about experiences from developments in different branches of the agrifood sector.*

**Key-words:** Executive Information Systems (EIS), Agribusiness, Critical Success Factors.

## 1.    Introduction

The main focus of *management-oriented economic research* is on the support of management activities through the provision of information (which might require models for information processing and information generation) or, alternatively, through the formulation of direct recommendations for the implementation of business activities.

This is based on a variety of principal alternatives which draw on different subject areas ranging from management science and industrial engineering to policy and market analysis.

With an initial focus on accounting systems, management-oriented *agricultural economics research* emphasizes sector oriented market and policy analysis, the development of general management recommendation for the farming community, and a utilization of models (including farm planning models) for this purpose.

However, this sector orientation does not account for the increasing market orientation and competitiveness of the agri-food sector which puts increasing pressure on management to identify management policies specific to its individual business situation. This requires *business management support* in the

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identification of decision alternatives and the selection of appropriate alternatives for implementation.

The baseline for support is constituted by information systems which deliver information with direct links to the managerial decision process. The identification of such information does not pose any principal problems in situations where decision problems are well defined and decision processes well understood. However, these assumptions do scarcely hold for decision situations at the executive level of business management, be it in farms, small and medium sized businesses or in large scale corporations.

This difficulty has limited the attractiveness of information systems based on modern information and communication technology for executive management, irrespective of the many attractive features of the technology itself. The paper addresses this problem and discusses principal development options and experiences from the development of information systems for executive management in various agrifood sectors.

The discussion builds on an outline and critical examination of information system and system development alternatives known from literature (chapter 2). It elaborates on the integration of new developments in the provision of executive management support into comprehensive system design approaches (chapter 3) and presents first results on the acceptance of prototype systems by the target group.


## 2. System alternatives for management support

### 2.1 Management support

The principal alternatives for the provision of management support in the identification and specification of management policies include
- the collection and provision of basic internal and external *information*;
- the *analysis* of the information;
- the development of *recommendations* on preferable actions;
- the formulation of *models* for information analysis and decision recommendations, and
- the design of *information delivery systems* which provide the organizational and technical framework for the delivery of appropriate management support.

Management support on a routine basis may be provided through *information systems* which are built around any one or any combination of these alternatives according to the needs of different management roles in business hierarchies. This link with management needs might focus on, either, the specific support of management *individuals* or on the common needs of management *groups*.

While the first alternative is easier to design and might provide better support, the second alternative might be the best choice concerning the costs of system development and maintenance. Regarding the structure of the agrifood sector, the second alternative which involves the additional task of identi-

fying an appropriate *compromise* for support delivery within a group, is the only realistic choice for the majority of the small and medium sized enterprises.

However, research on the design of compromise systems has been limited. This might be linked to the dependence of information systems on the availability of appropriate technology which, until recently, was primarily suited for larger corporations which have less interest in compromise systems but in appropriate individualized system support. The diffusion of information and communication technology (ICT) into small and medium sized businesses has intensified the need for research on the design and development of compromise information systems. The examples reported in this paper do all build on the approach and provide an insight into its feasibility.

## 2.2   System alternatives and management hierarchy

Various system alternatives have been designed around the different management support alternatives to meet a wide range of management needs. They constitute a historical development path stretching from early Management Information Systems (MIS; Davis, 1974) to Decision Support Systems (DSS; Keen and Scott Morton, 1978), Executive Information Systems (EIS), and Executive Support Systems (ESS; Rockart and Delong, 1988).

*Management Information Systems* or MIS traditionally constitute reporting systems based on monitoring information (bookkeeping) from business processes which are supposed to support process analysis and control. This view relates to the computer technology predominant during their emergence and contrasts with some later views which extend the term MIS to incorporate all types of management oriented information systems. *Decision Support Systems* or DSS aim at higher levels of management activity which deal with ill defined but still rather narrow decision problems. They build on analytical decision support models and an interactive approach for problem consolidation and solution.

As it turned out, neither MIS nor DSS did match the support needs of *executive management* responsibilities with their rather general and global management focus. Various studies (see, e.g., Carlson, 1951; Mintzberg, 1973, Kotter, 1982, Lawrence, 1986) have emphasized the importance of meetings for executive management support and the devotion of a major part (around 75%) of executives' time to this type of information gathering and support activity.

This raises the question of to what extent and in what form electronic information and support systems could be linked to such a working routine. Rockart and others (see, e.g., Rockart, 1979; Rockart and Treacy, 1982) have developed a framework for the design of suitable electronic information systems for executive support which has demonstrated its feasibility with executives in a variety of case studies (Rockart and DeLong, 1988; Watson et al., 1992; O'Shea, 1989). It stresses the need for
-     *status information* on situations and development trends in- and outside a company and
-     further *in-depth analysis* through 'personalized' (i.e., flexible) and model-based analysis support.

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Most documented existing systems restrict themselves to the provision of status information and the potential for simple personalized analysis (O'Shea, 1989). Such systems are usually referred to as *'Executive Information Systems'* or EIS and distinguished from 'Executive Support Systems' or ESS which provide, in addition, a more thorough model-based analytical support.

During the early development phases, the evolving approaches were not clearly related to different management roles in business hierarchies. Their focus was always on the *executive management* level but within the limits set by the current understanding of management's tasks and needs and the available information technology (see, e.g., Schiefer, 1989).

The development path might suggest development advances in management support. However, in today's view, the different approaches do not represent different levels of *support potential* but relate to different needs within the management hierarchy which reach from operational to executive (strategic) decision responsibilities. These different levels of management activity are not strictly confined to certain levels in an organizational hierarchy, i.e., while an executive type of problem responsibility is predominant at the level of top management, it might be embedded to a certain extent in other organizational levels as well.

This relates directly to companies or organizations with only one or a few management levels as in farms or in small and medium sized enterprises. It is not a single system approach which would serve their needs but it is a *combination of system characteristics* which focus on different problem scenarios.

This need might suggest that the various types of support systems might be developed and introduced into management support simultaneously. However, it is our experience, that systems which emphasize the provision of information (MIS, EIS) are more readily accepted by management than systems with more emphasis on model-based support (ESS and especially DSS). This could be explained by different levels of support complexity. While MIS and EIS must match the *information* requirements, DSS and ESS must match, in addition, the information processing *logic* of management's mental decision models.


## 3.    EIS and ESS development principles

3.1    Problem overview

Despite the straightforward analysis of support needs by Rockart (1979), the provision of adequate and efficiently organized decision support proved to be a complex task which has been the focus of extensive research efforts (see the principal works of Keen and Scott Morton, 1978; Sprague and Carlson, 1982; Rockart and DeLong, 1988 or Watson et al., 1992).

The lines of research emphasize
-    the identification of appropriate *support information* (including data information, decision rules, models, etcetera) and
-    the efficient organization of formalized and routinely served *support delivery* systems.

They both have in common that they are usually too complex to be solved by an analytical optimization process but require expert analysis, user involvement, and experiments (including simulation experiments) in simulated or real management support situations.

## 3.2    Identification of support needs

Present approaches for the identification of information needs (for overviews see, Davis, 1982 or Watson and Frolick, 1991) can be grouped into two principal alternatives which follow either a normative or a 'participative' line of analysis.

The *normative analysis* utilizes experts' knowledge and perception and is supported by a wide variety of logical system design methodologies and techniques (see, e.g., Sen, 1989). While the approach seems to work well for system developments in well defined problem domains, it is less suited for the ill defined problems common at the executive level of management. The reliance on experts' perception of objective information needs which might differ from the target groups perceived (subjective) information needs and their own perception of decision problems and solution approaches has not supported acceptance of such information systems at the executive level of management.

Increased requirements on the user orientation of systems has lead to a reorientation of system development towards *participative approaches* which incorporate users in the analysis of information needs and the system design in a stepwise improvement process which involves the development, testing, and use of system prototypes of various levels of sophistication (Boar, 1984).

The reorientation of information requirement analysis does not challenge the usefulness of logical system analysis and design methodologies but limits them to the design of the *organizational system structures* which serve predetermined information needs and focus on organizational feasibility and efficiency.

## 3.3    User participation in information requirement analysis

The participative approaches in information requirement analysis accept potential users as 'expert users' and focus on the information requirements linked to users' informal *mental decision models*.

Usually, mental decision models and the associated support requirements are not explicitly known, not even to decision makers themselves as has been demonstrated by the many failures of interview based requirements analysis efforts. Participative approaches attempt to extract the support needs from decision makers through indirect approaches which might employ,

-    *interview* techniques which support an indirect information requirement analysis;
-    observations of *decision behavior* and related information needs, or, in later stages of the system development process,
-    experiments with system prototypes.

The most well-known interview-based approach for user involvement in the analysis of information needs is the *Critical Success Factors (CSF)* analysis (Rockart, 1979) which has gained exceptional prominence in the development of corporate executive information systems (see Rockart and Bullen, 1986). It builds on an analysis of user *objectives* and employs a *multi-step approach* to indirectly specify information needs from critical success factors identified by the target group (see also Boynton and Zmud, 1984, who elaborate on the use of CSF analysis as a planning tool in organizational settings).

The need to relate support to actually *observed decision behavior* has been commonly recognized. As an alternative to real world observations, experimental settings with workshops have been suggested and implemented (Rockart and Crecenzi, 1984, Huirne et al.), in which users are confronted with various decision scenarios.

*Prototyping approaches* build on a stepwise refinement of an initially rather rude computer-based support system in an interative process of user involvement (Boar, 1984; Dickson and Wetherbe, 1985). They might include experiments in a laboratory setting or field tests with various degrees of integration into the decision environment of the executive user.

Empirical studies suggest that a combination of different approaches, usually from all three alternatives, stabilizes results and improves system performance (see, e.g., Rockart and Crescenzi, 1984; Wetherbe, 1991; Watson and Frolick, 1992).

Participative approaches have worked well with the design of information systems for (experienced) executive management (Rockert et al., 1988). The inherent *weakness* of the approaches is, however, their reliance on users' knowledge of decision problems and solution approaches which, if poor, generates information systems which support poor management.

Such situations require the identification of both, the users' and the experts' perception of needs and the formulation of a *compromise support system* which, while still finding acceptance with management users, integrates as much expert knowledge about support needs as possible (see Schiefer and Gotsch, 1994).

The compromise approach is usually associated with some limited initial training effort but cannot go beyond a level which is readily accepted by the target group. A further improvement would be part of a stepwise refinement process in which management gradually gained more experience until their own experience led them to deviate from expert knowledge and to increase reliance on their own mental decision models.

## 3.4 Delivery system

The delivery of decision support has an *institutional* and an *individual* aspect concentrating on the positioning of a system in an organization's information pyramid or on the user-system communication link, respectively.

Information system research usually views the information needs as directly related to different levels of the decision hierarchy assuming less need for information details towards the higher levels of the hierarchy. However, it

has been shown (see, e.g., Rockart, 1979) that this simplistic view is not true with regard to the needs of top level executives (and probably not for executives on other levels of an organization either), but that their needs encompasse all levels of information aggregation. An empirical study by McLeod and Jones (1992) related almost 40% of executives' information needs to lower level information sources reaching as far as 4 levels below their actual positioning in the organizational hierarchy.

The possibility to *'drill down'*, i.e., to quickly arrive at various levels of information detail has, together with the ability to provide customized and flexible analysis support, become a decisive feature of the EIS philosophy (Rockart and DeLong, 1988).

Developments on the individual aspects of the delivery system focus on the integration of decision makers' decision making capability into the decision support process, a system's flexibility to respond to varying support requests, and on the smoothness of user-system interaction through appropriate interface designs.

The move from traditional report-oriented systems to more *interactive* approaches advocating interactive decision support models tried to utilize some of the decision maker's own problem identification and problem solution abilities through an organized process of human-machine (model) interaction. While this is an appealing and theoretically well-founded approach (see also Simon, 1977), its implementation has been largely confined to 'what if' type of application scenarios.

The need for flexibility in the provision of executive decision support has been identified by Rockart and Treacy (1982) as a need for *'personalized analysis'* in Executive Information Systems. This type of system capability rests on the assumption that executives could acquire some system manipulation skills and, in addition, have the expertise to devise an appropriate scheme for analysis, assumptions which heavily depend on the level of support the system provides for these tasks as well as the level of analytical skills available at executive decision levels. Surveys of existing Executive Information Systems indicate the difficulties of attaining these capabilities (see, O'Shea, 1989).

The design of appropriate *interfaces* has been the focus of a growing body of literature on the ergonomy requirements of human-machine interaction. The central issues are ease of use, speed, and trust, i.e., a system's design should keep training needs to a minimum, offer its support as fast as possible, and provide appropriate measures of reliability.

There are some general guidelines for system characteristics which support an appropriate system design. Most of them are based on empirical evidence. However, the final evaluation of any specific implementation requires the experimental involvement of the target group.

It is common understanding, that training needs reflect a divergence between support needs and system performance which could jeopardize system acceptance. The present focus of the discussion is on appropriate system support for information perception, information linkage, and information search.

Speed requirements ask for minimum efforts to reach system support and for quick system response. Reliability measures are usually related to the timeli-

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ness, the accuracy, and the aggregation of information and might include the display of various dates, the identification of responsible personnel or sources, and the drill-down capability discussed above (see, e.g., Rockart and DeLong, 1988; Scally and Wilkinson, 1991).

## 4. Case study experiences

### 4.1 Overview

A series of five recent studies on the design of sector-oriented (compromise) EIS/ESS for firms by Ditz, Kelling, Kuron, Schulze-Duello, and v.Spiegel (see table 1) have followed the design principles discussed above and demonstrated the suitability of the approaches for compromise EIS/ESS through supportive feedback from direct and indirect management evaluations.

*Table 1    EIS/ESS development case studies*

| Study | Inform. Ext./Int. | Support Focus EIS/ESS | Sector | References |
|-------|-------------------|-----------------------|--------|------------|
| A | X | EIS | dairy | v.Spiegel/Schiefer,1992; v.Spiegel,1994 |
| B | X X | EIS/quality mgmt | milk farms | Lanz, 1994 |
| C | X X | EIS/strategic planning | meat proces. | Kelling/Schiefer,1993; Kelling,1994 |
| D | X X | EIS/material mgmt | agric. trade | Kuron/Schiefer,1992; Kuron,1993 |
| E | X X | EIS/logistics mgmt | agric. trade | Schulze-Düllo,1995 |
| F | X | EIS/price policy | tree growers | Ditz, 1995 |

The studies involved different agrifood sectors, i.e., meat processing, dairy operation, milk farms, agricultural trade, and tree growing. An additional study for agricultural extension is underway. They emphasized different aspects of an EIS and its extension towards an ESS with a focus on, e.g., the support of strategic planning, of market activities, of material management, and of customer oriented quality management. However, despite these differences, all studies showed a remarkable high similarity in the information requirements of different companies within the sectors as demonstrated by high levels of supportive feedback in the final steps of the design and development process. This supports the successful development of group-related compromise support systems.

### 4.2 Approach and results

In all studies, the information and support requirements were identified through a multi-step *Critical Success Factors* analysis which was complemented by expert opinions and user experiments. However, different approaches were

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used to integrate the CSF analysis into the analysis and prototyping process (table 2).

*Table 2    CSF analysis and prototyping process*

| A | reverse CSF analysis, prototyping |
|---|---|
| C | 'quick and dirty' CSF analysis, extended prototyping |
| D | detailled CSF analysis, limited prototyping |
| E | detailled CSF analysis, extended prototyping |
| B | extended IRA for selected CSF, prototyping |
| F | extended IRA for selected CSF, extended prototyping, field tests |

The studies D and E involved a detailled CSF analysis in companies including different steps of personal and mail interviews before the initiation of the prototyping process. Study C started the prototyping process after a first quick round of interviews and utilized several steps of prototyping for the further analysis of the CSF and the corresponding information items. Both approaches worked equally well but had to overcome different problems. In the first approach, the discussion about CSF and information might easily become too abstract for management users whereas the second approach needs to separate between the (negative or positive) impact of the delivery system on management users and their acceptance of the embedded CSFs and information items.

Study A used a reverse approach and identified CSF through an analysis of external information items that are offered in the sector and. This approach seems to work well in sectors with stable problem situations and a well established information base were the main focus in EIS development would have to be on the identification of information priorities and on the organization of appropriate delivery systems as, e.g., the organization of environmental scanning systems (Choo and Auster, 1993). However, the integrated discussion of information items and Critical Success Factors reduced the users' willingness to seriously consider information items that had not been part of their usual information gathering routine.

Studies B and F elaborated on the design of appropriate management support for a single critical success factor which involved the combination of external and internal information items (study B) and the organization of an elaborate feedback process between support system and system users (study F).

The *evaluation* of the prototype systems was built on two different evaluation approaches,
-       an expert analysis of a system's suitability to support the identified objectives and Critical Success Factors of users and
-       a *user evaluation of a system's suitability to cover their support needs.*

The studies have supported the view that the delivery system is of similar importance as the content of an EIS. A prototyping approach which builds on a stepwise adjustment of both, the delivery system and the information content to the needs of users is a precondition for a successful prototyping phase.

The user evaluation included interviews, workshop discussions and laboratory experiments but (with the exception of study F) no field tests over an extended period of system utilization, i.e., the final acceptance test. This required an efficiently organized information and delivery system and, in consequence, the linkage of research with professional system development activities.

## 5. Summary

Decision support for executive management tasks at all levels in the management hierarchy builds on information and support moduls which have a direct link to the mental decision models of executive management. As these models are not known, indirect approaches and prototyping processes in system development are being used to identify the support needs of executive management. A key element is the Critical Success Factors analysis which can be integrated into the development process in a variety of ways. A number of case studies from various agrifood sectors support the usefulness of the approaches in the development of executive information systems which meet the support objectives of executives and find acceptance with the target group.

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