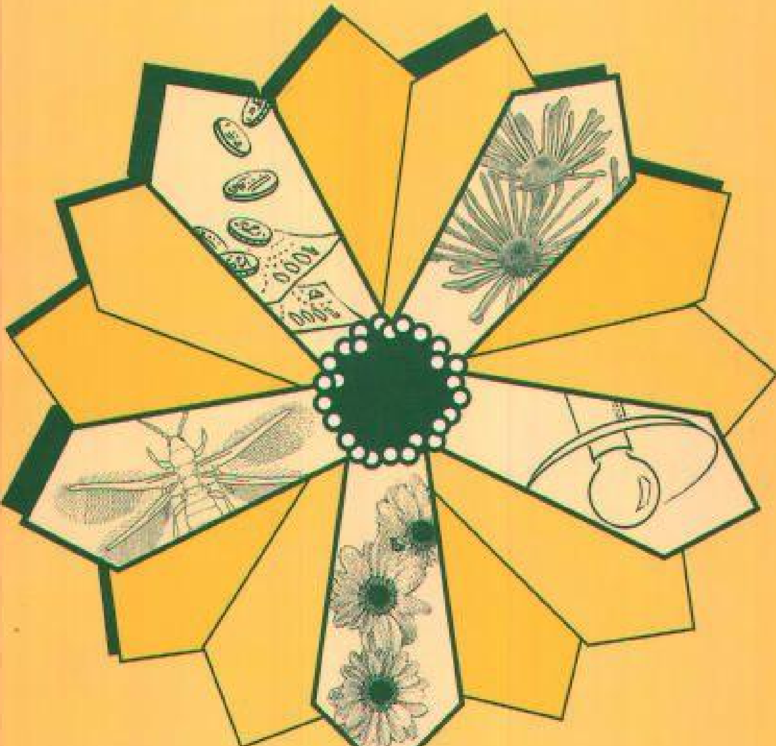
Decision making and economic performance of flower producers



G. Trip

Stellingen

1. De kwaliteit van besluitvorming kan worden getypeerd aan de hand van de begrippen *awareness*, *rationality* en *consistency*.
   (Dit proefschrift)

2. *Information display matrices* kunnen worden gebruikt bij analyse van besluitvorming als ook voor verbetering van besluitvorming.
   (Dit proefschrift)

3. Reflectie loont.
   (Dit proefschrift)

4. Het Wageningse Mansholtinstituut zou haar naamgever eren door meer politiek controversiële onderwerpen op de onderzoeksagenda te plaatsen.

5. Waardering van de aanwezige natuur in natuurwaardepunten biedt meer houvast voor natuurbescherming dan een waardering op basis van kosten en baten.

6. Gezien de mondiale bevolkingsaanwas en de mogelijkheid van migratie is afschaffing van de kinderbijslagregeling te overwegen.

7. Het verdubbelingssysteem bij roulette *lijkt* winstgevend doordat na een catastrofe de winst zich onmiddellijk herstelt; tegelijkertijd neemt het verwachte verlies toe in de tijd.

8. Mensen die het "druk, druk, druk" hebben zouden zich compacter mogen uitdrukken.

9. Finale toewijzing van de Olympische Spelen aan een organiserende stad via loting is eerlijker en goedkoper.

10. Het verwerven van de bijnaam "Lucky Ajax" is een verdienste van deze club.

11. Popmuziek wordt klassiek.

Stellingen behorende bij het proefschrift "Decision making and economic performance of flower producers". Ger Trip, Wageningen, 17 maart 2000.

DECISION MAKING AND ECONOMIC PERFORMANCE OF FLOWER PRODUCERS

Promotoren: Dr. ir. J.A. Renkema
Emiritus Hoogleraar Agrarische Bedrijfseconomie
Wageningen Universiteit

Dr. ir. R.B.M. Huirne
Hoogleraar Agrarische Bedrijfseconomie
Wageningen Universiteit

G. Trip

DECISION MAKING AND ECONOMIC PERFORMANCE OF FLOWER PRODUCERS

Proefschrift

ter verkrijging van de graad van doctor
op gezag van de rector magnificus
van Wageningen Universiteit,
dr. C.M. Karssen,
in het openbaar te verdedigen
op vrijdag 17 maart 2000
des namiddags te vier uur in de Aula.

Omslag: Piet Kostense
Druk: Grafisch Bedrijf Ponsen & Looijen B.V., Wageningen

Abstract

Decision making and economic performance of flower producers
Trip, G., 2000

Within Dutch agriculture, greenhouse horticulture stands out as a growing and innovative sector. In such circumstances of growth and innovation, one would expect a fast development of management support systems. However, apart from climate control, the role of computerized support systems for management purposes (planning/evaluation) is still very limited. The purpose of this study is get insight into the decision-making processes of greenhouse growers. A group of 26 specialized, comparable chrysanthemum growers has been followed during a one-year period 1993/94. Interviews have been held and data have been collected on firm structure, sales, prices, price predictions, production planning, information use, computer use, et cetera. An additional workshop with growers has been held to simulate and analyse their cultivar choice and information search behaviour.

Firm efficiencies have been related to the quality of decision making by means of the stochastic production frontier approach. The results show statistically significant associations between some aspects of the decision-making and the efficiency of firms. Especially the aspects of data recording and evaluation are found to be of importance. With respect to the cultivar choice, simulated by means of an information display matrix, in a game environment, it turns out that fifty percent of the participants fail to detect their optimal choice, in a multi-attribute utility sense. Analysis of the information search behaviour suggests that decision making can be improved by increasing awareness of attributes and their relative importance.

Keywords: greenhouse horticulture, chrysanthemum, cultivar, decision-making process, management support system, production planning, efficiency, stochastic frontier analysis, price prediction, information display matrix, multi-attribute utility

Decision making and economic performance of flower producers / G. Trip
PhD-thesis Wageningen University. - With ref. - With summary in Dutch.
ISBN 90-5808-175-3

Voorwoord

Een aantal mensen heeft een belangrijke bijdrage geleverd aan de totstandkoming van dit proefschrift. Ik neem hier graag de gelegenheid om hen hiervoor te bedanken.

Allereerst gaat mijn dank uit naar beide promotoren prof.dr ir. Jan Renkema en prof. dr. ir. Ruud Huirne. Jan, je hebt me bij mijn aanstelling in 1990 met enige nadruk moeten overtuigen van mijn capaciteiten als promovendus en ook gedurende de rit heb je je zo nu en dan als een echte mentor laten zien. Ruud, jouw bezielende leiding, humor en relativeringsvermogen hebben vaart gebracht in het onderzoek En, ik ben er trots op te mogen promoveren bij een *topeconoom*!

Andere wetenschappelijke begeleiding heb ik mogen genieten van prof. dr. Charles Vlek (Rijksuniversiteit Groningen), ir. Jan Ammerlaan (Proefstation voor Bloemisterij en Glasgroente) en dr. ir. Cees Leeuwis (Wageningen Universiteit) die naast de promotoren de begeleidingscommissie completeerden. Het aantal vergaderingen was beperkt, maar de *impact* was er wel degelijk. Verder is een wetenschappelijke bijdrage geleverd door professor Brian Hardaker (University of New England) die vroege versies van hoofdstukken 3 en 4 voorzag van nuttig commentaar. Brian, it is always stimulating - and good fun - to have you here as a visiting professor.

Bijzonder erkentelijk ben ik de 26 chrysantentelers die in November 1993 deelnamen aan de studiemiddag en - avond en daarna gedurende een jaar steeds bereid waren vragenlijsten in te vullen en bedrijfsgegevens voor mij bij te houden. Ik heb veel respect voor jullie ondernemerschap en de wijze waarop jullie je bedrijf *managen*. Bedankt voor de openheid waardoor ik een kijkje in jullie keuken mocht nemen.

Bij het opzetten van de vragenlijsten heb ik dankbaar gebruik mogen maken van de expertise van diverse mensen uit het veld: ing. Ben van der Hoeven, ing. Peter Vermeulen en Ruud Maaswinkel (Proefstation voor Bloemisterij en Glasgroente, locatie Naaldwijk), ir Jan Benninga en ir Ernst van Rijssel (Proefstation voor Bloemisterij en Glasgroente, locatie Aalsmeer), Dirk Jan Binnendijk (particulier voorlichter), Harold van Gennip (Middelburg Handelskwekerij BV) en Paul de Veld (DLV-Naaldwijk). Allen bedankt voor de tijd en inzet die jullie hebben gegeven.

Ing. Jan Nienhuis (Proefstation voor Bloemisterij en Glasgroente) wil ik bedanken voor het idee het onderzoek te richten op chrysantentelers. Hierdoor kon ik uitgaan van een redelijk uniforme groep. Voor de bemiddeling bij het verkrijgen van namen en adressen van deelnemers dank ik de NTS. De VBN heeft aanvullende prijsgegevens beschikbaar gesteld

waarmee de resultaten van de deelnemers konden worden vergeleken met landelijke gemiddelden.

Bij het testen van vragenlijsten is dankbaar gebruik gemaakt van de ervaring van chrysantenteler Lenssen uit Hout Blerick. Zijn zoon, Edward Lenssen, heeft in het kader van een afstudeervak Agrarische Bedrijfseconomie meegewerkt aan het opzetten van het *information display matrix*, een cruciaal onderdeel van het onderzoek. Edward, ook bedankt voor het feit dat je bereid was soms letterlijk de handen uit de mouwen te steken! Ook andere studenten hebben gedurende de periode 1993-1996 door middel van hun afstudeerscriptie een belangrijke bijdrage geleverd in de gedachtenvorming en uitwerking van deelresultaten, in chronologische volgorde: Christa Jonkheer, Lianne Kooiman, Chris Keizer, Lion de Kok, Adriaan van Zetten, Anton Arissen, Carin van der Lans en Iwan van der Knaap. Voor hand en spandiensten bij de uitvoering van de studiemiddag wil ik graag noemen Saskia Scheer.

Veel dank ben ik verschuldigd aan mijn collega's bij de leerstoelgroep Agrarische Bedrijfseconomie. Het onderzoek is meermalen aan de orde geweest in de onderzoeksgroep, bijgenaamd het DJO-overleg. Naast een stimulerende werkomgeving biedt de leerstoelgroep ook een plek voor gezelligheid en creatieve uitingen. Enkele (ex)collega's wil ik hier bij name noemen, terwijl mijn erkentelijkheid uitgaat naar de gehele groep: Marian Jonker en Anne Houwers die als secretaresses duizend-en-een taken verrichten, Jouke Oenema die mij bij vele onderdelen, waaronder het programmeerwerk, terzijde stond en Paul Berentsen die vanaf het begin een onmisbare *troubleshooter* is geweest. Paul, er is niemand naar wie de printer beter luistert dan naar jou!.

Tenslotte wil ik hier nog graag enkele dierbaren noemen. Belangrijk in mijn leven zijn vooral mijn ouders, die mij hebben gevormd en altijd gestimuleerd om het beste in mijzelf naar boven te halen. Het is jammer dat mijn moeder het welslagen van dit werk niet meer heeft meegemaakt. Verder wil ik hier noemen mijn broers en *zusje* en hun partners die een welkome versterking van de familie zijn en, niet te vergeten, Ali die van het ouderlijk adres weer een echt thuis heeft gemaakt. Mijn vrienden wil ik graag bedanken voor de warmte en de openhartigheid gedurende vele jaren en voor de gezamenlijk beleefde avonturen, in concertzalen, musea, op reis of thuis bij een spelletje *risk*. Speciaal wil ik noemen Pieter Jongsma. Pieter, het ga je goed! Tenslotte, Tieke, jou wil ik bedanken voor het grote avontuur dat we samen zijn aangegaan. Bedankt voor je liefde!

Woerden, 24 Januari 2000.

Ger Trip

Contents

Page

1 Introduction

1.1 Background

In the 1980s expectations on the introduction and use of computerized management information systems in agriculture and horticulture were high. It was expected that by the end of the INSP-project, funded by the Dutch government for the period of 1984-1988, the use of on-farm management information systems would be common (INSP, 1985).[1] Several initiatives for developing computerized management support systems[2] were taken within and beyond the INSP-project. However, in the early 1990s it became clear that expectations were not met in practice. The process of developing, introducing and using management support systems proceeded slower than expected (NRLO, 1991). One of the main reasons mentioned in the NRLO-study was that the development was largely technology driven, and the demand side was largely neglected. Therefore, potential users of management support systems should be closely involved in the development phase, because otherwise systems are developed that are "doing very well the wrong thing to do" (Checkland, 1992). The NRLO-study also advocated research to increase the knowledge of the decision-making processes of farmers and growers, since, as stressed by Alter (1999: 23), any management support system is no more (and no less) than a tool to improve the existing decision-making process.[3] And the effectiveness of the tool largely depends on the people who are supposed to work with it. This may seem evident, but in practice it is often neglected. This attitude is reflected in the common terminology used, which has a technical flavour (information technology, computer aided design, etcetera). To stress the human aspect, in fact, the label

---

[1] INSP is an acronym for INformation Stimulation Plan. The objective of the plan was to facilitate the introduction of management support systems by defining information models for several types of farming, including greenhouse horticulture. The information model is an integrated framework that describes the processes at a firm (process model), as well as the data flows (datamodel). (Nienhuis, 1986)

[2] We use management support systems as the overall term for devices that systematically retrieve and combine information meant to be useful for management purposes. These include management information systems, decision support systems and expert systems.

[3] The terms management (process) and decision making (process) are used throughout this study. Both terms are used for the process of acquiring and using available resources to reach specific goals, through the cyclical stages of planning-implementation-control. Decision making (process) is used when the emphasis is on analysing (specific details of) the planning-implementation-control cycle, whereas management (process) is used in a more general sense.

management support system had better be replaced by *manager* support system (Timmermans, 1991)[4].

1.2 Management by greenhouse growers

Within Dutch agriculture greenhouse horticulture stands out as a growing sector. The production value of greenhouse horticulture has increased during the past few decades. In 1985 the production value was NLG 6.2 billion, 17% of the total production value (NLG 36.4 billion) of agriculture. In 1998 the production value of greenhouse horticulture had increased to NLG 10.4 billion, 29% of the total agricultural production value, being NLG 35.6 billion (LEI-DLO, 1987 and 1999). Several aspects are relevant in this context. First, greenhouse horticulture operates in a far less restricted and regulated market environment than most other agricultural sectors. Production levels and prices are free, stimulating (international) competition among firms and creating a climate that has a positive effect on innovation. Another aspect that positively influenced innovation in greenhouse horticulture is its level of potential production control. Compared to other areas of crop production, more means are available to control climate and growing conditions, such as CO_2, temperature, water and light. So, there is more scope for optimization of the production process. This is an incentive for *scientification*, which stands for the involvement of scientists and the influence of science on the practical production level. Vijverberg (1996) studied several (technical) developments within greenhouse horticulture and the role science played. He concluded that, notwithstanding the influence of scientists having been an important stimulus, the main initiators of (technical) development have been the growers themselves.

The speed of diffusion of innovations has been increased by the fact that production takes place in a relatively small area, a production centre, where growers, suppliers and buyers (at auctions) frequently meet. Dutch greenhouse growers are known as being cooperative, at least within their peer groups, willing to share information, learning from each other through excursions and study clubs. The establishment of the Society of Dutch Horticultural Study Groups (NTS) in 1972 was an important milestone in the process of enterprise comparison and learning (Leeuwis, 1993).

In these circumstances one would expect a fast development, acceptation and diffusion of management support systems. However, apart from computerized climate

4 Timmermans advocates "beslissersondersteuning" (Dutch for decision maker support) against "beslissingsondersteuning" (Dutch for decision support). (Timmermans, 1991, prop. 3, addition to PhD-thesis)

control, which is standard in greenhouse horticulture, the role of computerized support systems for management purposes is still very limited. To explain this low level of computerized support system use, more insight is needed into the underlying decision-making processes. This has been the main reason to start research on existing management practices of greenhouse growers. The focus is on two important decisions, cultivar choice and product planning, which are at the heart of the grower's tactical management.[5] Moreover, both decisions seem to be suitable for initiatives in the field of management support systems.

1.3 Objectives and method

The main objective of this study was to get insight into the decision-making processes of greenhouse growers. This general objective has led to the following four research questions:

1. (from a descriptive point of view) how do growers plan, how do they make choices, how do they evaluate their results;
2. why are some growers more effective than others, especially with respect to production planning and cultivar choice;
3. (from a normative point of view) what are the weak spots in decision making, i.e. weaknesses in the level of rationality; and
4. (based on the descriptive and normative parts) what are the possibilities in the area of management support (systems).

Insight into the decision making was gained by observations of firms. A group of 26 specialized, comparable chrysanthemum growers were followed during a one-year period 1993/94, comprising over four production rounds. Interviews were held and data were gathered on firm structure, sales, prices, production, information use, computer use, et cetera. Prior to these bimonthly observations, the group had met in November 1993 to participate in an off-farm workshop.

---

[5] At two instances (beginning and end of the research) participating growers were asked to rate a list of possible critical success factors at their firm, on a scale from 1 (not important) to 5 (highly important). The average results of the ratings were: climate control (4.60), production planning (4.48), planning light & dark (4.46), cultivar choice (4.39), greenhouse layout (4.23), choice personnel (4.10), plant density (4.04), fertilizer (3.94), reinvestment long-term resources (3.89), pest control (3.87) and water supply (3.65).

1.4 Outline

First the results of a literature analysis are presented, investigating the ways in which management capacity can be studied. Four ways (and data sources) are distinguished to analyse management capacities. Off-farm experiments are considered to be one of these sources, longitudinal on-farm observations another one (Chapter 2).

In Chapter 3 the production data of the research group are analysed. Differences in turnover per m^2 among firms are taken as a starting point for a quantitative management analysis. Individual firm efficiencies are related to variables measuring the quality of each step of decision making with respect to the production planning. This quantitative analysis is performed by means of the stochastic production frontier.

In Chapters 4, 5 and 6 several aspects of cultivar choice are analysed. Since price fluctuations play a major part in causing differences in income among growers, the price predicting ability of growers was tested and compared (Chapter 4). Although price aspects are important, they represent only one aspect of the cultivar choice and other, cost price related, aspects should be included as well in the decision making. In order to analyse quality aspects of the cultivar choice, a laboratory experiment was performed during the initial workshop to simulate and analyse the information search and choice of every participant. The results are presented in Chapter 5.

Characteristics of the information-search process were analysed more deeply, the results of which are presented in Chapter 6. In addition to established search characteristics, three new indicators are introduced: attribute-focus, alternative-focus and choice-focus.

A general discussion (Chapter 7) on the methodology used and future use of management support systems concludes the thesis.

References

Alter, S. (1999). *Information systems: a management perspective.* Reading, Massachusetts, etc.: Addison-Wesley. (3rd ed.)

Checkland, P.B. (1992). *Quality of information systems: a soft systems approach.* Lecture held at the mini-symposium Quality of Information Systems, May 20, 1992, Wageningen University.

INSP-AGRO. (1985). *Voorstudie aanjaagprojekt.* The Hague: Ministery of Agriculture and Fisheries. (In Dutch.)

Leeuwis, C. (1993). *Of computers, myths and modelling: the social construction of diversity, knowledge, information, and communication technologies in Dutch horticulture and agricultural extension.* Wageningen: Wageningen University. (PhD-thesis.)

LEI-DLO (1987 and 1999). *Landbouw-Economisch Bericht.* The Hague: Agricultural Economics Research Institute. (Periodieke Rapportage 1-99, in Dutch)

Nienhuis, J.K. (1986). *Informatiemodel glastuinbouw*. Naaldwijk, etc.: Research Station for Floriculture and Glasshouse Vegetables. (In Dutch.)

NRLO. (1991). *Informatietechnologie in de land-en tuinbouw*. The Hague: National Board for Agricultural Research. (Report 91/3, in Dutch.)

Timmermans, D.R.M. (1991). *Decision aids for bounded rationalists: an evaluation study of multi-attribute decision support in individual and group settings*. Groningen: University of Groningen. (PhD-thesis; proposition 3.)

Vijverberg, A.J. (1996). *Glastuinbouw in ontwikkeling: beschouwingen over de sector en de beïnvloeding ervan door de wetenschap*. Delft: Eburon. (PhD-thesis, in Dutch).

2 How to define and study farmers' management capacity: theory and use in agricultural economics[1]

Abstract

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

2.1 Introduction

It is a well-established fact that economic performance can differ considerably between farms, even if they are operating under more or less similar production conditions. Differences in economic results are usually attributed to differences in the management of the farmer (e.g. Boehlje and Eidman, 1984). Management capacity can be seen as a separate, fourth factor of production, in addition to the traditional factors land, labour and capital (e.g. Case and Johnston, 1953). Then, what constitutes this special production factor? Despite many books and articles in the field of farm management and decision theory, the

[1] Article by Carin W. Rougoor, Ger Trip, Ruud B.M. Huirne and Jan A. Renkema; published in *Agricultural Economics* 18 (1998) 261- 272

management process itself largely remains a black box, and management capacity is rarely explicitly defined and measured. The aim of this article is (1) to give an overview of main aspects of management capacity, (2) to discuss the problems and opportunities with respect to measuring and collecting data of management capacity, (3) to review the empirical studies that relate management capacity to farm results and (4) to detect weak spots and give suggestions for improvements.

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

2.2 Aspects of management capacity

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

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

strategy, environment, resources, managerial preferences and organization, which must be brought in balance.

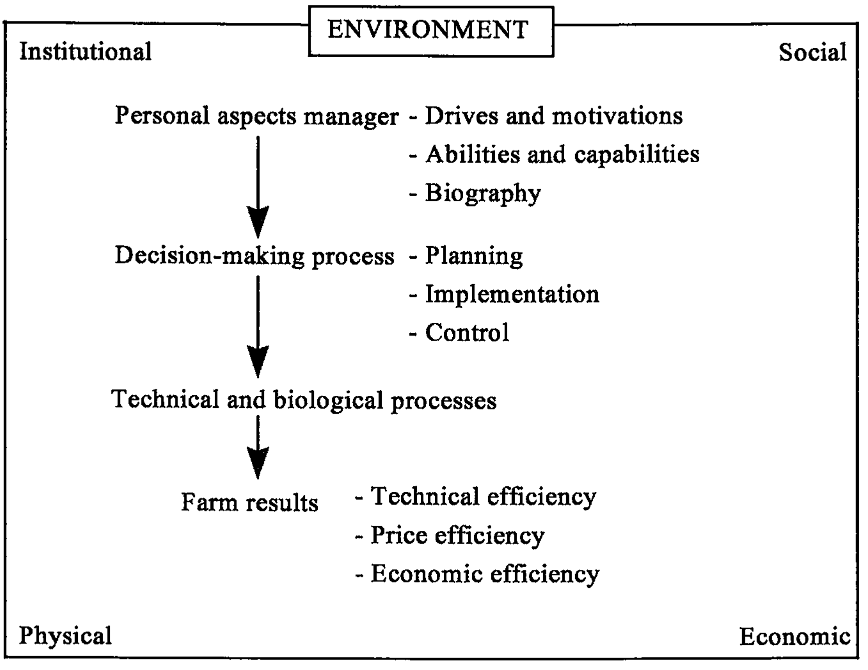


Figure 2.1 *Management capacities in relation to environment, biological processes and farm results*

Management capacity is defined here as having the appropriate personal characteristics and skills to deal with the right problems and opportunities in the right moment and in the right way. Starting point is the manager who has certain qualities. By means of his decision-making he will try to optimize (or at least influence) the technical and biological processes at the farm (see Figure 2.1). These processes, controllable to only a certain extent, determine the technical and economic results of the farm. Stochastic elements, such as the weather, the incidence of pests and diseases and fluctuations in the market (prices) also play their part. Farm managers perform their task in an environment which changes over time in a hardly predictable way and therefore causes risk and uncertainty in the decision-making. Boehlje and Eidman (1984: p. 670) distinguish four major dimensions: (1) the institutional environment (e.g. regulations on water, land and air pollution), (2) the social environment (e.g. the family of the farmer), (3) the physical environment (including the weather and the state of the technology) and (4) the economic environment (which determines prices of inputs and products).

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

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

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

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

2.3 Measuring management capacity

2.3.1 Personal aspects and decision-making processes

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

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

2.3.2 Data collection

Several data sources can be used to study management capacity. Mintzberg (1973: pp. 221-229) gives a review of methods used to gather data on managers. To study the management capacity of a farmer, being the executive of a small company, one can use either existing data or create new data. Several options are listed in Figure 2.2. These options are grouped into four main categories: (1) analyzing existing farm data, (2) single on-farm investigations, (3) longitudinal on-farm observations and (4) off-farm experiments.

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

GROUP 1	ANALYZING EXISTING FARM DATA
1.	Primary source: written plans, calculations, calenders, records kept, etc.
2.	Secondary source: tax data, accounting data, etc.
GROUP 2	SINGLE ON-FARM INVESTIGATIONS
3.	Interviews
4.	Questionnaires
GROUP 3	LONGITUDINAL ON-FARM OBSERVATIONS
5.	Unstructured observations (participation)
6.	Structured observations
7.	Records kept by farmer on request (panel data)
GROUP 4	OFF-FARM EXPERIMENTS
8.	Tests
9.	Role-playing, gaming, simulation
10.	(Computer) experiments

Figure 2.2 Forms of data collection to study management capacity of farmers

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

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

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

2.4 Review of empirical studies

2.4.1 Methodology

This section focuses on empirical studies that explicitly deal with management capacity of farmers in relation to technical and/or financial results at the farm level. Empirical studies have been selected on the basis of the following criteria: (1) one or more aspects of management capacity of the farmer has been measured, (2) technical and/or financial results have been measured, (3) a relationship between management capacity and results has been analyzed, and (4) the research has been published in scientific agricultural economics and related English-language journals in 1980 or later. Table 2.1 gives an overview of studies that meet these criteria.

The variables analyzed are investigated and compared with the aspects in Figure 2.1 (see previous section). Besides these variables measuring management capacity, Table 2.1 contains farm results. Studies are divided into those using the production frontier approach and those using other approaches. Battese (1992) reviews the methods that can be used to estimate the production frontier: deterministic frontiers, stochastic frontiers and panel data models. The current study is focusing on types of efficiency that can be measured. The production frontier approach distinguishes technical efficiency (TE), price efficiency (PE) (also called allocative efficiency), and economic efficiency (EE). Technical efficiency is the ability to avoid waste by producing as much output as input usage allows, or by using as little input as output production allows. Price efficiency is the ability to combine inputs and outputs in optimal proportions in light of prevailing prices (Fried et al., 1993). Economic efficiency is a measure of overall performance and is equal to technical efficiency times price efficiency (i.e., EE = TE * PE) (Bravo-Ureta and Pinheiro, 1993). The studies which do not use the production frontier approach use straightforward technical results (T) or financial results (F). In total twenty three studies will be discussed here, of which the majority is dealing with dairy farming, but also crop, greenhouse, swine and mixed farming are dealt with. First, the methods and techniques used to measure farm results will be discussed. After that the methods to study management capacity will be worked out.

Table 2.1 Variables describing management capacity included in empirical studies.

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

1) B=biography, D=drives and motivations, A=abilities and capabilities, P=planning, I=implementation, and C=control
2) TE = technical efficiency, PE = price efficiency (= allocative efficiency), EE = economic efficiency F = financial parameter, T = technical parameter

Management capacity in these empirical studies has been related to the farm results. What variables are used as indicator(s) for farm results? In Table 2.1 it can be found that nine studies compare management capacity with financial farm results (indicated by F, PE or EE in Table 2.1). Especially in the latest years, the production frontier approach has been used more and more to determine farm results. Stefanou and Saxena (1988) calculate the price, or allocative, efficiency. Ali and Finn (1989), Parikh et al. (1995), Bravo-Ureta and Rieger (1991), Adesino and Djato (1996) and Wang et al. (1996a and 1996b) calculate the economic efficiency. In other studies plain financial parameters are used as an indicator for farm results. Achten et al. (1983) use the money value of the real yield in horticulture. Jofre-

Giraudo et al. (1990) evaluate the influence of management capacity on economic benefit, however, in a subjective way. The manager is asked whether or not the benefits of their management changes had compensated the costs. Jose and Crumly (1993) use several debt and income indicators. Other studies focus on technical aspects only, for instance milk production (Sharma and Patel, 1988; Tarabla and Dodd, 1990), or respiratory disease in swine (Hurnik et al., 1994a,b). Some studies relate the management capacity to more than one technical parameter (Goodger et al., 1984, 1984/1985 and 1988; Bigras-Poulin et al., 1984/1985b; Cowen et al., 1989, Rosenberg and Cowen, 1990), ranging from the number of repeat breeders to somatic cell count (as an indicator for quality of milk), disease rates and culling rate. Overall it can be concluded that all kinds of different methods are used as an indicator for farm results. The studies which use the economic efficiency criteria, are the only ones that (can) combine technical and economic results.

Although many different methods to measure management capacity are available (see Figure 2.2) it turns out that in practice single on-farm observations are most frequently used. Kumbhakar and Heshmati (1995), Ali and Flinn (1989), Battese et al. (1996) and Wang et al. (1996a,b) use panel data. However, these data lack information on the decision making process: only the farm results over time are measured. Longitudinal on-farm observations are likely to generate more reliable and accurate data. However, they are more expensive and time-consuming.

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

2.4.2 Personal aspects

Quite some work has been done on the relationship between education and farm efficiency. From different studies it can be concluded that education has a positive influence on farm results, especially in developing countries. Lockheed et al. (1980), Bravo-Ureta and Pinheiro (1993), and Phillips (1994) review papers that measure the effect of a farmer's educational level and exposure to extension services on his productivity. They focus on studies performed in low-income regions. Overall, they find confirmation for the hypothesis that education, as a part of the farmers' biography, will have a positive effect on farmers' efficiency. Other studies (see Table 2.1) also indicate that education is positively correlated with farm results (Moock, 1981; Achten et al., 1983; Jamison and Moock, 1984; Bigras-Poulin et al., 1984/1985b; Stefanou and Saxena, 1988; Ali and Finn, 1989; Parikh et al., 1995; Battese et al., 1996; Wang et al., 1996). However, no significant effect of education on farm results is found by Kalirajan and Shand (1985), Tarabla and Dodd (1990), Boris and Rieger (1991) and Adesina and Djato (1996).

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

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

Table 2.1 indicates that ability and capability variables (as part of the personal aspects of the farmer) are rarely analyzed. Besides that, these variables are diverse, making it difficult to draw an overall conclusion on their effect on farm results. Variables mentioned in the studies vary from knowledge of cow behaviour, knowledge of technical recommendations and prices, understanding of technology, to assertiveness and temperament. No influence of level of assertiveness on farm results is found (Bigras-Poulin et al., 1984/1985b). Goodger et al. (1984) and Goodger and Kushman (1984/1985) calculate an overall management index. They put the same weight on all kind of aspects, to calculate an overall score. Knowledge of cow behaviour is one aspect of this index. They find a positive relation between the overall management index and farm results, but the separate effect of knowledge has not been determined. Understanding of technology, measured by asking the farmer to describe the different recommendations of new technologies, is found to have a significant (positive) effect on the yield of rice (Kalirajan and Shand, 1985). Jamison and Moock (1984) measure numeracy, literacy and an agricultural knowledge test score. These aspects are taken as variables in different production function regressions. Sometimes a positive effect is found on production, sometimes no effect could be determined. Jose and Crumly (1993) compare the temperament factors with financial measurements. They find that 'thinking people' have higher total assets than 'feeling people', and 'extravert people' have higher debts than 'introvert people'. From this small overview on relations between abilities and capabilities of the farmer and farm results, it can be concluded that the knowledge in this area is still rather limited in agricultural literature. It can be concluded that the influence of education is often studied, while other personal aspects are under-exposed.

2.4.3 Decision-making processes

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

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

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

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

To summarize the above, two observations can be made. First, studies which use the production frontier approach usually look at age/experience and education of the farmer and to the use of extension services (as part of the planning), yet ignore other personal aspects of the farmer and his decision-making process. Other studies take into account more aspects, but none includes all aspects of management capacity (B, D, A, P, I and C; see Table 2.1). Second, when an aspect is taken into account, the elaboration of it differs greatly between studies, leading to a wide range of variables measured.

2.5 Discussion and conclusions

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

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

Recent studies frequently use the production frontier approach to estimate technical and/or economic efficiency at farms. Elements of management capacity can be added to the list independent variables in this approach. Most often education and experience are taken into account. The method has met critique on the applicability of the rules of neoclassical economics to traditional agriculture (e.g. Torkamani and Hardaker, 1996). Furthermore, for the purpose of relating farm results to management capacity, the production frontier approach must be compared to other methods. The path model approach, for instance, gives the opportunity to set up a stepwise analysis, as shown in Figure 2.1 (where personal aspects influence the decision making process, which, in turn, influences the farm results). So, whether to use the production frontier approach or an alternative approach, needs attention on forehand, taking into account the pros and cons of the different alternative methodologies.

Most empirical studies on management capacity of farmers, in relation to farm results, use questionnaires and interviews for data collection. These are usually executed without repetition, leading to single measurements. To effectively analyze the role of all aspects of management capacity, other methods can be useful. On-farm investigations, with regular repetition, are more appropriate to study management capacity of farmers. Such longitudinal observations are more in line with the dynamic nature of decision-making processes. Also, they give opportunities for verification and are therefore likely to give a more realistic picture. Off-farm experiments with farmers, e.g. in a computer laboratory, can be used to simulate decision-making processes, to assess certain abilities and capabilities of the farmers and to find out about their drives and motivations and their attitude toward risk. However, there is considerable evidence to suggest that the external validity of decision-making research that relies on laboratory simulations of real-world decision problems is low

(Ungson and Braunstein, 1982: p. 39). To provide evidence on validity of different methods, the need for multimethod approaches is generally acknowledged.

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

References

Achten, J.M.F.H., Nienhuis, J.K. and Alleblas, J.T.W. (1983). A quantitative model for measuring management level. *Acta Horticulturae* 135, 39-61.

Adesina, A.A., Djato, K.K. (1996). Farm size, relative efficiency and agrarian policy in Côte d'Ivoire: profit function analysis of rice farms. *Agricultural Economics* 14, 93-102.

Ali, M., Flinn, J.C. (1989). Profit efficiency among Basmati rice producers in Pakistan Punjab. *American Journal of Agricultural Economics* 71, 303-310.

Battese, G.E. (1992). Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics. *Agricultural Economics* 7, 185-208.

Battese, G.E., Malik, S.J., Gill, M.A. (1996). An investigation of technical inefficiencies of production of wheat farmers in four districts of Pakistan. *Journal of Agricultural Economics* 47, 37-49.

Bigras-Poulin, M., Meek, A.H., Blackburn, D.J. and Martin, S.W. (1984/85a). Attitudes, management practices, and herd performance - a study of Ontario dairy farm managers. I. Descriptive aspects. *Preventive Veterinary Medicine* 3, 227-240.

Bigras-Poulin, M., Meek, A.H. and Martin, S.W. (1984/85b). Attitudes, management practices, and herd performance - a study of Ontario dairy farm managers. II. Associations. *Preventive Veterinary Medicine* 3, 241-250.

Boehlje, M.D. and Eidman, V.R. (1984). *Farm management*. New York, etc.: John Wiley & Sons.

Bravo-Ureta, B.E., Pinheiro, A.E. (1993). Efficiency analysis of developing country agriculture: a review of the frontier function literature. *Agricultural and Resource Economics Review* 22, 88-101.

Bravo-Ureta, B.E., Rieger, L. (1991). Dairy farm efficiency measurement using stochastic frontiers and neoclassical duality. *American Journal of Agricultural Economics* 73, 421-428.

Carlson, S., (1951). *Executive behaviour: a study of the work load and the working methods of managing directors*. Stockholm: Strömbergs.

Case, H.C.M. and Johnston, P.E. (1953). *Principles of farm management*. Chicago, etc.: J.B. Lippincott Company.

Castle, E.N., Becker, M.H. and Nelson, A.G. (1987). *Farm business management: the decision-making process*. New York: Macmillan Publishing Company. (3rd ed.)

Covey, S.R. (1989) *The seven habits of highly effective people*. London, etc.: Simon & Schuster.

Cowen, P., Schwabe, C.W., Rosenberg, H.R., Bondurant, R.H., Franti, C.E. and Goodger, W.J. (1989). Reproductive management practices among Tulare, California, dairy herds. I. Census and descriptive aspects. *Preventive Veterinary Medicine* 7, 83-100.

Cross, T.L., King, R.P., Dobbins, C.L. and Fuller, E.I. (1994). *Information management for your farm; facilitator's guide.* Minnesota Agricultural Experiment station. (Station bulletin 604).

Davis, R.T. (1957). *Performance and development of field sales managers.* Boston: Harvard Business School.

De Hoop, D.W. (1988). Management processes in dairy and pig farming and the construction of systems. In: Korver, S. and Van Arendonk, J.A.M. (Editors), *Modelling of livestock production systems*, 77-85. Dordrecht, etc.: Kluwer. (EC seminar, 7-9 April 1987, Brussels, Belgium)

Dewey, C.E., Martin, S.W., Friendship, R.M., Kennedy, B.W. and Wilson, M.R. (1995). Associations between litter size and specific herd level management factors in Ontario swine. *Preventive Veterinary Medicine* 22, 89-102.

Dillon, J.L. and Hardaker, J.B. (1993). *Farm management research for small farmer development.* Rome: FAO. (2nd ed.)

Fried, H.O., Lovell, C.A.K., Schmidt, S.S. (eds.) (1993). *The measurement of productive efficiency.* New York: Oxford University Press.

Goodger, W.J., Galland, J.C., Christiansen, V.E. (1988). Survey of milking management practices on large dairies and their relationship to udder health and production variables. *Journal of Dairy Science* 71, 2535-2542.

Goodger, W.J., Kushman, J.E. (1984/85). Measuring the impact of different veterinary service programs on dairy herd health and milk production. *Preventive Veterinary Medicine* 3, 211-225.

Goodger, W.J., Ruppanner, R., Slenning, B.D., Kushman, J.E. (1984). An approach to scoring management on large-scale dairies. *Journal of Dairy Science* 67: 675-685.

Harling, K.F. and Quail, Ph. (1990). Exploring a general management approach to farm management. *Agribusiness* 6, 425-441.

Hedges, T.R. (1963). *Farm management decisions*. Englewood Cliffs: Prentice-Hall.

Huirne, R.B.M., Harsh, S.B., Dijkhuizen, A.A. (1997). Critical success factors and information needs on dairy farms: the farmer's opinion. *Livestock Production Science* 48, 229-238.

Hurnik, D., Dohoo, I.R., Donald, A. and Robinson, N.P. (1994a). Factor analysis of swine farm management practices on Prince Edward Island. *Preventive Veterinary Medicine* 20, 135-146.

Hurnik, D., Dohoo, I.R. and Bate, L.A. (1994b). Types of farm management as risk factor for swine respiratory disease. *Preventive Veterinary disease* 20: 147-157.

Jamison, D.T., Moock, P.R. (1984). Farmer education and farm efficiency in Nepal: the role of schooling,. extension services, and cognitive skills. *World Development* 12, 67-86.

Jofre-Giraudo, E., Streeter, D.H. and Lazarus, W. (1990). The impact of computer infomation systems on dairy farm management decisions. *Agribusiness* 6, 463-474.

Johnson, G.L., Halter, A.N., Jensen, H.R. and Thomas, D.W. (eds.) (1961). A study of managerial processes of Midwestern farmers. Ames, Iowa State University Press.

Jose, D. and Crumly, J.A. (1993). Psychological type of farm/ranch operators: relationship to financial measures. *Review of Agricultural Economics* 15, 121-132.

Kadlec, J.E. (1985). *Farm management: decisions, operation, control.* Englewood Cliffs: Prentice-Hall.

Kalirajan, K.P. and Shand, R.T. (1985). Types of education and agricultural productivity: a quantitative analysis of Tamil Nadu rice farming. *Journal of Development Studies* 21, 232-243.

Kay, R.D. and Edwards, W.M. (1994). *Farm management.* New York, etc.: McGraw-Hill Inc.(3rd ed.)

Kiernan, N.E. and Heinrichs, A.J. (1994). Identification of farm manager types through cluster analysis of calf and heifer management practices. *Preventive Veterinary Medicine* 18, 225-236.

Kumbhakar, S.C., Heshmati, A. (1995). Efficiency measurement in Swedish dairy farms: an application of rotating panel data, 1976-88. *American Journal of Agricultural Economics* 77, 660-674.

Lockheed, M.E., Jamison, D.T. and Lau, L.J. (1980). Farmer education and farm efficiency: a survey. *Economic Development and Cultural Change* 29, 37-76.

Mintzberg, H. (1973). *The nature of managerial work.* New York, etc.: Harper & Row.

Moock, P.R. (1981). Education and technical efficiency in small-farm production. *Economic Development and Cultural Change* 29, 723-739.

Muggen, G., (1969). Human factors and farm management: a review of the literature. *World Agricultural Economics and Rural Sociology Abstracts* 11, 1-11.

Parikh, A., Ali, F. and Shah, M.K. (1995). Measurement of economic efficiency in Pakistani agriculture. *American Journal of Agricultural Economics* 77, 675-685.

Phillips, J.M. (1994). Farmer education and farmer efficiency: a meta-analysis. *Economic Development and Cultural Change* 43, 149-165.

Poppe, K.J. (1991). *Information needs and accounting in agriculture.* The Hague: Agricultural Economics Research Institute (LEI). (Mededeling 444)

Rockart, J.F. (1979). Chief executives define their own data needs. *Harvard Business Review* 57, 81-93.

Rosenberg, H.R. and Cowen, P. (1990). Management differences and dairy results. *Agribusiness* 6, 267-279.

Sharma, K.N.S. and Patel, R.K. (1988). Quantification of management input in milk production. *Indian Journal of Animal Sciences* 58(2), 253-259.

Simon, H.A. (1982). *From substantive to procedural rationality.* In: Models of bounded rationality, Vol. 2, 424-443. Cambridge, etc: The MIT Press. (First published in 1976)

Simon, H.A. (1977). *The new science of management decision.* Englewood Cliffs: Prentice-Hall. (revised ed.)

Slovic, P., Fischhoff, B. and Lichtenstein, S. (1977). Cognitive processes and societal taking. In: Jungermann, H. and De Zeeuw, G. (eds.), *Decision making and change in human affairs.* Dordrecht: Reidel.

Stefanou, S.E., Saxena, S. (1988). Education, experience, and allocative efficiency: a dual approach. *American Journal of Agricultural Economics* 70, 338-345.

Tarabla, H.D. and Dodd, K. (1990). Associations between farmers' personal characteristics. *British Veterinary Journal* 146, 157-164.

Torkamani, J., Hardaker, J.B. (1996). A study of economic efficiency of Iranian farmers in Ramjerd district: an application of stochastic programming. *Agricultural Economics* 14, 73-83.

Ungson, G.R., Braunstein, D.N. (1982). *Decision Making: an interdisciplinary inquiry.* Kent Publishing Company.

Wang, J., Cramer, G.L., Wailes, E.J. (1996a). Production efficiency of Chinese agriculture: evidence from rural household survey data. *Agricultural Economics* 15, 17-28.

Wang, J., Wailes, E.J., Cramer, G.L. (1996b). A shadow-price frontier measurement of profit efficiency in Chinese agriculture. *American Journal of Agricultural Economics* 78, 146-156.

3 Decision-Making Processes And Firm Efficiencies Of Commercial Greenhouse Growers[1]

Abstract

Although given much attention in textbooks, the concept of decision making is largely ignored in empirical studies explaining differences in firm efficiency. This study makes concepts of decision-making theory operational by defining variables that can be measured and used to represent the quality of the decision-making process. The impact of these decision-making variables on firm efficiencies of 26 specialized flower producers has been measured by means of the stochastic frontier production function. A one-step procedure developed by battese and coelli (1995) is used in which technical and decision-making parameters are jointly estimated. The results show positive associations between the quality of decision-making (especially data recording and firm evaluation) and the level of firm efficiency.

3.1 Introduction

Differences in technical and economic results between comparable firms operating under similar conditions, are historically found to be highly significant (Zachariasse, 1974). In explaining these differences one can focus on various levels. Technical and biological processes are the basic levels at which differences in actual firm inputs and outputs can be analyzed. Use of fertilizer, labor input, mechanization, irrigation, storage of product, crop rotations are examples of variables that can be used at this level (e.g. Thijssen (1992); Wilson et al. (1998)). At a deeper level, however, one can focus on the personal aspects of the farmer: drives and motivations, abilities and capabilities and biographical facts. Variables at this *personal level* may be age, years of experience, level of education, intellectual and social skills (e.g. Jose and Crumly, 1993; Parikh et al., 1995).

One aspect is largely lacking in this field of research. This is the level of organizational decision making, also known as the management level, usually described as

[1] Paper by Ger Trip, Geert J. Thijssen, Jan A. Renkema and Ruud B.M. Huirne; submitted to *Journal of Agricultural Economics*

the cyclical process of goal setting - planning - implementing – controlling.[2] The theoretical concept of organizational decision making is given ample attention in literature, outside agricultural science (Cyert and March, 1963; Simon, 1977; Davis and Olson, 1985) as well as inside (Boehlje and Eidman, 1984; Kay and Edwards, 1994). It is the level that can be seen as intermediate between the personal aspects and the technical/biological processes. It looks at how farmers, with given personal characteristics, manage their firm, i.e. manage the biological and technical processes. Recently, Wilson et al. (1998) stressed that more detailed information about the decision making should be collected and included in the framework of explaining differences in firm efficiencies. The main reasons for traditionally not taking into account decision-making aspects seem to be the complexity of the concept, the difficulty to quantify relevant variables and the costly aspect of collecting data (Kirkley et al., 1998; Rougoor et al., 1998).

This study addresses the question of quantifying and measuring the quality of the decision-making process, as reflected in (1) goals and policy of the grower, (2) the quality of planning, (3) the intensity of data recording and (4) the quality of evaluation. Beyond that, it uses the framework of the stochastic frontier production function (Aigner et al., 1977) to estimate the effects of the decision-making variables on differences in firm efficiencies. A one-step procedure developed by Battese and Coelli (1995) is used, in which technical and decision-making parameters are jointly estimated. The study is focussed on managerial aspects of commercial greenhouse growers in The Netehrlands. A group of specialized flower producers has been selected that produce under similar conditions. During one year several firm visits were carried out to observe the decision-making process.

The purpose of the study is twofold. Firstly, the contribution of this study to the literature is that it includes the paradigm of the decision-making theory, the process of how managers should make decisions, into the framework of firm efficiency. It analyzes whether empirical support can be found for the so often presented model of decision making, the famous cycle of goal setting-planning-implementing-controlling. Secondly, from a more practical point of view, the purpose of the study is to detect the crucial aspects of the decision-making process, accountable for differences in efficiency. This can be a useful tool for farmers/growers and their advisers to improve firm results. Improvements in the process of goal setting-planning-implementing-controlling may lead to a reduction of inefficiency at firm level. Especially when (financial) setbacks are detected and analyzed at an early stage, effective management actions can be taken (Huirne et al., 1992).

[2] The division into stages of the cyclical decision-making process varies between authors, but a basic structure is goal setting- planning-implementing-controlling. Each stage can be further divided into sub-stages.

3.2 Background and material

This empirical research refers to a group of 26 fully specialized chrysanthemum firms in the Netherlands, producing flowers throughout the year in heated greenhouses. Nearly all Dutch chrysanthemum firms are family firms. A typical firm has about one and a half hectares of glasshouses, operated by two relatives e.g. father and son, two brothers or a husband and wife, assisted by other family members and a small number of other personnel. In May 1994 the total number of, specialized and non-specialized, chrysanthemum firms in The Netherlands was 732, with a total production area of chrysanthemums of 769 ha (LEI-DLO/CBS, 1995). The flowers were sold at auctions, in an open competitive way. The average price per stem was about 46 (guilder) cents in 1994. The total value of production in 1994 was 600 million Dutch guilders (about 350 million US dollars), a second position in the ranking of turnover of flowers, after roses (800 million guilders), but before tulips (300 million guilders).

All specialized firms of the research sample were located in the areas "Westland" and "De Kring", two major greenhouse regions in the Western part of The Netherlands, near the cities of The Hague and Rotterdam. These participating firms were randomly drawn from a member list of the Dutch Federation of Horticultural Study Groups (LTO/NTS Glasshouse Cultures) of which almost all Dutch chrysanthemum growers are a member. The study started with a group session during one afternoon and evening in November 1993, followed by a year of (individual) bimonthly firm visits. During the group session several worksheets and tasks on production planning and cultivar choice were completed by the growers. In subsequent firm visits short interviews and additional tasks were carried out.

In addition, the firms supplied data on their production technology (capital and labor used), production processes and sales. Every grower was asked to record all sales per period of four weeks, corresponding to the administrative system of the Dutch auctions, for every cultivar in production. With respect to the production process, dates of harvesting, length of vacancy, dates of subsequent planting and plant density were recorded for every production cycle in every section of the greenhouse.

Characteristics of the 26 firms in our sample are given in Table 3.1. The average turnover per m² showed a large variation between firms, from 67.1 to 126.1 guilders per m² per year, with an average of 90.8. The average selling price of these 26 firms was 47.5 cents per stem. One firm managed to get 63.9 cents on average during the year, the lowest average selling price was 39.2 cents. The quantities varied between 163.4 and 226.4 stems per m² per year, with an average of 191.2. Weighted by quantities the average price was 48.0 cents per stem, which was a little above the average price of the total production sold at the Dutch auctions in the same period: 46.4 cents.

Table 3.1 Characteristics of the research sample of 26 specialized chrysanthemum firms/growers (November 1993 - November 1994)

Var.	Description	Average	Range Minimum	Maximum
T	Turnover (Dfl, $(m^2)^{-1}$, $year^{-1}$)	90.8	67.1	126.1
P	Average selling price (Dfl)	0.475	0.392	0.639
Q	Quantity stems ($((m^2)^{-1})$, $year^{-1}$)	191.2	163.4	226.4
AG	Age grower (years)	37.3	22	52
EX	Experience as chrys. grower (years)	12.4	2	25
NE	Number of entrepreneurs on firm	1.7	1	4
NA	Net production area (ha)	1.35	0.65	2.82
CY	Construction year of greenhouse	1982.4	1970	1992
SL	Supplementary lighting (1=yes, 0=no)	0.32	0	1
LA	Estim labor use (hrs, ha^{-1},$year^{-1}$)	6890	5262	9247

The average age of the participants was 37.2 years, the youngest being 22, the oldest 52. Some had many years of experience with chrysanthemum growing, others just a few years. The average size of the chrysanthemum production glasshouse area of the firms in the sample was 1.35 ha. The difference with the population average (769 ha / 732 firms =1.05 ha per firm, LEI-DLO/CBS, 1995) could be explained from the fact that non-specialized firms, which usually have small areas, were excluded from the research, in order to have comparable firms.

With respect to modernity of the firms: the oldest glasshouses were build in 1970, the youngest in 1992. On 32% of the total area supplemental light was used. The input of labor varied between 5,262 and 9,247 hours per m² per year.

3.3 The model

The focus of the study is on the tactical level of decision making, where the grower's objective is to maximize firm output, given the available firm structure and firm technology. We take the firm structure and technology, which are part of the strategic decision making and long-term planning, as given. The elements of the model are shown in Figure 2.1. The management qualities are reflected in the model as firm efficiencies in the process of transferring input to output. The level of turnover per m² is used as the end result of firm output. This is justified because - on short/medium term - growers tend to think and act in terms of maximizing turnover per m² given the available firm technology (as result of the long-term strategy).[3]

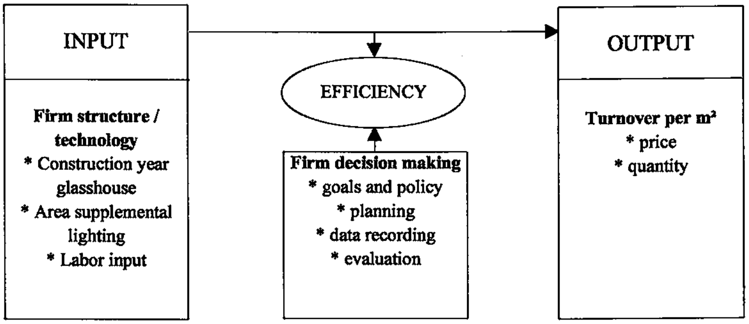


Figure 3.1 *Efficiency in production as a result of firm decision-making variables*

A higher level of production technology represents a higher level of attainable turnover. The construction year of the greenhouse, the size of the area of supplemental lighting and the labor input are the main variables accountable for differences in firm technology. Also, these variables are accountable for the level of fixed costs (interest, depreciation, electricity and fixed labor). Other substantial (variable) costs, like plant material and sales costs are more or less linear related to the level of turnover and therefore not taken into account.[4].

The four elements of the quality of the firm decision making, see Figure 3.1, reflect the four main stages of the cyclical process, the paradigm of the decision-making theory; (see *3.1 Introduction*). Given its production technology a firm will achieve a certain level of

[3] Support for this assumption was found when, at the end of the year, participants were asked if they had been striving for attaining maximum turnover. Apart from three growers all said that they had striven for the maximum and would do so the next year as well. Three growers had let go of 1.5%, 2% and 5% of the maximum turnover because of a short holiday in summer or because of never working on Sundays.

[4] Cost data were not included in the investigation. Some firms have detailed, accurate and comparable cost data, for others it would demand a huge effort to deliver these. We decided not to ask for this because of the small benefit it would bring for the analysis (because of the almost linear relationship between these costs and turnover), and because of the risk of a self selection bias in the sample.

turnover as a result of how well the decisions are made and implemented, i.e. how efficient it has been operating.

To formulate this model a stochastic production frontier approach is used. The distance between the turnover frontier and the actual data defines the level of (in)efficiency.[5] The estimated inefficiency is defined as the distance between the actual turnover per m^2 per year of a certain firm and the possible turnover given the state of its production technology (state of the glasshouses, labor input and investment in supplemental lighting). Often, a (physical) quantity measure is used as the dependent variable in the stochastic frontier analysis, leading to an estimate of technical (in)efficiency. However, the use of (money) values as dependent variable has been applied also, e.g. *total gross farm returns* (Battese and Coelli, 1988) or *added value* (Aigner et al., 1977).

In a one-stage estimation procedure inefficiencies as well as reasons for these inefficiencies (based on decision making and managerial practices) are estimated. Based on Battese and Coelli (1995) and Coelli et al. (1998) the following model was used:

$$Ln(T_i) = Ln(X_i)\beta + V_i - U_i \quad i = 1 \dots 26$$

where:

T_i is the turnover per m^2 per year of the i-th firm,

X_i is the vector of technology inputs (construction year of the glasshouses CY, area of supplementary lighting SL and labor input LA) for the i-th firm,

β is a vector of unknown parameters,

V_i are random variables which are assumed to be independently identically distributed (iid) $N(0, \sigma_v^2)$, and independent of the U_i,

U_i are non-negative random variables which are assumed to account for economic inefficiency and are assumed to be independently distributed as truncations at zero of the $N(m_i, \sigma_u^2)$ distribution; where:

$m_i = z_i\delta$, where

z_i is a vector of decision-making variables (goals and policy, planning, data recording and evaluation) which may influence the efficiency of a firm and

δ is a vector of parameters to be estimated.

---

[5] See Fried et al. (1993) for mathematical techniques and applications and to Battese (1992) for an overview of empirical applications in the field of agricultural economics.

This way, pure random disturbance (V) is separated from disturbances that can be attributed to the level of the decision making (U, via δ). The level of (in)efficiency is estimated as $e^{-U(i)}$.

3.4 Measuring decision making

3.4.1 Goals and policy

Setting business goals is the basis for every organization, large or small. Without goals there is no guide to make management decisions nor to measure their results. The general idea is: the more clear, preferably written, specific, measurable and time-scheduled, the goals, the more powerful management can be (Kay and Edwards, 1994). Goals are set on different levels of decision making, from the strategic to the operational level. The goals on a lower level can be seen as the *means* to achieve the goals on a higher level in a goal hierarchy or value tree (Von Winterfeldt and Edwards, 1986).

Table 3.2 Average scores and ranking of potential critical success factors by 26 chrysanthemum growers; Likert-type scale 1-5 (unimportant - very important)

Factor	November 1993		November 1994	
	Score	Rank	Score	Rank
Climate control	4.62	1	4.58	1
Production planning	4.50	2	4.46	2/3
Control light and dark	4.46	3	4.46	2/3
Cultivar choice	4.42	4	4.35	4
Firm layout	4.19	5/6	4.27	5/6
Reinvestment policy (greenhouses etc.)	4.19	5/6	3.58	11
Plant density	4.08	7	4.00	7
Fertilizer supply	3.96	8	3.92	8/9/10
Choice of personnel	3.92	9	4.27	5/6
Disease control	3.81	10	3.92	8/9/10
Water supply system	3.38	11	3.92	8/9/10
Average	4.14		4.16	

The concept of critical success factors (CSF) was used to detect the goals of the growers. CSF were explained to growers as the few key issues that must be done exceedingly well to be successful (Rockart, 1982, p. 85).[6] All 26 growers were asked to score 11 listed potential CSF on a scale from 1 (not important) to 5 (very important). This task was held in November 1993 and repeated one year later, to see if there is consistency in goals (see Table 3.2). There was a reasonable level of consistency at *group level*, expressed by a rank correlation over time of +0.77. Most important factors were climate control, production planning, control light and dark, cultivar choice and the layout of the greenhouse. Less important were water supply system, disease control, fertilizer supply and plant density. The position of the choice of personnel went up and the importance of the reinvestment policy went down during the year (Table 3.2). Despite this agreement at group level, there was a low consistency in time at the *individual level*. Only five growers were reasonably consistent over time, with a rank correlation above 0.5 and the average rank correlation was only +0.32.

The growers were also asked to add three new CSF to the list, to see if they were able to express other goals in addition to those listed. The added CSF, used to quantify the ability to express additional goals, ranged from 'cost control' to 'having a good mood'. The added CSF were judged on added value (2 points if the factor was new, 1 point if there was some addition, 0 points if there was no addition to the factors already listed) and specificity (2 points if the factor was specific, 1 if there was some specificity, 0 points if the factor was not specific at all). These scores, based on added value and specificity, ranged from 1 to 9 with an average of 5.15. They were used in the stochastic frontier analysis, see also Table 3.4.

3.4.2 Quality of the planning

Planning is a powerful means for attaining the organizational goals. A plan serves as a schedule - it specifies the intermediate steps towards the desired outcome - and can be seen as a goal itself (Cyert and March, 1963, p.111-112)[7]. Therefore, we are interested in the quality of the planning in relation to economic performance.

Like before, we assume a strategic long-term plan has already been made and we focus on the production planning at tactical level. Growers were asked to give their best estimates for harvesting dates and subsequent planting. Estimates were given for all sections

[6] A similar approach can be found in Boyatzis (1982, p. 48) who asked managers if a certain job element differentiates between *superior* and *average* performance in the job.

[7] According to the same authors, plans also function as precedents - they set a trend the rationale of which is only re-examined occasionally - and as a theory, since they reflect the vision of the decision-maker on relationships between causes and effects in the real world (Cyert and March, 1963, p. 111-112).

of the greenhouse, containing plants in different stages of growth[8]. Some growers already had the production plan written down, in which case a look on a computer print or a hand-written sheet was enough to obtain the necessary data. Others had to walk through the greenhouse, look at the 'cultivar-card' hanging at a leg of the particular section to see which day the cuttings were planted and then calculate the expected harvest date (and subsequent vacancy and planting date). This task was performed twice: in winter 1993 and in summer 1994.

The predictions turned out to be rather inaccurate[9]. The maximum absolute error (at the beginning of the next planting) in winter varied from 5 to 21 days between growers, with an average of 9.9 days and in summer the maximum error ranged from 1 day to 16 days, with an average of 6.1 days. Most growers tended to be too optimistic since their actual planting was generally later than the estimated planting. In winter 17 out of 26 growers usually had a delay in planting, in summer 21 (out of 26).

The deviation between estimation and realization was taken as a measure for the quality of the planning and the participating growers were ranked with respect to the deviation made in the planning tasks. The total error in a planning task was calculated as the sum of three absolute deviations: the start of the harvest, the duration of harvesting and the duration of subsequent vacancy[10]. A ranking was made for the winter and the summer planning. It turned out that the better planners in winter were also likely to be better planners in summer (Spearman rank correlation R=0.64; type I error p=0.00). The average ranking (summer and winter) was used in the stochastic frontier approach, see also Table 3.4.

3.4.3 Intensity of data recording

Data recording itself is not a sufficient requirement for making better decisions. Data alone have no value until the decision maker gives meaning to them and uses them for current or future decisions. Data have to be transformed to meaningful and useful information (Davis

---

[8] When a firm had over 16 sections, a selection of 12 sections was taken, divided over the greenhouse area, to keep the effort for this task within reasonable limits.

[9] Far less accurate than the growers had indicated in advance: deviations would lie within one week in winter and would be even smaller - a couple of days at the highest - in summer.

[10] When all three deviations go into the same direction (e.g. a delay) then this total error sums up to the deviation between planned and realized planting, when they do not point into the same direction, the total error is larger than the deviation based on planting date only. Example: predicted date start harvest 1401 (week 14 day 1), end harvest 1403 and start next planting 1405, and the realizations are 1405, 1501 and 1505 respectively, the error sums up to 4 + 1 + 2 = 7 days. When the realizations would have been: 1405, 1406, 1501, the error would be $4 + |-1| + 0 = 5$ days.

and Olson, 1985, p. 200-202). The hypothesis here is that growers who keep many data have more chances of making better decisions and will eventually get better economic results.

Most growers used a 'cultivar-card' for writing down (production) data of each production lot[11]. They used this card during the vegetative and generative production stages and usually keep it after harvest in order to make use of it in a later moment, for instance after exactly one year when the same (light) conditions are present. Some growers wrote down many things on the cultivar-card, quantitative data as well as qualitative remarks, they might use accompanying means for data recording as well, others only wrote down some basics. The intensity of the data recording is of interest in this study, since it represents part of the decision-making perspective and might explain some of the variation in economic results. A measuring device was made to score the intensity of the data recording and analysis (see Table 3.3). Twelve relevant items were listed and for each item that was recorded one point was given to the grower. Two of these items referred to the use of a PC for data recording and analysis.

Table 3.3 *Measuring device for the intensity of the data recording and analysis of 26 chrysanthemum growers*

Does the grower record following item:	Max score	Mean score
plant density (of each production lot)	1	0.69
production dates (planting, short day period, interruption, harvest)	1	1.00
crop length (at beginning short day period and harvest)	1	0.42
use of growth regulator (dates, dosage and crop length)	1	0.75
qualitative remarks (quality of stem and leaves, etc.)	1	0.38
light intensity (per day)	1	0.21
prices & weights of product sold	1	0.67
use of nutrition, disease control, energy and water (per period)	1	0.63
labor costs (per period)	1	0.54
other variable costs (per period)	1	0.08
using a PC for recording and analysis of sales	1	0.33
using a PC for recording and analysis of production data	1	0.25
TOTAL	12	5.96

Some items were recorded by most growers: production dates, use of growth regulator, plant density, prices and weights and use of nutrition (etc.). Labor costs and crop length were

[11] A production lot comprises a number of cuttings planted at one instance, given the same treatments and grown to be ready for harvest at almost the same time.

recorded at about fifty percent of the participating firms. Qualitative remarks, light intensity and other variable costs were written down by a minority. PCs for recording and analysis were used by a minority of about one third. The average total score for data recording was 5.96, fifty percent of the maximum score. The individual scores ranged from 1.00 to 11.00 and were used in the stochastic frontier approach, see also Table 3.4.

Table 3.4 Decision-making variables used in stochastic frontier analysis

Var.	Description	Average	Range Minimum	Maximum
G	Ability to formulate additional goals	5.15	1.0	9.0
P	Ranking in planning task (average summer and winter)	13.5	2.5	25.0
D	Data items recorded	5.96	1.0	11.0
E	Number of evaluation measures used	1.55	0.0	3.0

3.4.4 Quality of evaluation

Evaluation consists of the process of measuring performance and comparing measured performance with the standards established in the plan. The whole process is referred to as control and its importance is obvious: keeping in touch with the desired goals (Boehlje and Eidman, 1984, p. 662-665). Evaluation/control is needed to make effective adjustments in the next step of the decision making.

During the last firm visit at the end of November/ beginning of December 1994, growers were asked to evaluate their firm results for 1994. They were asked to (1) express their level of satisfaction with respect to the results, (2) give measures on which the evaluation was based and (3) quantify the measures if possible. The underlying assumption is that a high quality of the evaluation is reflected by being able to express the level of satisfaction and, moreover, by being able to base it on (as many) measures and figures.

The level of satisfaction with the results of a certain year may be based on a comparison with the results in the previous year(s) or in comparison with the results of colleagues/peers in the same year. In line with Katona (1975, p. 297) we prefer to use the last one, since it is influenced less by general cyclical fluctuations in the business. The average level of satisfaction with the own results compared to peers was 3.6 on a scale from 1 (very unsatisfied) to 5 (very satisfied). Two growers out of 26 were not able to give a level of satisfaction, because, as they said, they did not know the results of colleagues.

The number of *quantitatively based* [12]measures varied from 0 to 3, with an average of 1.55. Most-mentioned measures were price (12.5 times), production (10 times), turnover (6 times), labor costs (5 times) and other costs (3 times). The number of measures given by each grower was used as a yardstick for the quality of the evaluation and used in the stochastic frontier approach, see also Table 3.4.

3.5 Estimation results

The estimated coefficients of the model are given in Table 3.5. From the beta estimates one can calculate the effects of firm technology on turnover.[13] On average a one year younger glasshouse yielded 0,84 guilders per m^2 more. So the maximum effect of differences in modernity was about 18 guilders per m^2 per year (the oldest greenhouse in the sample was build in 1970, the youngest in 1992). No prior estimates were available to compare this figure with. The estimated effect of supplementary lighting on turnover was 21.8 guilders per m^2 per year, which lied close to the estimate (20.7) made in quantitative information for greenhouse horticulture (IKC, 1994). One hour of extra labor input (per ha) lead to an estimated increase in turnover of 23.9 guilders (per ha); less than the standard costs (35.2) of one hour of skilled regular personnel (LEI-DLO/CBS, 1995). Yet, a substantial part of the labor input came from unskilled, casual workers that costed less.

Beyond these effects, the level of turnover also depended on efficiency aspects of the decision making. It turned out that there is a positive effect of data recording on the level of efficiency (see δ_3; note that the negative sign of δ_3 means a positive influence because of the negative sign attached to U in the model). Also, the level of evaluation had a positive influence on efficiency. No relation was found, however, between the efficiency on the one hand and the goal formulation and the planning ability on the other hand.

[12] A full point for quantification was given when a grower could state e.g. "my production was 173, the average production of other (comparable) firms was about 183". When he said e.g.: "my production was 173, slightly less than others", he got a score of 0.5 for quantification and when he was only able to tell that e.g. "the level of production was nearly the same", he got a score of 0.25 for quantification.

[13] The beta's are the estimated elasticities, except for SL, which is brought into the frontier equation merely as a dummy variable, taking on values 1, 0 or close to 0 (when a firm has a few additional lights).

Table 3.5 Estimated coefficients in the stochastic frontier model

Parameter	Estimate (st. error)	T-value	Significant?
β_0 (constant)	-136.7 (1.1)	-124.77	nr
β_1 (construction year)	18.41 (0.21)	86.38	++
β_2 (labor input)	0.181 (0.135)	1.34	+
β_3 (suppl. lighting)	0.215 (0.040)	5.43	++
δ_0 (constant)	0.330 (0.084)	3.93	nr
δ_1 (goals)	0.003 (0.010)	0.31	o
δ_2 (planning)	-0.000 (0.004)	-0.05	o
δ_3 (data recording)	-0.020 (0.009)	-2.32	++
δ_4 (evaluation)	-0.034 (0.020)	-1.67	+

++ = highly significant, + = moderate significant, o = not significant
nr = not relevant

With respect to the ability to express additional operational goals and the lack of influence on efficiency, an explanation can be that operational goals are influenced by sudden incidences. This is reflected by a low level of consistency in what growers mention as CSF. An average (Spearman) rank correlation between scores given to CSF at two different moments (November 1993 and November 1994) of only +0.32 was found. Only five growers were reasonably consistent over time, with a rank correlation above 0.5. In 18 cases the correlation coefficient lied between 0 and 0.5. Even negative correlations were found, in three cases, indicating either drastically changed opinions or a lack of opinion. Another explanation of a missing association between efficiency and the goals of the entrepreneur can be that the role of the other family members as well as external advisers in formulating goals was not taken into account, whereas their opinion and contribution can be important (Gasson, 1988 and 1992).

The planning variable seems to play no significant role in the estimation of efficiencies[14]. The following consideration may be an explanation for this unexpected result. The difficulty of the planning task depends on the cultivar(s) in production. Estimates for standard cultivars with well-known production characteristics are easier made than estimates for relatively new cultivars. It may be that the more-conscious planners are more likely to take the challenge of producing *difficult* cultivars and therefore fail to be recognized as good

[14] Also, no correlations were found between the planning performance and personal/firm characteristics (age, experience, number of entrepreneurs, production area, construction year, supplementary lighting, labor input - see Table 1).

planners. So, it is still possible that planning does lead to better results. Support for this idea is found in the (rank) correlation between the planning performance and the level of vacancy - the time between harvesting and subsequent planting - in the glasshouse (Spearman rank correlation R = 0.62, type one error p = 0.00), i.e. the better planners have at least less vacancy.

The estimated efficiencies ($e^{-U(i)}$) varied between 0.97 (firm 22) and 0.71 (firm 8), with an average of 0.84. Table 3.6 lists the (in)efficiencies of all firms and also the decision-making variables. Four firms (3, 13, 15 and 24) are in the top 10 on every aspect of the decision making, yet two of them (15 and 24) are not in the top 10 with respect to efficiency. Five firms (4, 5, 9, 12 and 16) are never found in the top 10 of any decision-making variable. Accordingly, their position in the efficiency list is low.

Table 3.6 Estimated efficiency scores and decision-making variables of all 26 firms

			Decision-making variables [b]							
firm	efficiency	(rank)	G	(rank) [a]	P	(rank) [a]	D	(rank) [a]	E	(rank) [a]
1	0.928	(6)	6	(10)	10.25	(10)	5.5	(14.5)	1	(19)
2	0.874	(10)	5	(15)	10.5	(11.5)	7.17	(9)	1.5	(14.5)
3	0.957	(3)	8	(3)	8	(7)	11	(1.5)	3	(3)
4	0.745	(23)	1	(25.5)	15	(15)	1.5	(24)	0	(24)
5	0.715	(25)	1	(25.5)	24	(24.5)	4	(20)	0	(24)
6	0.839	(11)	5	(15)	6	(4.5)	3.67	(21)	1	(19)
7	0.779	(19)	6	(10)	2.5	(1)	7	(10)	1	(19)
8	0.713	(26)	4	(19)	17.75	(18)	3.5	(22)	2	(9)
9	0.767	(21)	5	(15)	22	(22)	5.5	(14.5)	0	(24)
10	0.787	(18)	7	(6)	6	(4.5)	8.5	(6)	1.5	(14.5)
11	0.732	(24)	6	(10)	24	(24.5)	1	(25.5)	2	(9)
12	0.768	(20)	4	(19)	10.5	(11.5)	4.5	(19)	1.5	(14.5)
13	0.918	(9)	7	(6)	7	(6)	11	(1.5)	2	(9)
14	0.803	(16)	6	(10)	15.25	(16)	5	(17)	0	(24)
15	0.823	(12)	8	(3)	8.5	(8)	9.5	(4)	3	(3)
16	0.809	(15)	5	(15)	16.75	(17)	2	(23)	1.3	(16)
17	0.809	(14)	7	(6)	23.5	(23)	5	(17)	0	(24)
18	0.927	(7)	3	(22)	13.5	(14)	10	(3)	2	(9)
19	0.950	(4)	4	(19)	19	(21)	6.17	(12)	2	(9)
20	0.762	(22)	8	(3)	25	(26)	1	(25.5)	3	(3)
21	0.924	(8)	5	(15)	18	(20)	6	(13)	3	(3)
22	0.968	(1)	3	(22)	13.25	(13)	8.5	(6)	3	(3)
23	0.822	(13)	2	(24)	9.75	(9)	5	(17)	1	(19)
24	0.796	(17)	6	(10)	3.75	(3)	8.5	(6)	2	(9)
25	0.931	(5)	9	(1)	17.75	(19)	8	(8)	2	(9)
26	0.964	(2)	3	(22)	3.5	(2)	6.5	(11)	1.5	(14.5)

[a] if scores are equal, average ranks are calculated

[b] G, P, D and E refer to goals, planning, data recording and evaluation respectively (see text)

3.6 Conclusions and discussion

Starting point for this study have been recommendations to include management decision-making variables, as non-physical inputs, into the framework of measuring firm (in)efficiencies, recently expressed by Wilson et al. (1998: 303). So far, however, empirical studies in this field were generally focused on physical inputs (fertilizer, irrigation, etc.) and, in some cases, supplemented by personal indicators (age, experience, education, etc.) of the manager.

In this study, the paradigm of the decision-making theory, the process of how people should make decisions along the cycle of goal setting-planning-implementing-controlling, was included in the analysis. First, concepts of decision-making theory were transformed into operational variables, suitable for quantification. Data and measurements on these variables were collected on 26 firms during a one-year-period. Firm observations, interviews, (knowledge) tests and repeated (planning) tasks were part of this data collection. Then, these decision-making variables were included in the framework of the stochastic frontier production function to estimate the effects on differences in firm efficiencies. A one-step estimation procedure (Battese and Coelli, 1995) was used, in which technical and decision-making variables were jointly estimated.

The results show statistically significant associations between some aspects of the decision-making variables and the efficiency of firms. Especially the aspects of data recording and evaluation were found to be of importance. Firms with a high intensity of data recording and a high level of firm evaluation had smaller inefficiencies. The aspects of goal setting and planning were not found to be associated with higher (or lower) levels of efficiency.

Some remarks should be made with respect to these results. First, the transformation from decision-making concepts into operational variables, is necessarily arbitrary to some extent. So although the variables were carefully chosen to represent the various steps in the decision-making process, ongoing research in this area is needed to find out if better quality indicators exist. Second, one phase of the decision-making process could not be included into the analysis. This is the stage of the implementation, where appropriate actions are needed to bring plans into action and a skillful, practical attitude ('green fingers') is needed to work with the resources available. We did not find a satisfactory way to measure the quality level at this stage. By including this phase, the level of variation in efficiency one can expect to explain might increase.

Besides the purpose of testing key elements of the decision-making theory, this study also wants to contribute to improving the level of management of the growers. By detecting positive associations between firm efficiencies and decision-making variables (data collection and evaluation) we conclude that possibilities are available for improving firm results by further developing managerial skills. However, although associations were found one can question if these are causal relations. Growers and their advisers should judge themselves whether in a specific case, where a particular aspect of the decision-making process is performed poorly, possibilities for improvement are present and higher firm results can be obtained (Alleblas, 1991).

References

Aigner, D., Lovell C.A.K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics* 6, 21-37.

Alleblas, J.T.W. (1991). Towards an automated system of management advice in glasshouse horticulture. *Acta Horticulturae* 295, 169-176.

Battese, G.E. (1992). Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics, *Agricultural Economics*, 7, 185-208.

Battese, G.E. and Coelli, T.J. (1988). Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of Econometrics* 38, 387-399.

Battese, G.E. and Coelli, T.J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics* 20, 325-332.

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

Boyatzis, R.E. (1982). *The competent manager: a model for effective performance.* New York: John Wiley & Sons.

Coelli, T., Rao, D.S.P. and Battese, G.E. (1998). *An introduction to efficiency and productivity analysis*. Boston etc.: Kluwer Academic Publishers.

Cyert, R.M., and March, J.G. (1963). *A behavioral theory of the firm.* Englewood Cliffs, NJ: Prentice-Hall.

Davis, G.B., and Olson, M.H. (1985). *Management information systems: conceptual foundations, structure, and development.* New York: McGraw-Hill. (2nd ed.)

Fried, H.O., Lovell, C.A.K. and Schmidt, S.S. (eds). (1993). *The measurement of productive efficiency: techniques and applications.* New York, Oxford: Oxford University Press.

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

Gasson, R. (1992) Farmers' wives - their contribution to the farm business. *Agricultural Economics* 43, 74-87.

Huirne, R.B.M., Dijkhuizen, A.A., Renkema, J.A. and Van Beek, P. (1992) Computerized analysis of individual sow-herd performance. *American Journal of Agricultural Economics* 74, 388-399.

IKC (1994). *Quantitative information for greenhouse horticulture 1994-1995.* Aalsmeer, Naaldwijk: Information and Knowledge Centre in Agriculture.

Jose, H.D. and Crumly, J.A. (1993). Psychological type of farm/ranch operators: relationship to financial measures. *Review of Agricultural Economics* 15, 121-132.

Katona, G. (1975). *Psychological economics.* New York: Elsevier.

Kay, R.D., and Edwards, W.M. (1994). *Farm management.* New York: McGraw-Hill. (3rd ed.)

Kirkley, J., Squires, D. and Strand, I.E. (1998). Characterizing managerial skill and technical efficiency in a fishery. *Journal of Productivity Analysis* 9, 145-160.

LEI-DLO/CBS (1995). *Tuinbouwcijfers 1995.* The Hague, Voorburg: LEI-DLO. (In Dutch)

Parikh, A., Ali, F. and Shah, M.K. (1995). Measurement of economic efficiency in Pakistani agriculture. *American Journal of Agricultural Economics* 77, 675-685.

Rockart, J.F. (1982). Chief executives define their own data needs. *Harvard Business Review* 57, 81-93.

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

Simon, H.A. (1977). *The new science of management decision.* Englewood Cliffs, NJ: Prentice-Hall. (Revised edition)

Thijssen, G.J. (1992). Supply response and input demand of Dutch diary farms. *European Review of Agricultural Economics* 19, 219-235.

Von Winterfeldt, D., and Edwards, W. (1986). *Decision analysis and behavioral research.* Cambridge: Cambridge University Press.

Wilson, P., Hadley, D., Ramsden, S. and Kaltsas, I. (1998). Measuring and expalaining technical efficiency in UK potato production. *Journal of Agricultural Economics* 49, 294-305.

Zachariasse, L.C. (1974). *Farmer and farm results: an analysis of causes of differences in profitability of similar arable farms in the North-East-Polder.* Wageningen: Wageningen Agricultural University. (PhD-thesis, in Dutch)

4 Price predicting ability of farm managers; empirical findings with flower producers in The Netherlands[1]

Abstract

Differences in income among horticultural growers, producing under similar conditions are known to be substantial. Among the factors causing differences in income between commercial growers, prices play a major part. Both price variation over time and price differences among cultivars provide valuable management information to growers to adapt their production policy. This study focuses on price predicting skills of specialized Chrysanthemum growers. The study, based on a survey among 26 participants, shows that growers who predict absolute prices well for one period do not have a higher chance of predicting well for other periods. With respect to predicting relative price positions (relative to other cultivars or other firms) evidence is found, however, that this is a skill, especially for estimating the relative market position. Also, evidence is provided that price differences among cultivars are non-random in time and it is concluded that growers could adapt their production planning and cultivar choice to benefit from expected price variations.

4.1 Introduction

Commercial flower production is an example of an agricultural sector where product differentiation has always been important. Consumers' preferences for colors and shapes may change rapidly over time and producers try to anticipate these trends and fluctuations in demand by adapting their production planning and cultivar choice. Differences in color and shape of otherwise similar products can have a large impact on selling price. In this study, the focus is on a group of specialized chrysanthemum growers. With a production value of about 300 million US $, chrysanthemums are the second largest flower product in The Netherlands, after roses (400 million US $) and before tulips (150 million US $).

Both price variations over time and price variations among cultivars are substantial. These price variations range from short term, daily fluctuations (e.g order at which products

[1] Paper by Ger Trip, Ruud B.M. Huirne and Jan A. Renkema; submitted to *Review of Agricultural Economics*

are sold at the auction) over which the grower has no control, to variations that become manifest at a longer period of time. Special celebration days play an important role in the demand for flowers. In the week(s) before e.g. Valentine's Day, Mother's Day, Easter and All Soul's Day, demand for flowers is increased. Changing consumer preferences ("market niches"), shifts in quality image of producers, as well as seasonal fluctuations in supply and demand, have an impact at a somewhat longer period in time. This paper addresses the issues of price variations from a farm management point of view, and its objective is to know which variation in price can be effectively predicted and used to improve the cultivar choice, and as a result, farm income.

4.2 Cultivar choice

The majority of the chrysanthemum production in The Netherlands is sold at the auction and the use of other marketing channels (direct selling and contract selling) has been very limited. However, this does not mean that growers have no room for marketing strategies. Chrysanthemum growers can choose from more than 300 cultivars (varieties), differing in color, form, size, disease-rate, production time, labor input, price expectation, etc. All these biological and economic aspects need to be considered when making the cultivar choice. Although a specific cultivar can have its own optimal production conditions, growers easily switch from one to the other. Since the average production cycle is less than three months, and moreover, the greenhouse is divided into several sections with subsequent planting, the decision of replacing cultivars is a frequent decision. Both aspects, financial consequences and frequency, make cultivar choice an important management instrument to safeguard continuity and income.

Related to the question of cultivar choice is the quality policy. Once the cultivars have been selected, the grower must choose *how* to grow them. Several measures will have an impact on the quality and price of the final product. E.g. plant density will influence the weight distribution of the branches, which is relevant because the flowers will be sold at the auction in different weight categories. Also other measures may be taken by growers to improve their quality image in the area of presentation and durability of the product. The fact that flowers are sold under the producer's name at the auction may be an incentive for growers to excel amongst their competitors or, on the contrary, may lead to operate at a low quality profile and a focus on other objectives (e.g. decreasing production costs).

4.3 Hypotheses

This article focuses on price predicting ability of growers, with special emphasis on (1) price variation over time and (2) price variation among cultivars. It tests the following hypotheses: (H1) non-random price patterns exist and (H2) growers can make effective use of these price patterns. With respect to the price predictions the following hypotheses will be tested. (H3) Some growers are persistently better in predicting prices than others, (H3a) with respect to absolute price levels and (H3b) with respect to relative price positions. (H4) Price predictions improve when they relate to the own situation (own cultivar, own supply), (H4a) for growers as a group and (H4b) for individual growers. (H5) Price predictions improve when additional historic price information is made available to the grower, (H5a) for growers as a group and (H5b) for individual growers. The focus of the study is on the question whether predicting prices can be considered a skill or must be considered a lottery. We look at both absolute price levels as well as relative price positions, defined as the market position (prices of one cultivar relative to other cultivars) and the quality position (prices of one firm relative to other firms).

4.4 Survey on price predictions

The ability to predict prices has been measured using a survey of 26 specialized chrysanthemum growers in the spring of 1994. The growers contributed to a larger management research during one year, from November 1993 until November 1994, in which several parts of the decision making were observed and analyzed. The firms were randomly drawn out of the population of specialized chrysanthemum firms in the regions 'Westland' and 'De Kring'; two main regions of production, located near the cities of Rotterdam and The Hague. These firms produced chrysanthemums throughout the year in heated greenhouses. The number of cultivars grown at each firm during the year varied from 1 to 15, with an average of 6.0. The cultivar *Reagan* was responsible for about half of the total production and no other cultivar had a share in production larger than five percent. Prices differed considerably among firms, from Dfl. 0.392 to Dfl. 0.639 (average selling price per branch during 1994), with an average of Dfl. 0.475.

The survey consisted of four parts; each grower had been asked to make a prediction of:

(task 1) the selling price of his own supply of his main cultivar (M), (task 2) the selling price of the total supply, including that of his colleagues, of this cultivar (M) at the Dutch auctions,

(task 3) the overall selling price of chrysanthemums at the Dutch auctions,

(task 4) as task 3, but with additional information about historic prices (on the past four years).

The growers gave most likely (point) predictions, as well as intervals within which the price 'will lie with 95% certainty'. We chose to follow the convention of the flower auctions to divide the year in 13 four-week-periods and studied the price predictions at this level. The predictions were made at the end of May 1994 (auction period 6) and referred to period 7 (June 20 till July 15), period 9 (August 15 till September 9) and period 11 (October 10 till November 4) of the auction season. Furthermore, the growers gave price predictions for the overall supply of chrysanthemums in 1994.

These price predictions, when confronted with the realizations, show how well a grower predicted the absolute and relative price levels. The relative prices reflect the *market position* of the main cultivar chosen (relative to other cultivars) and *the quality position* of the firm (relative to other firms, producing the same cultivar).

Price realizations from the co-operative Dutch Flower Auctions (VBN) were used for the comparisons of prediction and reality.

4.5 Seasonal Price Variability

Average four-week-period prices varied between Dfl. 0.86 and Dfl. 0.22 during the years 1990 till 1994. A seasonal pattern in the 13 four-week-periods in each year was rather dominant: see Figure 4.1. The highest prices were found in the winter periods 1 and 2, and the lowest prices were found in the summer periods 7 and 8. Furthermore, prices decreased somewhat over the years.

The price fluctuations were modeled and estimated by means of the ARMA technique (Box and Jenkins, 1970). This means that the data were explained solely by their own history and not by relating them to a set of other variables (Pindyck and Rubinfield, 1991: 413). Equation (1) turns out to be an adequate model, both in terms of explanation of the data from the estimation period (period 1 1990 till period 5 1994) and in prediction of the prices in forecast period (period 6 1994 till period 13 1994). The standard errors of the parameters are given between brackets.

$$P_t = 0.483*P_{t-13} + 0.182*P_{t-26} + 0.299*P_{t-39} - 0.932*\varepsilon_{t-4} + \varepsilon_t \qquad (1)$$
$$\quad (0.133) \qquad (0.094) \qquad (0.099) \qquad (0.042)$$

The motivation of this model is the following. The price in period T is best described by the prices of one, two and three years before (lags 13, 26 and 39). The sum of these so-called auto-regressive (AR) terms equals 0.964, i.e. less than 1, reflecting a declining trend in price. A so-called moving average MA(4) term was added to increase the rate of explanation (95%) and to make the model more stable. This term reflects the supply response of the growers. When prices are relatively high in period T, (new) growers are inclined to switch to chrysanthemums, which will lead to a rise in supply and a fall in price after a few periods. So this term reflects the well-known cyclical oscillation in production and price, found relevant for many agricultural products (Goodwin, 1994: 100:112).

Equation (1) has the property that it not only explains the fluctuations in the data for the estimation period, it also predicts fairly well. The mean absolute error is Dfl. 0.028 for the forecast period (period 6 till period 13 1994) and the maximum error is Dfl. 0.064 (period 7). The correlation (R^2) between model forecasts and realizations is 0.92. So the model is a point of reference at which the predictions of the growers can be compared. Now that Hypothesis 1 - non-random price patterns exist - turns out to be valid for variations over time, we switch to the other component: variations among cultivars.

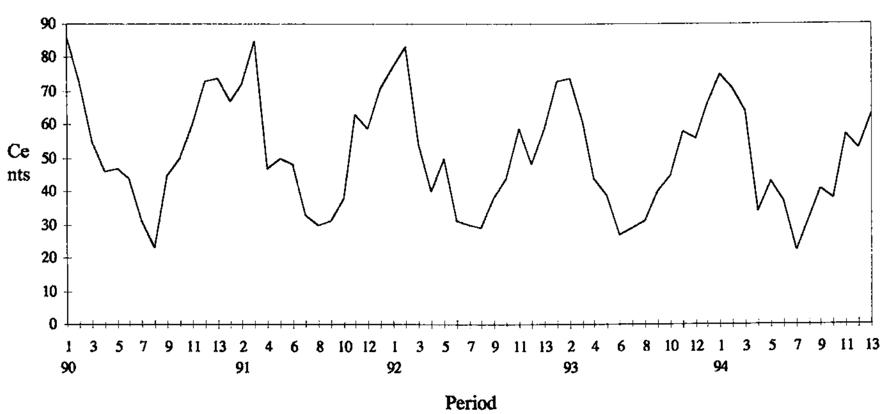


Figure 4.1 Average auction prices of chrysanthemums per four-week-period from 1990 till 1994

4.6 Price Variation among Cultivars

Apart from variations in time, selling prices also vary among cultivars, within the same period. Some cultivars are likely to generate higher prices because they take more resources (production time and space) per unit than others. Then, (part of) these price differences may be attributed to differences in production costs, e.g. caused by a longer production cycle. However, quite often production costs are similar and prices still differ substantially. This can be the case for color mutants of one cultivar. An illustration is given in Table 4.1. Five color mutants of the cultivar *Reagan*, the main cultivar in the period 1992-1994, are compared. These mutants are equal with respect to growing conditions and thus have the same cost of production. The selling prices, however, can be different because of consumers' and traders' preferences for colors in a certain period and because of differences in supply. Prices in Table 4.1 are represented as deviations (%) from the average price of all chrysanthemums.

The average prices of *Reagan Orange* and *Reagan Salmon* lie somewhat (6.3% and 3.0% respectively) above overall chrysanthemum average price. Choosing these mutants would have been the best policy in retrospect. However, in some periods these mutants yielded very poor results, up to 30% below the average chrysanthemum price, whereas other *Reagan* mutants had fine results in the same period (e.g. periods 1992-6 and 1992-7). Another thing that becomes apparent from Table 4.1 is that positive and negative deviations seem to be clustered in time, i.e. a negative price deviation in period T is likely to be followed by a negative deviation in the next period (T+1). A statistical test shows that this clustering is indeed non-random.[2]

Now that non-random price patterns have been proven to exist over time and among cultivar mutants (Hypothesis 1), the question arises: is it possible to make use of these price patterns for practical decisions on the firm (Hypothesis 2). From Table 4.1, one can calculate that a theoretically perfect strategy of persistently choosing the highest-priced *Reagan* color mutant, out of the five listed, would have led to an average price that lies 13.8% above the overall chrysanthemum price.

[2] A non-parametric test, the Wald-Wolfowitz runs test (see e.g. Bain and Engelhardt, 1987: 454:456) was applied to the data of Table 1. A run is defined as a series of either positive (including zero) or negative values. In case of randomness in time, one expects a certain number of runs, given the total amount of negative (A) and non-negative values (B). If the number of runs is either too small (not many alternating signs) or too large (many alternating signs) the hypothesis of randomness will be rejected. For example, for *Reagan White* the real number of runs (10) is far less than the expected number of runs (20.4) and the hypothesis of randomness can be rejected at a very small probability of mistake (p=0.0007). Randomness was also rejected for the other *Reagan* colors.

Table 4.1 *Auction prices of five mutants of the Reagan cultivar, during 1992-1994, per four-week-period, in deviations (%) from the overall chrysanthemum price.*

	Colour mutant of cultivar *Reagan*				
Period	White	Yellow	Salmon	Orange	Sulphur
1992-1	14.29	10.39	19.48	27.27	-5.19
1992-2	22.89	13.25	27.71	20.48	-3.61
1992-3	12.96	25.93	12.96	16.67	3.70
1992-4	-10.00	0.00	-10.00	-15.00	2.50
1992-5	12.00	-4.00	-24.00	-26.00	-4.00
1992-6	19.35	0.00	-29.03	-32.26	12.90
1992-7	20.00	0.00	-26.67	-30.00	10.00
1992-8	10.34	3.45	-6.90	-10.34	17.24
1992-9	-5.26	0.00	-7.89	-7.89	2.63
1992-10	-11.36	-6.82	-4.55	6.82	4.55
1992-11	-8.47	0.00	1.69	13.56	3.39
1992-12	-12.50	-2.08	14.58	22.92	0.00
1992-13	-6.78	-5.08	22.03	23.73	0.00
1993-1	2.74	-1.37	21.92	21.92	2.74
1993-2	10.81	2.70	22.97	17.57	8.11
1993-3	9.84	-1.64	14.75	16.39	3.28
1993-4	9.09	-4.55	0.00	11.36	-2.27
1993-5	12.82	-17.95	-5.13	-5.13	-17.95
1993-6	0.00	-25.93	3.70	14.81	-18.52
1993-7	-3.45	-6.90	10.34	13.79	-6.90
1993-8	-19.35	9.68	12.90	19.35	3.23
1993-9	-10.00	5.00	0.00	7.50	-2.50
1993-10	-8.89	6.67	-6.67	2.22	2.22
1993-11	0.00	12.07	3.45	8.62	12.07
1993-12	5.36	10.71	0.00	3.57	12.50
1993-13	7.58	6.06	-4.55	-9.09	9.09
1994-1	-6.67	9.33	17.33	12.00	6.67
1994-2	-11.27	7.04	21.13	19.72	12.68
1994-3	-15.63	10.94	9.38	20.31	10.94
1994-4	-20.59	2.94	2.94	5.88	5.88
1994-5	-4.65	-18.60	0.00	4.65	-13.95
1994-6	0.00	-24.32	-5.41	0.00	-24.32
1994-7	0.00	-27.27	-4.55	0.00	-22.73
1994-8	-3.13	-9.38	0.00	-6.25	-15.63
1994-9	-9.76	2.44	-9.76	-4.88	-4.88
1994-10	-15.79	0.00	-5.26	13.16	-5.26
1994-11	-7.02	8.77	-1.75	14.04	5.26
1994-12	-11.32	1.89	3.77	7.55	7.55
1994-13	-15.87	-14.29	26.98	25.40	-12.70
Average	-1.22	-0.54	3.02	6.27	-0.03
St.dev.	11.65	11.37	13.95	15.05	10.38

By contrast, constantly choosing the wrong color mutant (out of these five) would have yielded a price that lies 12.4% below the overall chrysanthemum price. When restricted to only *Reagan White* or *Reagan Yellow*, the two largest cultivars in terms of production, one gets the following picture. In 18 out of the 39 four-week-periods *Reagan White* was priced higher than *Reagan Yellow* and in 21 periods *Reagan Yellow* got better prices. Constantly choosing the right color, either *Reagan White* or *Reagan Yellow*, in each period would give a considerable price difference of 13.3% compared to constantly choosing the wrong one. These figures give an idea of how much is at stake concerning the cultivar choice. Price differences are likely to be higher when in addition other (*non-Reagan*) cultivars are taken into account.

4.7 Heuristic Choice Strategies

The previous strategies assume perfect foresight of price movements, an assumption that is not realistic but gives insight into the financial window for improvement. In addition, we compare three more realistic, heuristic choice strategies. A basic strategy (A) would be to plant a fixed amount of several cultivars (or color mutants) in each period, so to keep a fixed and equal *portfolio* and to minimize price-risks. Another strategy (B) would be to react on recent prices and plant in period T the cultivar that had the highest price in period T-1. This kind of behavior, when followed by many growers, would lead to huge cyclical swings. A somewhat more sophisticated cyclical strategy (C) would be to plant in period T the cultivar that had the highest positive price *change* from period T-2 to period T-1. These three strategies were applied to the data of Table 4.1. We assume that planting in periods 2 till 8 leads to production after three periods (12 weeks) and planting in periods 9 till 1 leads to production after four periods (16 weeks). Table 4.2 compares the average results for all three strategies (applied to the price data of Table 4.1).
In strategy B *Reagan Orange* is the main color, whereas in strategy C it has the smallest share. *Reagan White* and *Reagan Yellow* play an important role in strategy C but not in strategy B. Notwithstanding these differences in production shares, both strategy B and C give an average price that lies a little above the overall chrysanthemum price, whereas the price resulting from strategy A lies a little below it. The absolute difference in price between B (or C) and A is about 1 cent (≈2%* Dfl. 0.50) per branch. This means for an average firm (about 10.000 m^2 and 200 branches per m^2 per year) an advantage of about Dfl. 20.000 (10.000 US $) per year in comparison to the basic strategy.

Whether strategy B and C can be pursued by a grower in reality depends upon the facilities given by the breeding company he is ordering his cuttings from. If the breeding company allows for last-minute orders and has the necessary supply, they are possible to pursue. But, the price difference is rather small and should be tested on a broader scale to gain credibility. So far, some support is obtained for Hypothesis 2.

Table 4.2 *Comparison of three heuristic planting strategies: A: equal shares, B: according to highest price in previous period, C: according to highest price movement in previous period.*
(Prices based on period 1992-1994 for five Reagan color mutants).

	Production shares of Reagan mutant					Price deviation from average	
Strategy	White	Yellow	Salmon	Orange	Sulphur	(n=34)	(n=33)
A	20.0%	20.0%	20.0%	20.0%	20.0%	-1.45%	-1.22%
B	14.7%	7.4%	16.2%	44.1%	17.6%	+0.98%	
C	39.4%	18.2%	15.2%	12.1%	15.2%		+0.59%

4.8 Growers' Price Predicting Ability

Predicting prices is an essential activity for farmers and growers with respect to their planning process (Boehlje and Eidman, 1984: 17). If making price predictions is a skill, the better predictors must somehow have better knowledge or better understand the market and may use this knowledge or understanding to make more profitable decisions, e.g. concerning the choice of cultivars (and mutants) and concerning steering the supply towards more profitable periods. The question to be answered (see also Hypothesis 3) is: do some growers persistently predict prices better than others? To answer this question a survey was administered to 26 growers and repeatability in predicting performance was tested, as well as the other hypotheses (H4 and H5) concerning price predicting ability.

Table 4.3 shows that, except for period 7, the growers, on average, gave accurate predictions.[3] These average group predictions are better the more they are related to the growers' own situation (main cultivar, own supply; Hypothesis 4a). Also, in general the quality of the predictions improved when additional price information, prices of corresponding periods over the years 1990 until 1993, was supplied (Hypothesis 5a). Then, the average group predictions moved into the right direction and the prediction errors decreased for all three periods; see Table 4.3 (sit. 4a versus 3a). However, for the whole year the price prediction got worse after giving additional price information, due to two growers who changed their predictions to an extreme level into the wrong direction, for some unknown reason.

Table 4.3 *Price realizations (guilder-cents), predictions (guilder-cents) and relative prediction errors (%) for chrysanthemums in 1994; group averages*

	Period 7 1994	Period 9 1994	Period 11 1994	whole year 1994
(1) Price realization main cultivar, own supply	25.1	40.7	56.9	na
(1a) prediction	33.8	40.7	54.9	na
prediction error	*+34.7%*	*0.0%*	*-3.5%*	*na*
(2) Price realization main cultivar, total supply	23.1	40.7	56.4	na
(2a) prediction	31.8	38.6	53.2	na
prediction error	*+37.7%*	*-5.2%*	*-5.8%*	*na*
(3) Price realization chrysanth., total supply	22.0	41.0	57.0	46.1
(3a) prediction	31.1	38.5	52.8	46.4
prediction error	*+41.4%*	*-6.1%*	*-7.4%*	*+0.6%*
(4a) prediction with add. price inform.	30.9	39.3	56.7	47.2
prediction error	*+40.6%*	*-4.1%*	*-0.5%*	*+2.4%*
(4b) prediction, model 1	28.4	34.7	57.6	46.3
prediction error	*+29.1%*	*-15.4%*	*+1.1%*	*+0.4%*

na = not available

As a group the growers may have given fairly accurate predictions, but what about *individual* predicting skills? The absolute prediction error was used to assess the quality of the price predictions of individual growers (see Table 4.4). The range from minimum error to maximum error was usually large, which means that some growers predicted the price fairly well, while others made a poor prediction. As an illustration, in task 1 the prediction errors ranged from 3.4% to 87.5%, with an average of 46.3%. For period 9 the errors ranged from 2.2% to 50.0%, with an average of 12.7%. And the average error for period 11 was 12.9%, with a minimum of 0.0% and a maximum of 38.9%. The relative number of 'hits' (cases where the realized price lay within the given '95%-certainty-interval') was 24% (period 7), 61.5% (period 9) and 56.0% (period 11), significantly lower than 95%. Apparently, many growers found it difficult to deal with variation and had a tendency to overestimate their predictive quality. Similar results of overconfidence in prediction and

[3] In period 7 the weather in the relevant export countries was extremely hot, which had a negative influence on the consumer's tendency to buy flowers and therefore caused low prices. These were also considerably lower than the forecast from the (Box-Jenkins) model, which was 29.1% too high.

underestimation of variance were found by Eales et al. (1990) for other agricultural producers. A general review on this aspect of overconfidence of decision makers can be found in Lichtenstein et al. (1982), who defines a so-called surprise index (which is equal to 5% in case of a 95%-certainty-interval). Surprise indices as high as 30% to 50% are usually found, where they should be 5% or even 3%.

Table 4.4 Absolute price prediction errors for the year 1994 based on 26 individual predictions by growers

	Period 7 1994	Period 9 1994	Period 11 1994	whole year 1994
(1) main cultivar, own supply				
(1a) average error	46.3%	12.7%	12.9%	na
(1b) range min - max error	3.4 - 87.5%	2.2 - 50.0%	0.0 - 38.9%	na
(1c) hits in almost-certain-interval[a)]	24.0%	61.5%	56.0%	na
(2) main cultivar, total supply				
(2a) average error	44.8%	10.5%	13.7%	na
(2b) range min - max error	5.4 - 90.9%	0.0 - 40.0%	2.4 - 34.0%	na
(2c) hits in almost-certain-interval[a)]	23.7%	69.2%	69.2%	na
(3) total chrysanthemums				
(3a) average error	41.4%	9.9%	14.0%	3.4%
(3b) range min - max error	22.7- 81.8%	0.0 - 26.8%	1.8 - 36.8%	0.2 - 13.5%
(3c) hits in almost-certain-interval[a)]	19.2%	57.7%	38.5%	73.1%
(4) total chrys; with add. price inform.				
(4a) average error	40.2%	6.3%	4.5%	3.6%
(4b) range min - max error	22.7- 81.8%	0.0 - 26.8%	0.0 - 14.0%	0.2 - 19.3%
(4c) hits in almost-certain-interval[a)]	7.7%	73.1%	76.9%	73.1%

[a)] 'hit' if 95%-certainty-interval given by the grower contained realized price
na = not available

If price predicting is a skill, then we would expect the same growers to be the better predictors in each period and the prediction errors between the periods should be positively correlated. This turned out to be occasionally so: positive correlation (significant at a level of 0.05) was found in 5 out of 18 cases (task 2: periods 9 and 11; task 3: period 7 and whole year; task 4: periods 7 and 11, period 7 and whole year, period 11 and whole year). In the other 13 cases no significant correlation was found. So, the evidence of predicting absolute prices being a skill rather than a matter of coincidence (Hypothesis 3a) is not strongly supported.[4]

Contrary to the group level results (Table 4.3), it no longer holds that predictions are better the more they relate to the own situation (main cultivar, own supply; Hypothesis 4b). However, in general, the beneficial effect of additional price information on prediction quality (Hypothesis 5b) still holds, with the same exception as reported for the group level.

4.9 Predicting Market and Quality Position

The prices given in the survey can be used also as relative price predictions of (1) the *market position* of the cultivar grown (relative to other cultivars) and (2) the *quality position* of the firm (relative to other firms, producing the same cultivar). Task 1 in combination with task 2 gives the expected quality position of the firm. The expected market position of cultivar M can be derived from task 2 in combination with task 3. In general the growers were optimistic both about their quality and market position. The expected price advantage in comparison to peers, i.e. the quality position, was +6.3% (period 7), +5.4% (period 9) and +3.2% (period 11), with +5.0% on average (derived from Table 4.3). Since the realized price advantage was +3.2% on average (+8.7%, 0.0% and +0.9% in periods 7, 9 and 11 respectively) their optimism was justified, although to a smaller extent. The growers were also optimistic about the performance of their main cultivar among all chrysanthemum varieties: they predicted a market position advantage of +2.3% (period 7), +0.3% (period 9) and +0.8% (period 11). This optimism with respect to their market position was justified for period 7 (+5.0%), but not for period 9 (-0.7%) and period 11 (-1.1%).

The question whether some growers were persistently better in assessing their quality and market position than others was also investigated (Hypothesis H3b). As before, correlation between prediction errors in different periods was taken as a measure. Prediction errors were calculated as absolute percentage deviations between predicted and actual values. As an illustration, grower C's expected quality position for period 7 was +1.07 (45/42), whereas his actual quality position turned out to be +1.23 (27/22) and so his prediction error for this period was $|-13\%|$. The prediction errors were calculated for all 26 participants and all three periods. It turned out that there was a significant positive correlation between the prediction errors of periods 9 and 11 (correlation+0.49, significant

[4] The use of rank correlations does not change this conclusion.

at p=0.01) and no significant correlations between periods 7 and 9 as well as periods 7 and 11. So there is only little evidence that growers who estimate the quality position of their firm accurately for one period will do so for another period. With respect to the market position, the evidence is more clear: prediction errors were correlated between all periods: +0.50 (periods 7 and 9; significant at p=0.01), +0.39 (periods 7 and 11; significant at p=0.05) and +0.65 (periods 9 and 11; significant at p=0.00). So there is much evidence that growers who estimate the market position of their main cultivar accurately for one period will do so for other periods as well. So it seems that predicting *relative* market positions is indeed a skill (Hypothesis H3b).

4.10 Conclusions and discussion

This paper addressed the question if price predicting by flower producers can be considered a skill or must be considered merely a lottery. For the purpose of answering this question a survey was held with 26 specialized chrysanthemum growers, who predicted prices for several periods in the year 1994. At first, actual prices were analyzed and statistically tested for non-randomness. It turned out that price variations over time and price variations among cultivars follow, indeed, non-random patterns.

Little evidence, however, was found that predicting absolute price levels is a skill rather than just coincidence. Growers who predicted well for one period did not necessarily do so for other periods. Only occasionally positive significant correlations were found between prediction errors of different periods. Growers were more consistent in predicting *relative* price positions. We introduced two relative indicators: (1) market position (of the cultivar grown, relative to other cultivars) and (2) quality position (of the firm, relative to other firms producing the same cultivar). It turned out that estimating the relative market position can be considered a skill, i.e. some growers predicted these positions persistently better than others. With respect to the relative quality position the evidence is less clear.

The question addressed in this paper is related to question of whether or not price expectations by agricultural producers are *rational*, i.e. in accordance with the outcome of the best supply and demand model. Irwin and Thraen (1994) give a review of the rational-expectations hypothesis in agriculture and conclude that there is no consensus regarding verification or falsification of it. The rational-expectations model assumes perfect knowledge on the part of producers. It leaves no room for learning the 'true' parameters of the model and it ignores the fact that gathering and analyzing information involve a cost as well (Brorsen and Irwin, 1996). So the concept of bounded rationality as developed by Simon (1977) seems to be more appropriate.

The importance of price predictions as part of a market outlook, depends on instruments for the grower to anticipate market trends and fluctuations. The main instrument to anticipate trends and fluctuations in expected supplies, demands and prices is the production policy. This includes *product choice*, *product differentiation* as well as the *production planning*. The importance of price predictions also depends on their level of reliability. *Product choice*, could benefit a lot from reliable price predictions, however these predictions are necessarily based on subjective, uncertain grounds and therefore their level of reliability is low. Nevertheless, heuristic rules for product choice based on recent price movements can lead to (small) increases in average selling price, as shown by the calculations in this paper with respect to different chrysanthemum cultivars. So, it seems possible to benefit from the non-random structure of price variation among products.

With respect to *product differentiation* as an instrument to anticipate consumer wishes and to react upon expected price fluctuations, one should keep in mind that this is only relevant for products that are perceived by the buyers as heterogeneous. Flowers, like chrysanthemums, roses, tulips, etcetera, with different colors and (other) quality aspects are examples of such products. The majority of agricultural production, however, is rather homogeneous and price competition on farm level hardly exists. In order to be competitive, minimizing production costs and maximizing output are more adequate instruments to these producers of e.g. milk, beef, wheat and potatoes. However, possibilities for product differentiation seem to increase as a result of increasing consumer awareness of production environment, leading to eco-labels and labeled local products. In this situation, the market form moves towards monopolistic competition and product and price variation among farmers becomes more important.

The effectiveness of *production planning* (of planting, harvesting, storing, selling) as a tool to benefit from non-random seasonal price patterns, is limited by the amount in which the specific biological and chemical growth and aging processes can be controlled. For instance, in this paper, the production cycle of chrysanthemums is rather fixed, i.e. once cuttings are planted the possibility for accelerating or delaying the growing, blooming and selling are limited to only a few days. This means that steering the production to more profitable periods can only be done at the cost of more vacancy in the greenhouse. Some fine-tuning, however, can be achieved by differences in plant density. For other agricultural products for which storing is an option, e.g. apples and potatoes, more price control is possible from this instrument.

Future work may look at ways in which growers can improve their price predictions, based on probability judgements. It can also be directed to include other (cost-related) factors in the decision-making with respect to product choice and product differentitaion. A multi-criteria decision-making model including price expectations and other cost-related factors which are less subject to variation, such as the growing time, harvest labor and plant density may be helpful in understanding and supporting the product choice.

References

Bain, L.J., and Engelhardt, M. (1987). *Introduction to probability and mathematical statistics.* Boston: PWS Publishers/Duxbury Press.

Boehlje, M.D., and Eidman, V.R. (1984). *Farm Management.* New York: Wiley.

Box, G.E.P., and Jenkins, G.M. (1970). *Time series analysis: forecasting and control.* San Francisco: Holden-Day.

Brorsen, B.W., and Irwin, S.H. (1996). Improving the relevance of research on price forecasting and marketing strategies. *Agricultural and Resource Economics Review* 25 (1):68-75.

Eales, J.S., Engel, B.K. Hauser, R.J. and Thompson, S.R. (1990). Grain price expectations of Illinois farmers and grain merchandisers. *American Journal of Agricultural Economics* 72, 701-708.

Goodwin, J.W. (1994). *Agricultural price analysis and forecasting.* New York: John Wiley & Sons.

Irwin, S.H., and Thraen, C.S. (1994). Rational expectations in agriculture? A review of the issues and the evidence. *Review of Agricultural Economics* 16, (1):133-158.

Lichtenstein, Fischhoff, S., B. and Phillips, L.D. (1982). Calibration of probabilities: The state of the art to 1980. In: Kahneman, D. Slovic, P. and Tversky, A. (eds.) *Judgment under uncertainty: Heuristics and biases.*, 306-334. Cambridge: University Press.

Pindyck, R.S., and Rubinfield, D.L. (1991). *Econometric models and economic forecasts.* New York: McGraw-Hill. (3rd ed.)

Simon, H.A. (1977). *The new science of management decision.* Englewood Cliffs NJ: Prentice-Hall. (Revised ed.)

5 Evaluating Farmers' Choice Processes In The Laboratory; Workshops With Flower Producers[1]

Abstract

This paper describes the result of a research workshop on cultivar choice in which 26 specialized flower producers participated. Choosing cultivars is a multi-attribute decision. Each cultivar comprises a set of unique biological and economic characteristics (attributes) and the choice problem is to select a package of attributes, that gives the highest level of satisfaction. The workshop consisted of several tasks aimed at measuring the individual quality level of the decision process. The technique of the information display matrix (IDM) was introduced as a means to simulate the choice processes. The IDM consists of alternatives (rows) and attributes (columns) and by opening information cells the decision maker can observe the specific information. The results of this study indicated that the performance in the IDM-simulation had some predictive power for the performance in real life, especially on turnover and yield. Further analysis of the tasks in this workshop could be used to detect weak spots in the individual decision making. The differences among growers with respect to their level of consciousness/awareness, (economic) rationality and consistency were substantial.

5.1 Introduction

Production decisions and investment behavior of farmers are studied often at an aggregate level, or through the assumption of representative firms, where the underlying individual decision making processes are kept in a black box. This approach, yielding average supply responses, average income effects, etc., is usually adequate for developing and evaluating agricultural policy (see, e.g., Parry, 1999). However, from a farm management point of view, a look within the black box of individual decision making and choice may be very worthwhile. The purpose of explicitly analyzing and modeling individual farmers' choice

[1] Paper by Ger Trip, Jan A. Renkema and Ruud B.M. Huirne; submitted to *Review of Agricultural Economics*

processes is to increase the understanding of (the variety in) the behavior, which can be used for individual management support. Also, it can be used to develop decision support tools.

The focus of this paper is on the decision-making process of flower producers choosing among a set of alternative varieties (cultivars). This is an important decision because of its financial consequences. Also, it is a decision that should be reconsidered regularly since new varieties appear that are more efficient in production and/or better meet the consumers' preferences. This makes cultivar choice an important management instrument to safeguard continuity and income.

Choosing cultivars by flower producers is a multi-attribute decision. Each cultivar comprises a set of unique biological and economic characteristics (attributes) and the choice problem is to select a package of attributes, that gives the highest level of satisfaction to the grower, e.g. measured as subjective expected utility.

The research aim of this paper is to determine the variation among growers in individual quality level of decision making. We will apply concepts from literature on the principles of decision analysis. Three general aspects of the quality of decision making emerge from the literature (e.g. Simon, 1978): level of consciousness/awareness, level of (economic) rationality and level of consistency. To determine these levels, several tasks have been developed and presented to a group of 26 growers in an off-farm workshop. The main part of the workshop consisted of a cultivar choice simulation game, played by means of a computerized information display matrix (IDM). This is a technique for studying decision making that has been applied in consumer research and research on organizational behavior (see, e.g. Hogarth, 1987). This paper introduces the technique for farmers' decision making. We will discuss the technique, its (dis)advantages and show its possible benefit to agricultural economists. First, a brief overview of off-farm experiments for studying farmers' choices will be given as a context.

5.2 Off-farm experiments

Off-farm experiments for studying decision making of farmers are a powerful tool, but scarce as well (Rougoor et al., 1998). Occasionally researches are reported in which workshops with farmers are used for analyzing aspects of the decision making. An example of a workshop is the so-called Top Farmer Crop Workshop, with about 50 to 80 participating farms from the US North Central (cornbelt) region, annually held at Purdue University, since 1968. This commercial three day workshop provides an update of recent theory (e.g. on crop economics and production technology) and practical implementation (e.g. analyzing one's own farm with a linear-programming model), thus creating value to the participants. Parallel to the main program of this workshop questionnaires are completed by the participants concerning aspects of their decision-making, e.g. on their use of (external) information (Ortmann et al., 1993) and their marketing strategies (Musser et al., 1996; Patrick et al., 1998). In these cases the convenience of having a number of farmers present at one place is the main advantage of the workshop structure, whereas otherwise the approach is no different from conventional on-farm interviews and questionnaires. Another example of a workshop with farmers where the focus is on education and research is a side product, is described by Harsh et al. (1996) for Michigan livestock farms. They conclude that a vast majority of the farmers do not prepare a strategic plan for their operation. A 50/50 mix of research and teaching is described by King et al. (1995) who use several concepts to analyze the information system (record keeping, information sources, etcetera) of 31 farms from different types of production.

Workshops with farmers in which their decision making constitute the main part of the program are described by Huirne et al. (1997), who work with dairy farmers in various regions (USA and The Netherlands) at different times, to detect their goals, critical success factors and information needs. They find consistency over time if the farmers are analyzed as a group, however, when analyzed individually, significant differences in goals and critical success factors are found. Since these workshops are primarily set up for research purposes, the benefits to farmers are more indirect, lying in the area of increasing awareness of their management goals and practices. Typically these workshops last for half a day or an evening.

The condition of creating added value to the participating farmers is also described by Cross (1993). He reports the use of a farm management game within the framework of a two-day extension workshop and concludes that the participants get value from analyzing their management alternatives and getting almost immediate feedback on their decisions. The question whether games are suitable for research purposes, however, is still in discussion. The basic premise is that the results of the game carry over from the laboratory environment to the more complex natural environment. Baker (1983) uses a business game in a workshop with fifty grain elevators and concludes that the goals and the ranking of goals in the game appear to be related to the importance of real-life goals. However, no relation has been found between performance in the game and performance in real life. Verstegen et al. (1998) use tools from the research field of experimental economics to analyze the sow replacement strategy of 86 pig farmers. The characteristics of the sow replacement problem are conveyed into an investment project selection problem. The choice of an abstract analogue to the original problem is motivated by the fact that when natural problems are used, subjects can have beliefs, derived form their experiences, that affect their decisions but are unknown to the researchers. Also, in order to keep participants motivated and to simulate real life consequences, an economic incentive is used; subjects get paid according to the effectiveness of their decisions. Verstegen et al. find the experiment a useful tool in estimating the (positive) impact of a management information system (MIS) on the decision making. However, the connection between experiment and real life is questioned by them since the participants in general replaced projects too early, whereas in real life most farmers tend to replace sows too late. Furthermore, on an individual farmer level, the MIS-effects in the experiment are not correlated to the MIS-effects estimated in a supplementary survey.

5.3 The IDM as a research tool

Another technique for simulating decision-making processes is the so-called information display matrix (IDM) or information board (Hogarth, 1987: 78), representing combinations of alternatives (e.g. cars) and attributes (e.g. price, speed, energy use, etc.). Each cell of the matrix contains the information of an alternative-attribute combination. When designed for computer use, it is called a computerized or electronic IDM. When the subject, whose decision making is being studied, first sees the matrix, it is blank. That is, he or she knows that there are a given number of alternatives (rows, labeled for instance car A, car B, car C, car D, etc.) and a number of attributes (columns, labeled e.g. price, speed, energy, etc.). The subject can ask for information concerning any of the cells in the matrix. When this information is requested (e.g. by mouse clicking), it is shown in the appropriate place in the matrix.

IDM's have been used as a tool for research since 1975. Early use of it has been made in consumer choice theory (Jacoby, 1975; Jacoby et al. 1976; Bettman and Jacoby, 1976, Jacoby, 1977 and Payne, 1976ab). The focus has been on monitoring and analyzing the information search strategy of consumers when evaluating and choosing certain alternative products (brands). The IDM has proven to be a powerful technique in analyzing various aspects of human decision making. Choice strategies, information search strategies, use of heuristic choice rules can be analyzed (Hogarth, 1987: 78-82). The effects of bounded rationality in Simon's sense can be further extended in the IDM. E.g., the effects of a limited memory capacity can be analyzed by erasing the information once it has been displayed and time pressure can be simulated by restricting the available time for making a choice.

Despite its power, the technique has met criticism as well. A critical evaluation of the IDM as a tool to analyze information search behavior is given by Bettman (1979: 197). He signals a possible bias that may arise because (1) information seeking is so obviously under observation, (2) participants may bring prior knowledge to the experiment, especially when actual brand names are used, (3) only the external response is studied, not the internal, mental processes, e.g. is the participant looking for new information or to confirm a choice already made, (4) in reality information may be found accidentally, while looking for something else, and finally (5) the matrix structure makes it equally easy to process information by alternative or by attribute, whereas in reality information is often organized by alternative (brand) only, hindering attribute processing. These limitations should be carefully addressed when using this technique.

The IDM has been used continuously through the next decades after its introduction, mainly in consumer research, cognitive psychological research and (organizational) decision theory. Recent examples from different areas are Sonnemans (1998) who studies the strategies people use in search behavior and found that on average subjects stop searching for information too early, Bailey (1997) who relates the thoroughness of the information search to the level of motivation of subjects, Lin and Su (1998) who find an improved level of decision accuracy after subjects have been trained using an expert system in the decision domain.

5.4 Workshops on cultivar choice

5.4.1 Participants

A workshop on production planning, including cultivar choice, was held in November 1993. The workshop took place during one afternoon and evening, from 4 pm to 10 pm. The participants represented 26 fully specialized chrysanthemum firms, producing flowers throughout the year in heated greenhouses.[2] All these firms were located in the areas "Westland" and "De Kring", two major greenhouse regions in the Western part of The Netherlands, near the cities of The Hague and Rotterdam. These participating firms were randomly drawn from a member list of the Dutch Federation of Horticultural Study Groups

[2] The length of the production cycle of chrysanthemums is less three months. Furthermore, the greenhouse of a chrysanthemum grower is usually divided into several sections with plants in different stadiums of maturity. These circumstances make production planning and cultivar choice for these growers highly important issues.

(LTO/NTS Glasshouse Cultures) of which almost all Dutch chrysanthemum growers are a member. Participants agreed to a subsequent research year that consisted of (individual) bimonthly on-firm surveys. A year in which also their firm production data were collected.

5.4.2 Program

During the workshop, eight worksheets and tasks on production planning and cultivar choice were completed by the growers. Three worksheets/tasks of the program were directly aimed at getting insight into the decision making process with respect to cultivar choice. The main part of the program consisted of a simulation of the cultivar choice through means of the computerized information display matrix (IDM).

Task 1 (awareness)
In the first part the awareness of relevant attributes was measured. Growers were asked to individually make a list of all factors that came to their minds when judging and comparing alternative cultivars. The task was framed as: "Advise grower Chris who is looking for a new cultivar for production, which will be either cultivar P or Q. Chris wants to maximize financial results. Advice Chris by mentioning as many factors as possible that are relevant in comparing cultivar P with Q." One factor was given to help them getting started: 'response time' as measure for the length of production (more specifically the duration of the *short day period* for generative growth). About ten minutes were spent on this task.

Task 2 (IDM)
The second part consisted of the IDM. It was programmed and played on laptop computers. Every row in the matrix represented one alternative (cultivar) and every column represented one attribute. So each cell of the IDM contained the, initially hidden, information of one alternative with respect to one attribute. Participants could ask for the information by clicking on that particular cell. The size of the information board was 15 (alternatives) * 11 (attributes), i.e. 165 information cells. The alternatives were fictitious, non-existing cultivars, labeled by European city names. However, these fictitious cultivars were constructed in a realistic vein, i.e. having reasonable attribute values. The attributes were derived from a goal hierarchy that translated the general goal of a profit maximizing cultivar choice into more specific goals (Winterfeldt and Edwards, 1986). It was constructed as a result of depth interviews with leading sector experts, from the fields of extension and farm-advice; see Figure 5.1. The goal hierarchy met the criteria of being complete, decomposed

as far as possible and not being redundant (Clemen, 1991). Eleven attributes were taken from this goal hierarchy and used in the IDM.[3]

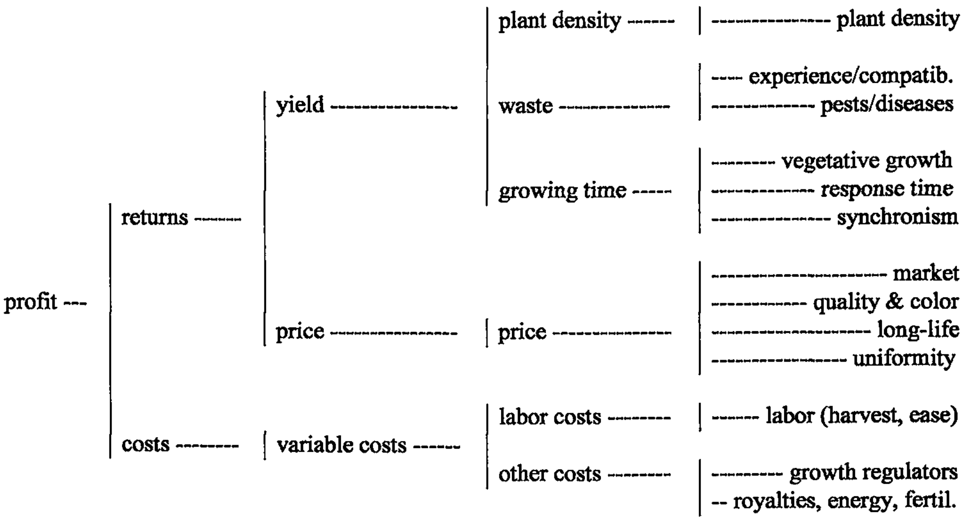


Figure 5.1 Goal hierarchy for a profit maximizing cultivar choice in chrysanthemum production

The individual task of each grower in the IDM was to open information cells up to a maximum of 83, i.e. fifty percent of the total information, and then to make a choice by allocating 10.000 m^2 of glasshouse area to the available alternatives. Also a short motivation was asked. Participants were given 90 minutes to complete this task, which turned out to be enough for everyone, so no time pressure was present. A sheet containing explanation of the attributes, including the ranges in performance, was given as a handout for easy reference, together with a sheet that contained the 15*11 matrix structure of alternatives and attributes, which could be used for making notes and calculations. The task was extensively introduced to make sure that all participants understood the IDM-exercise, including the use of the laptop computer.

[3] From the 13 sub-attributes at the right hand side of the goal hierarchy (Figure 1), synchronism and uniformity were taken together (labeled as uniformity) and vegetative growth was not included. The remaining11 attributes were used in the IDM. They are also represented in Table 1 as the first 11 rows.

Task 3 (attribute weights)
In the third part, participants were asked to rate the importance of a set of pre-listed cultivar attributes, similar to the ones used in the IDM. The task was to allocate approximately 100 points, in such a way that the relative amount of points given to each attribute reflected its importance, a so-called percent distribution approach (Watson and Buede, 1987:200). For ease of comparison, these allocations were re-scaled in such a way that the sum for each subject was equal to 1. About ten minutes were spent on this task.

Task 4 (ratings attribute levels)
During a follow-up visit on the firms, participants were asked to rate the various levels of attribute performance on a scale from 1 to 100. As an example, the various levels for the attribute "long life" used in the IDM were 10, 20 or 30 days. Subjective ratings for these levels could be e.g. 50, 70, 90 for a linear marginal utility of extra days (grower 5) or 40, 70 and 80 for a diminishing marginal utility (grower 6) or even 60, 80, 70 to represent a diminishing absolute utility (grower 4).

5.4.3 Measuring quality of decision making

The purpose of these tasks is to analyze the quality level of decision making. In the literature three general dimensions of quality emerge. First, *awareness* of goals, opportunities and problems are a prerequisite for (rational) decision-making. Simon (1978:9) introduced the term circle of awareness for problem relevant considerations that are within the knowledge of the decision maker. This circle can be influenced through time by learning. We designed task 1 to measure the current state of awareness with respect to the cultivar choice problem at hand.

A second key notion in literature on decision making is the concept of *rationality*. Human beings are known to be imperfect decision makers, showing a bounded rationality. However, as Tisdell (1996:50-52) points out, the variety in possible behavior under the condition of bounded rationality is rich and worthwhile to analyze. With respect to the decision process and final choice, perfect economic rationality becomes manifest in an efficient search for information followed by an optimal choice.

Rationality in information selection could be investigated by the design of task 2. A rational decision maker would select the information of the IDM by attribute, starting with the most important attribute, followed by the second most important attribute, and so on. Selecting by attribute is known to generate more rational choice than selecting by alternative (Van Raaij, 1976). Furthermore, a rational decision maker would open a maximum number of information cells up to the limit, since the marginal cost of information is zero up till this maximum.

Rationality in choice was analyzed by combining tasks 2, 3 and 4. To see if the choices made by the participants reflected their rational optimum, we adopted the multi-attribute utility model. MAU-scores were calculated as the weighted averages, based on the decision maker's subjective weights (given to attributes) and ratings (given to levels of attribute performance). Use of these so-called weighted additive values as a standard for rational choice is common in literature (see, e.g. Payne, 1993). As an example, based on his subjective weights (task 3) and ratings (task 4), the three best cultivars for grower 12 would be Dublin, Berlin and Zurich. The calculated subjective MAU-scores for these cultivars were 76.2, 73.2 and 73.1. Yet, in the IDM game, grower 12 did not choose any of these cultivars. In stead, he allocated 5000 m^2 to London White (MAU-score 70.8) and 5000 m^2 to London Yellow (MAU-score 67.5), realizing an average MAU-score as high as 69.1. So his choice was sub-optimal: the maximum attainable MAU-score was higher than the realized MAU-score, indicated as *subjective loss*. For grower 12, this loss was 7.1 (weighted additive value points).

A third general aspect of quality of decision making, closely connected to the concept of rationality, is the notion of *consistency*. Watson and Buede (1987:11-13) essentially define consistency as speaking and acting in a way that is consistent with earlier adopted rules, that reflect the values of the decision maker. Applied to the study at hand, we assume that the participants hold values on the importance of cultivar attributes. These values should be revealed in a consistent way in tasks 1, 2 and 3, i.e. an important attribute should not be forgotten in task 1, should have a large portion of information selected in task 2 and should have a high amount of points allocated in task 3.

5.5 Results

5.5.1 Level of awareness

In this paper the current state of awareness was measured by asking participants to mention as many factors relevant for the problem at hand (cultivar choice). The number of cultivar attributes being mentioned in task 1 by the growers varied between 5 and 11, with an average of 7.5; see Table 5.1.

Table 5.1 *List of cultivar attributes mentioned by growers in an open task*

GROWER / ATTRIBUTE[1]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Total
quality (color, flower, stem, leaves)	•	•	•	•	•	0	•	•	•	•	•	0	•	•	0	0	•	•	•	0	•	•	•	•	•	0	20
response time	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	26
experience/compatibility[2]	•	0	0	•	0	0	•	0	0	•	0	0	0	•	•	•	0	•	0	0	•	•	•	0	•	0	12
pests/diseases[3]	0	•	•	0	0	•	•	•	•	0	•	•	•	•	•	0	0	•	•	•	0	•	•	•	•	•	19
long-life[4]	0	•	0	0	0	•	0	•	0	0	0	•	•	0	0	0	•	•	•	•	•	•	0	0	•	0	12
labor (harvest, ease)	•	0	•	0	•	•	•	•	0	•	0	0	•	0	•	•	•	•	0	•	•	•	0	•	0	•	17
uniformity/synchronism[5]	0	•	•	•	•	•	0	0	0	•	0	•	•	0	•	•	0	•	•	•	•	•	0	0	0	•	16
growth regulators	0	0	•	0	0	•	0	•	0	•	•	0	0	•	•	•	0	0	•	•	0	•	0	•	•	0	13
plant density	0	0	•	•	•	0	0	0	•	0	0	0	0	0	0	•	•	0	•	0	•	0	0	0	0	•	9
royalties	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	•	0	0	0	0	0	0	0	•	0	0	2
market[6]	•	•	•	•	•	0	•	0	•	•	0	0	0	•	•	•	•	•	0	•	•	0	•	•	•	•	19
vegetative growth[7]	0	•	•	0	0	•	0	•	•	•	0	•	•	0	•	•	0	0	•	0	0	•	•	0	•	0	14
year round production/ time of year	0	0	0	•	0	0	0	0	0	0	•	0	0	•	•	•	0	0	0	0	0	0	0	•	•	0	7
energy/temperature	•	0	0	0	0	0	0	•	0	0	0	0	0	0	0	0	0	0	•	•	0	0	0	0	0	0	4
costs (general)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	•	0	•	0	0	0	0	0	0	0	0	2
fertilizer	0	0	0	0	0	•	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
pollen allergy	0	0	0	0	0	0	0	0	0	0	•	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL	6	7	9	7	6	8	6	8	6	8	6	5	7	7	9	11	6	9	9	8	8	9	6	8	9	6	194
in agreement with IDM (**)	5	6	8	6	6	6	6	6	5	7	4	4	6	6	7	8	6	8	7	7	8	8	5	7	7	6	

Notes:

[1] first eleven attributes (quality till market) are also in IDM, order of attributes similar as in IDM

[2] experience/compatibility includes any reference to the farm structure, existing practices and complementary cultivars

[3] pests/diseases includes any reference to one or more specific pests/diseases or to the susceptibility to pests/diseases in general

[4] long-life includes any reference to the quality in the other parts of the chain (breeder, post harvest treatments, selling, transport, retailer, consumer)

[5] uniformity/synchronism includes any reference to equal growth, synchronism in flowering and equal (high) weight

[6] market includes any reference to demand, supply, market, financial outlook and price

[7] vegetative growth includes any reference to the speed and vigor of the crop, especially the start and the vegetative period

Double factors were excluded, e.g. several references to pestsor diseases were counted as one factor.[1] The overall level of awareness with respect to cultivar choice was fairly high. Response time, quality, market, pests/diseases, labor, uniformity, vegetative growth and the need for growth regulators were mentioned by at least fifty percent of all participants. Other factors that were mentioned quite often were compatibility/experience, long-life, plant density and the possibility to produce the cultivar throughout the year. Rarely mentioned were energy, royalties, general costs, fertilizer and pollen. All these factors are found relevant for the problem at hand - and thus represented in Figure 1 - except for year round production/time of year, an element that was not part of the problem formulation, and pollen allergy, which was seen as a special factor that is only relevant for a minority of producers.

5.5.2 Level of economic rationality

A rational information search strategy was clearly demonstrated by grower 10. The order in which he opened the information cells of the IDM is given in Figure 5.2a. He used a refinement of the search by attribute by eliminating alternatives during the selection process. After having noticed the response time (RTI) and the need for labor (LAB) for every alternative, he eliminated one cultivar (Amsterdam), and after the next attribute (long-life; LLF) he eliminated three more alternatives, and so on, until the maximum amount of cells was opened. Reordering rows (highly observed alternatives to the top) and columns (highly observed attributes to the left), yields a regular pattern (Figure 5.2b). The information search process of this grower 10 was dominated by vertical, intra-dimensional cell transitions, also known as type 3 transitions (Payne, 1976b). With respect to their search strategies, the participants were classified into one of three head categories: alternative-based searching, attribute-based searching and mixed searching. A participant fell into the first category if the amount of type 2 (horizontal) transitions was larger than the amount of type 3 transitions by at least 10 percentage points. Likewise, classification into the second category followed when the amount of type 3 transitions was larger than the amount of type 2 transitions by at least 10 percentage points. Otherwise, a participant fell into the mixed category.

---

[1] Before correcting for double factors the total amount of factors mentioned varied between 6 and 17, with an average of 9.5.

CULTIVARS	ATTRIBUTES										
	QUA	RTI	EXP	PES	LLF	LAB	UNI	GRO	PDN	ROY	MKT
AMSTERDAM	▮▮▮	1	▮▮▮	▮▮▮	▮▮▮	16	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
ATHENS WHITE	45	2	▮▮▮	▮▮▮	31	17	▮▮▮	▮▮▮	56	▮▮▮	65
ATHENS YELLOW	46	3	▮▮▮	▮▮▮	32	18	▮▮▮	▮▮▮	57	▮▮▮	66
ATHENS ROSE	47	4	73	▮▮▮	33	19	78	▮▮▮	58	▮▮▮	67
BERLIN	48	5	74	▮▮▮	34	20	79	▮▮▮	59	▮▮▮	68
DUBLIN	49	6	▮▮▮	▮▮▮	35	21	▮▮▮	▮▮▮	60	▮▮▮	69
COPENHAGEN	50	7	▮▮▮	▮▮▮	36	22	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
LISBON	51	8	▮▮▮	▮▮▮	37	23	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
LONDON WHITE	52	9	75	▮▮▮	38	24	80	▮▮▮	61	▮▮▮	70
LONDON YELLOW	53	10	▮▮▮	▮▮▮	39	25	▮▮▮	▮▮▮	62	▮▮▮	▮▮▮
OSLO WHITE	▮▮▮	11	▮▮▮	▮▮▮	40	26	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
OSLO YELLOW	▮▮▮	12	▮▮▮	▮▮▮	41	27	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
PARIS	54	13	76	▮▮▮	42	28	81	▮▮▮	63	▮▮▮	71
WARSAW	▮▮▮	14	▮▮▮	▮▮▮	43	29	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
ZURICH	55	15	77	83	44	30	82	▮▮▮	64	▮▮▮	72

Figure 5.2a *Information search order of grower 10 (cell numbers refer to the order in opening ; ▮▮▮ refers to an unopened cell)*

CULTIVARS	ATTRIBUTES										
	RTI	LAB	LLF	QUA	PDN	MKT	EXP	UNI	PES	GRO	ROY
ZURICH	15	30	44	55	64	72	77	82	83	▮▮▮	▮▮▮
ATHENS ROSE	4	19	33	47	58	67	73	78	▮▮▮	▮▮▮	▮▮▮
BERLIN	5	20	34	48	59	68	74	79	▮▮▮	▮▮▮	▮▮▮
LONDON WHITE	9	24	38	52	61	70	75	80	▮▮▮	▮▮▮	▮▮▮
PARIS	13	28	42	54	63	71	76	81	▮▮▮	▮▮▮	▮▮▮
ATHENS WHITE	2	17	31	45	56	65	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
ATHENS YELLOW	3	18	32	46	57	66	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
DUBLIN	6	21	35	49	60	69	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
LONDON YELLOW	10	25	39	53	62	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
COPENHAGEN	7	22	36	50	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
LISBON	8	23	37	51	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
OSLO WHITE	11	26	40	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
OSLO YELLOW	12	27	41	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
WARSAW	14	29	43	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
AMSTERDAM	1	16	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮	▮▮▮
mentioned in task 1	yes	yes	no	yes	no	yes	yes	yes	no	yes	no
subjective weight	0.14	0.16	0.06	0.12	0.08	0.07	0.05	0.15	0.11	0.04	0.02

Figure 5.2b *Information search order of grower 10 after reordering rows and columns (heavily observed alternatives and attributes to the top and to the left, respectively)*

According to this classification 9 participants followed an alternative-based search strategy, 12 followed an attribute-based strategy and 4 followed a mixed strategy (and from one participant the information was lost); see Table 5.3. So, more than half of all participants followed a sub-optimal search strategy. Another surprising result is the amount of information opened. The total number of cells opened ranged from 26 to 83, with an average number of 61 cells. Only two out of 26 participants made use of the maximum allowed number of 83 information cells.

Sub-optimality in choice was quantified by subjective loss in terms of the MAU-score (see previous section). An overview of MAU-scores (maximum attainable and realized) as well as the calculated losses is given in Table 5.3. It shows that the losses varied between 0.0 (i.e. optimal choice) and 8.0 expected value points, with an average of 2.4, approximately 3% of the attainable average MAU level (71.7).

5.5.3 Level of consistency

Consistency was analyzed at group level as well as individual level. First, on a group level, there was a fairly high consistency between tasks 1, 2 and 3: all led to more or less the same ranking of attribute importance; see Table 5.2. The biggest shift in ranking was found for plant density, a factor that was not mentioned very often in the first (open) task, but was viewed many times in task 2 and rated highly in task 3. Smaller shifts in ranking were found for pests/diseases and market; both factors became less important during the workshop.

Table 5.2 Importance of cultivar attributes; group average ranks based on 26 chrysanthemum growers

No.	Attribute	Rank in		
		Task 1	Task 2	Task 3
1	quality	3	2	2
2	response time	1	1	1
3	experience	8.5	10	9
4	pests/diseases	4	5	8
5	long-life	8.5	8	7
6	labor	5	6	3
7	uniformity	6	7	4
8	growth regulators	7	9	10
9	plant density	10	4	5
10	royalties	11	11	11
11	market	2	3	6

When the growers were analyzed individually, substantial differences in the level of consistency arose. Grower 10, as an example, was fairly consistent, only showed some (minor) inconsistencies between the tasks. The attributes long-life (LLF) and plant density

(PDN) were opened quite a lot in his IDM, however were not mentioned in task 1 and given fairly low weights in task 3. The amount of growth regulator (GRO) was mentioned as a relevant factor in task 1, but was not viewed in the IDM at all and also given a low weight in task 3. On the other hand, uniformity (UNI) and pests/diseases (PES) received high relative weights in task 3, but were hardly viewed in the IDM.

Deciding upon a single quantitative measure that best describes the level of consistency we derived at the statistical correlation between the rank order of attributes in task 2 and task 3. These rank correlations varied between +0.93 (grower 7) and +0.16 (grower 5), with an average of +0.58; see Table 5.3. Eleven participants showed a highly significant rank correlation which was higher than +0.60, i.e. the hypothesis of uncorrelated rank orders could be rejected in these cases ($p < 0.05$), reflecting correlated, consistent values. In the other fifteen cases the null-hypothesis of uncorrelated rankings could not be rejected.

5.5.4 Combination of aspects

Relations between the decision making quality aspects (awareness, rationality in search, rationality of choice and consistency) were analyzed. A relation was found between the rationality in search and the rationality of choice. It turned out that the average subjective loss for attribute-wise searchers (1.5; N=12) was significantly lower than for alternative-wise searchers (3.6; N=9). The hypothesis of equal mean loss between both groups was rejected in a T-Test at $p=0.03$. Other associations between the quality aspects were not found, i.e. the bivariate correlations between the other aspects represented in Table 5.3 were not significant.

5.5.5 Relation between experiment and real life

The experimental laboratory findings were related to the real-life firm results. This was done based on data on production, prices, yields, turnover, etc., recorded for all participants during the year after the experiment. The rankings found in the experiment with respect to level of awareness (task 1), level of rationality (defined as minus the subjective loss) and level of consistency, were compared with the rankings with respect to turnover, yield and price. In order to compensate for differences in firm size these measures were taken per m^2. Also corrections were made for differences in firm structure, i.e. normative levels of turnover, price and yield were estimated for each firm, taking into account its construction year of the greenhouse, the input of labor and whether or not it used supplementary lighting.

These three factors gave a basic representation of the firm structure and supplied an adequate indication of the cost level of the firm.

Table 5.3 *Characteristics of the decision-making processes of 26 chrysanthemum growers in a workshop on cultivar choice; task 1 'awareness', task 2 'information display matrix', task 3 'attribute weights', task 4 'ratings attribute levels'*

Grower	Task 1 factors mentioned	Task 2 cells opened	search type	Task 2 & 3 correlation	Task 2, 3 & 4 MAU maximum	MAU realized	MAU loss
1	6	49	Altern.	+0.64	75.0	74.5	0.5
2	7	53	Attr.	+0.79	80.0	79.6	0.4
3	9	52	Attr.	+0.89	79.5	79.5	0.0
4	7	55	Altern.	+0.62	72.7	69.2	3.5
5	6	52	Altern.	+0.16	73.6	70.9	2.7
6	8	53	Altern.	+0.78	69.1	66.4	2.7
7	6	56	Attr.	+0.93	76.8	75.2	1.6
8	8	65	Attr.	+0.36	68.0	64.4	3.6
9	6	72	Altern.	+0.42	80.0	72.0	8.0
10	8	83	Attr.	+0.64	67.4	67.3	0.1
11	6	56	Attr.	+0.54	75.1	71.4	3.7
12	5	54	Altern.	+0.43	76.2	69.1	7.1
13	7	83	Attr.	+0.58	75.5	75.5	0.0
14	7	76	Altern.	+0.53	73.3	69.6	3.7
15	9	58	Mix	+0.49	74.0	72.8	1.2
16	11	26	Mix	+0.82	80.0	75.7	4.3
17	6	48	Attr.	+0.81	72.4	72.0	2.4
18	9	72	Mix	+0.52	64.4	62.3	2.1
19	9	61	Altern.	+0.64	74.4	72.6	1.8
20	8	82	Attr.	+0.29	74.5	74.0	0.5
21	8	49	Attr.	+0.42	76.8	76.8	0.0
22	9	70	*	+0.49	82.3	78.4	3.9
23	6	73	Mix	+0.53	70.0	69.6	0.4
24	8	80	Attr.	+0.67	81.9	78.0	3.9
25	9	65	Attr.	+0.47	71.4	69.3	2.1
26	6	47	Altern.	+0.49	68.4	65.8	2.6
average	7.5	61		+0.58	71.7	69.3	2.4

*) information was lost by erroneous computer handling

It turned out that there were some statistical significant relations between the experiment and real life (Table 5.4). Participants demonstrating a high level of awareness in the experiment scored, on average, a higher normative turnover per m^2 and also a higher yield per m^2 (actual as well as normative), however not a higher price. The same relations between experiment and real-life held for the level of rationality: less subjective loss in the

IDM-game went together with a higher performance on turnover and yield, not on price. Finally, no relations were found between level of consistency and real-life performances.

Table 5.4 Correlations between experimental findings and firm results of the 26 participating chrysanthemum growers

Levels in experiment	Firm result turnover/m²		yield/m²		price/stem	
	actual	norm	actual	norm	actual	norm
level of awareness	0	+	++	++	0	0
level of rationality	0	++	++	++	0	0
level of consistency	0	0	0	0	0	0

++ significant rank correlation ($R \geq 0.39$; $p<0.05$)
+ weak rank correlation ($0.33 \leq R < 0.39$; $p<0.10$)
0 no rank correlation ($R < 0.33$)

This means that the experimental findings had some predictive power for the real-life performances on turnover and yield. Yet, the variation in performances 'predicted' by the experimental findings in terms of R^2 was small, limited to approximately 20% (R^2). No price variation could be predicted by the experimental findings. The reason for this might be that prices were more influenced by accidental market fluctuations, whereas yields were within the management influence of the grower.

5.6 Conclusion and discussion

In this paper we analyzed the decision making of a group of 26 specialized chrysanthemum producers in a workshop. Their decision making regarding the cultivar choice was simulated by means of an information display matrix (IDM). The results of the IDM, together with additional tasks, were used to measure the level of quality of the decision making. Three aspects were considered: level of awareness, level of (economic) rationality and level of consistency. The results uncovered individual weaknesses in the quality of the decision making, indicating that possibilities for improvement of the cultivar choice were present. Also the experimental findings had some predictive power for the real-life performances.

The remaining part of this final chapter will discuss the validity of the models and techniques used, the potential use of the models and the future of off-farm experiments.

5.6.1 Validity of models and techniques used

The IDM has been used quite often in different areas of research, most notably marketing, cognitive psychology and organizational behavior. The technique is a powerful means to make choice behavior explicit and to analyze many aspects of the underlying decision making process (Hogarth, 1987). However, one may question the validity of the technique and the reliability of its results. Perfect validity would exist if the decision makers would exhibit the same behavior in the laboratory experiment as in real life. However, several factors may disturb the results and one should be aware of these potential biases and take precautions. The most serious biases may arise from: (1) confusing game and real-life experiences, (2) opportunistic behavior and (3) desirable behavior. Mixing game and real-life experiences may happen, for instance, when a certain alternative gets recognized and acquired information gets filtered and missing information gets filled in with own beliefs. Opportunistic behavior may arise when participants are not properly motivated or when they see it as "just a game". Desirable behavior may arise when the participants are aware of their decision making being studied and want to make a good impression e.g. by using as little information as possible.

Several actions were undertaken to reduce these potential biases. First, to distinguish game and real-life, the decision alternatives were fictitious, and introduced to the participants as such to avoid false 'recognition'. Second, to increase the level of motivation, the information in the game was realistic, i.e. the attributes were chosen carefully to give as a complete picture as possible and the attribute performance levels were set within realistic ranges. The model input was verified in interviews with sector experts. Also, the motivation of the participants was increased by the group workshop-setting that stimulated an atmosphere of competition among peers. All in all, we believe that by carefully preparing the IDM simulation and giving adequate instructions, biases in behavior were small, if present at all.

The level of economic (ir)rationality in the decision making was based on the subjective loss, defined as distance between the maximum attainable multi attribute utility (MAU-)score and the realized MAU-score. However, a grower may deliberately accept a small loss by allocating part of the production area to the second (and third) best cultivar, because of risk spreading. This effect will usually be small since the MAU-scores for the best and the second-best were usually close, e.g. grower 10 who divided his production area over three cultivars incurred a loss of only 0.1.

Thirteen participants (50%) do not choose their optimal - in MAU sense - cultivar. The main explanation for this is that they use decision heuristics instead of the more demanding weighted additive MAU-model. The model falls into the so-called class of compensatory models, as opposed to the non-compensatory class (see e.g. Hogarth, 1987), and represents choice behavior in which unfavorable outcomes on some attributes can be compensated by favorable outcomes on others, and vice-versa. This means that a relatively high mental effort is requested. Therefore decision makers tend to use less demanding, satisfying decision rules, based on only a few attributes and probably a subset of alternatives to arrive at their final choice. These heuristic rules need to examine considerably less information and some of them provide choices that approach the level of accuracy of the weighted additive MAU-model. A finding that can be proved by computer simulation (Payne, 1993). However, this is true for the more sophisticated heuristics (e.g. the elimination-by-aspects) and the fact remains that some decision makers are far less successful in using a heuristic strategy. All in all, the distance from the maximum weighted additive MAU-score remains a valid measure for the level of bounded or ir-rationality.

The technique used to elicit the decision maker's subjective attribute weights was simple and direct ("divide approximately 100 points over the given attributes"). Also subjective ratings to several levels of attribute performance were asked in a direct way ("rate on a scale from 1-100"). A critical evaluation of these direct assignment methods can be found in Watson and Buede (1987:200-204). They find that a direct method with respect to the attribute weights usually produces weights that are too close together compared to more deliberate procedures. The main reason is that directly assigned weights only reflect a general notion of importance, and the decision maker tends to find every aspect important. Only when the specific (choice) problem is clearly stated and the ranges in attribute performances (form worst to best) are considered as well, meaningful weights can be given. In our case, the assignment of attribute weights (task 3) was preceded by the cultivar choice simulation (task 2), in which the attributes were explained and the ranges in attribute performance were given. This seems to overcome the effect mentioned by Watson and Buede.

5.6.2 Potential use of models

With respect to the potential use and applicability of the IDM, one can conclude that it is suitable as a simulation technique for those decisions that can be represented as a multi-attribute choice problem. This may seem a serious limitation, however, many strategic or tactical decisions to be made by the farmer are indeed of a multi-attribute nature (enterprise selection, selection of personnel, capital suppliers, marketing channels, etcetera) or can be re-framed as such. For instance, the question whether to adopt a new technology can be see in the framework of a multi-attribute model, when one of the alternatives is defined as the current technology. So the potential use of the IDM for research purposes is broad.

Additive weighted multi-attribute utility scores for the cultivars were used as indicators of the level of rationality. One may wonder if this MAU-model can be used as a framework for decision support. Therefore, we explained the concept of MAU to the growers and asked them to give their opinions on the potential use of such a MAU-model as a decision support for their cultivar choice. Three groups could be distinguished. The first group consisted of seven growers (27%) who rated the potential use as very low (lower than 50 on a scale from 0-100). Thirteen growers (50%) were moderately positive (ratings higher than 50, lower than 70). The last group of six growers (23%) was highly interested; they rated the potential use of a MAU-model as a decision aid higher than 80 (on the scale from 0-100). Among the positive remarks: "it forces you to look at it more closely" and "useful as a first selection", "it gives an overview" and "you can check your own feeling". Among the negative remarks: "you can not choose without seeing them", "the spontaneity gets lost", "if you have to wait for the correct data, you're late already" and "I'm not interested in the ideal one". It seems that the model can be useful for support of the cultivar choice, however only for those growers who are interested in some sort of rational test.

5.6.3 Future use of laboratory off-farm experiments

Laboratory experiments with farmers in which part of their decision making is analyzed are still scarce. The main reason seems to be the costly aspect of this research method. Developing good experiments is a highly creative and time consuming business. Organizing research workshops with farmers can be tedious when there is no direct, short-term interest for them. The opportunity costs of being away from their firm may be an obstacle for participation. The advantage of participating in research workshops in which their decision making is studied will be rather indirect, lying in the area of increased awareness of own goals and management practices. From a research point of view, however, these experiments may be very useful in increasing knowledge of how people make decisions and in discovering weaknesses in the decision making process. Workshops in which several players of the production chain participate, for instance, may reveal differences in perspectives and shed light on how to improve cooperation. Knowledge that, in the end, will benefit the sector.

References

Bailey, J.R. (1997). Need for cognition and response mode in the active construction of an information domain. *Journal of Economic Psychology* 18, 69-85.

Baker, G.A. (1983). *The goals and performance of grain elevator managers: a laboratory experiment*. Purdue: Purdue University. (Unpublished dissertation)

Bettman, J.R. (1979) *An information processing theory of consumer choice*. Reading, Massachusetts: Addison-Wesley.

Bettman, J.R., and Jacoby, J. (1976). Patterns of processing in consumer information acquisition. In: B.B. Anderson (ed.), *Advances in consumer research* 3, 315-320.. Chicago: Association for Consumer Research.

Clemen, R.T. (1991). *Making hard decisions: an introduction to decision analysis*. Boston: PWS-Kent Publishing Company.

Cross, T.L. (1993). AgVenture: a farming strategy computer game. *Journal of Natural Resources and Life Sciences Education* 22:103-107.

Harsh, S.B., Ferris, T. Shaltry, J. and Millsap, R. (1996). Strategic planning and its influence on the decision making process of the farm business. In: Beers, G., Huirne R.B.M. and Pruis, H.C. (eds) *Farmers in small-scale and large-scale farming in a new perspective: objectives, decision making and information requirements*, 97-107. The Hague: LEI-DLO, 1996.

Hogarth, R.M. (1987). *Judgement and choice: the psychology of decision*. Chichester: John Wiley & Sons. (2nd ed.)

Huirne, R.B.M., Harsh, S.B. and Dijkhuizen, A.A. (1997). Critical success factors and information needs on diary farms: the farmer's opinion. *Livestock Production Science* 48, 229-238.

Jacoby, J. (1975). Perspectives on a consumer information processing research program. *Communication Research* 2, 203-215.

Jacoby, J., Chestnut, R.W. Weigl, K.C. and Fisher, W. (1976). Pre-purchase information acquisition: description of a process methodology, research paradigm, and pilot investigation. In: B.B. Anderson (ed.), *Advances in consumer research* 3, 306-314. Chicago: Association for Consumer Research.

Jacoby, J., Szybillo, G.J. and Busato-Schach, J. (1977). Information acquisition behavior in brand choice situations. *Journal of Consumer Research* 3, 209-216.

King, R.P., Cross, T.L. Dobbins, C.L. and Fuller, E.I.. (1995). Lessons learned from farm information system workshops. In: Huirne, R.B.M., Harsh, S.B. and Dijkhuizen, A.A. (eds.) *Farm level information systems*, 237-256. Wageningen Agricultural University. (Conference proceedings, Woudschoten, May 10-14, 1993.)

Lin, D.Y.M. and Su, Y.L. (1998). The effect of time pressure on expert system based training for emergency management. *Behaviour and Information Technology* 17, 195-202.

Musser, W.N., Patrick, G.F. and Eckman, D.T. (1996). Risk and grain marketing behavior of large-scale farmers. *Review of Agricultural Economics* 18, 65-77.

Ortmann, G.F., Patrick, G.F. Musser, W.N. and Doster, D.H. (1993). Use of private consultants and other sources of information by large cornbelt farmers. *Agribusiness* 9, 391-402.

Parry, I.W.H. (1999). Agricultural policies in the presence of distorting taxes. *American Journal of Agricultural Economics* 81, 212-230.

Patrick, G.F., Musser, W.N. and Eckman, D.T. (1998). Forward marketing practices and attitudes of large-scale midwestern grain producers. *Review of Agricultural. Economics* 20, 38-53.

Payne, J.W. (1976). Heuristic search processes in decision making. In: B.B. Anderson (ed.), *Advances in consumer research* 3, 321-327. Chicago: Association for Consumer Research.

Payne, J.W. (1976). Task complexity and contingent processing in decision making: an information search and protocol analysis. *Organizational Behavior and Human Performance* 16, 366-387.

Payne, J.W., Bettman, J.R. and Johnson, E.J. (1993). *The adaptive decision maker.* Cambridge: Cambridge Univ. Press.

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

Simon, H.A. (1978). Rationality as process and as product of thought. *Journal of the American Economic Association* 68, 1-16.

Sonnemans, J. (1998). Strategies of search. *Journal of Economic Behavior and Organization* 35, 309-332.

Tisdell, C.A. (1996). *Bounded rationality and economic evolution: a contribution to decision making, economics and management.* Cheltenham, Brookfield: Edward Elgar.

Van Raaij, W.F. (1976). *Consumer choice behavior: an information-processing approach.* Tilburg: Tilburg University. Press. (PdD-thesis)

Verstegen, J.A.A.M., Sonnemans, J. Huirne, R.B.M., Dijkhuizen, A.A. and Cox, J.C. (1998). Quantifying the effects of sow-herd management information systems on farmers' decision making using experimental economics. *American Journal of Agricultural Econonomics* 80, 821-829.

Von Winterfeldt, D. and Edwards, W. (1986). *Decision analysis and behavioral research.* Cambridge: Cambridge University Press.

Watson, S.R. and Buede, D.M. (1987). *Decision synthesis: the principles and practice of decision analysis.* Cambridge: Cambridge University Press.

6 Comparing attribute-based and alternative-based information search strategies; Monte Carlo simulation and empirical results

Abstract

From empirical settings that use information display matrices (IDMs) it is well-known that some people search for information in mainly an alternative-based way, while others search mainly attribute-wise. This study re-addresses the question why searching by attribute is more likely to generate rational choice. This question is explored in a Monte Carlo simulation as well as in an empirical setting. In addition to established search characteristics, three new indicators have been introduced: attribute-focus, alternative-focus and choice-focus. These turn out to be useful in detecting strengths and weaknesses of the search strategy. A comparison of the Monte Carlo and the empirical part indicates that higher subjective losses are incurred by decision makers who do not distinguish sharply enough between important and less-important attributes. This result suggests that decision making could be improved by increasing awareness of attributes and their relative importance

6.1 Introduction

Choices between two or more alternatives with each alternative described by a number of attributes are referred to as multi-attribute decisions. The information for a multi-attribute decision can be stored in the form of a matrix - known as the information display matrix (IDM) or information board - defined by the number of decision alternatives (rows) and the number of attributes (columns) (Hogarth, 1987). Each cell of the matrix contains a single piece of attribute information for one alternative. IDMs are widely used in consumer's magazines, sales brochures, tourist guides. Another example for business purposes can be found in agriculture, where growers can make use of product lists supplied by breeders, researchers and extension officers.

IDMs are also extensively used as a research means to uncover aspects of the decision-making process. The general process of decision making can be divided into several steps (Van Raaij, 1976; Kleindorfer et al., 1993). For instance, (1) problem recognition and formulation of objectives, (2) allocation of time and other resources to identify alternative solutions, (3) information search, (4) processing of information by evaluation of attributes, (5) choice by applying some sort of decision-rule, (6) post-decision processes, e.g. implementation, legitimation and evaluation of choice. The IDM has been proved a useful device in describing and analyzing many aspects of human decision processes, such as the consequences of people's limited information processing capacity, bounded rationality and the use of heuristic decision-rules (see, e.g., Payne et al., 1993). This research means also has its limitations, such as the fact that the matrix presentation of information makes it equally easy for a decision maker to process information by alternative (row-wise) or by attribute (column-wise), whereas in reality information is often organized by alternative (brand), hindering attribute processing (Bettman, 1979).

An aspect that is underexposed in research on decision making is the relation between the characteristics of the information search and processing (steps 3 and 4) on the one hand and the quality of the final choice (step 5) on the other hand. Attribute-based (column-wise) searching and processing is supposed to generate choice that is more rational than does alternative-based (row-wise) searching and processing. The latter is seen as a manifestation of satisficing behavior, where alternatives are sequentially examined, rather than fully compared, and the choice process stops when an acceptable, not necessarily optimal, alternative is found (Kleindorfer et al., 1993). Empirical evidence of attribute processing superior to alternative processing is given by Van Raaij (1976), who found that students tend to search and process relatively more by attribute, in comparison to housewives. He also found that choices made by the students are more close to the (assumed) *rational* normative linear-additive model in which the value of an alternative is given by the product of attribute weights and attribute values.

This paper compares several attribute-based and alternative-based search strategies in decision making. It addresses the question why attribute-based searching is likely to generate more rational choices. This general question is explored in two ways: (1) by means of a Monte Carlo simulation in which search strategies are compared for various forms of the IDM and (2) by means of an empirical task in which participants (flower producers) choose alternatives from an IDM. In particular, attention will be given to defining and measuring rational decision making. With respect to assessing decision makers' search strategies we make use of the concept of procedural rationality (Simon, 1976, 1982, p.131). Simon defines behavior to be procedurally rational when it is the outcome of appropriate deliberation. To assess the level of 'deliberation' one can focus on what people actually do or what they say they do during the decision-making process (Jacoby et al., 1976). An example of the latter approach is the use of verbal, think aloud, protocols. Examples of the former approach are the recording of eye fixations (see, e.g., Lohse and Johnson, 1996) and the analysis of the recorded information search strategy, which is followed here. The purpose of the study is to detect sub-optimal behavior with respect to the search of information and to find possibilities for improvement of the decision-making process.

6.2 Method and material

6.2.1 Monte Carlo simulation of search strategies

The design of the Monte Carlo simulation is such that it matches the empirical choice task described later on. The following procedure has been repeated 10,000 times, using a Borland Pascal 7.0 routine. An IDM of 15 (alternatives) * 11 (attributes) is filled with scores (x_{ij}) which are independently and randomly drawn from a uniform distribution on [0,100]. Attribute weights (w_j) are also randomly drawn from a uniform distribution and then re-scaled in such a way that their sum equals 1. The attributes (columns) are then reordered in the IDM in diminishing importance from left to right. Now the process of opening the unknown cells begins. In line with the limited information processing capacity theory, the number of information cells to be opened (n) is restricted. The number of cells will be equal for all search strategies that will be compared.

A search strategy is defined as a set of guidelines for searching and processing the information available in the IDM (steps 3 and 4 of the decision-making model as introduced before). They give a prescription of which cell to open, how to combine the new information with the information already available and then, as a result, give a prescription of which cell to open next. The specific search strategies that will be analyzed and compared in this study are briefly described in Table 6.1. More detailed descriptions are given in the next section as well as in Appendix 6.1.

*Table 6.1 Search strategies used in the simulation for the IDM of alternatives * attributes*

Strategy	Description	Cell transitions
I	Random	open cells randomly
II	Alternative-based	move row-wise
III	Alternative-based with minimum level	move row-wise as long as the expected value (EV) of this row (alternative) at least equals S
IV	Attribute-based	move column-wise from left to right
V	Attribute-based with elimination	move column-wise from left to right and eliminate q_i alternatives after column I

At the end of the search process a supplementary decision rule or choice strategy is needed for evaluating the acquired information and making a final choice. A well-known distinction is between the classes of compensatory and non-compensatory decision rules (Hogarth, 1987; Payne, 1993; Plous, 1993). The first class represents choice behavior in which unfavorable outcomes on some attributes can be compensated by favorable outcomes on others. The most prominent representative in this class is the weighted additive value ($\Sigma w_i * x_{ij}$). Payne (1993) uses this value as a point of reference in his simulation of various decision strategies. Effort, measured as the total number of elementary information processes (EIPs) needed and accuracy of several other decision rules are given in relation to this reference. He shows that non-compensatory decision rules, such as the lexicographic or the elimination-by-aspects model, examine considerably less information and provide choices that approach the level of accuracy of the weighted additive model.

In this study also the weighted additive value will be used as the normative point of reference. Search strategies will be compared on the basis of this criterion. Furthermore, two search strategies will use the weighted additive value in their guidelines, i.e. in determining the search order.

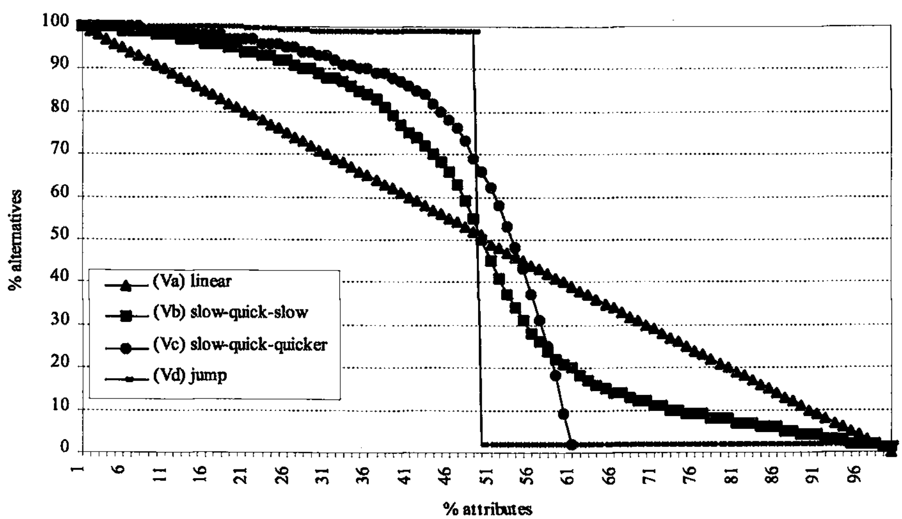
In addition to the basic simulations a sensitivity analysis will be performed. The influence will be measured of varying: (1) the size (alternatives * attributes) of the IDM, (2) the distribution of attribute weights (w_i) and (3) the amount (n) of information to be opened.

6.2.2 Description of search strategies

During the process of opening cells the expected weighted additive values of the alternatives change and the updated values determine the search order. All search strategies have in common that at the beginning, when there is no information (i.e. all information cells are unknown), all alternatives have the same expected additive value (equal to 50). Since they are all equally likely to contain the optimal solution, the *row* (alternative) to start the search process with is in principle random. However, with respect to the *columns*, it is logical to start with the first column since it contains the most important attribute. We therefore start the process with cell (A,1); i.e. the information in the first row, first column will be considered first. The content of this cell together with the search strategy followed determines which cell will be opened next.

The first strategy (strategy I, see Table 6.1) is neither alternative-based nor attribute-based. It opens cells randomly and represents the lowest level of rationality and it functions as a base to which the other strategies will be compared. The second strategy will be that of a purely alternative-based (inter-dimensional, row-wise) search, where the information cells are opened row-wise. The alternatives are handled consecutively. Strategy III is a modification by introducing a minimum expected weighted additive value S. As long as the expected weighted additive value exceeds S more cells of the same alternative are opened. However, when the value falls below S, the search process switches to the next alternative. Strategy IV is a purely attribute-based (intra-dimensional, column-wise) search, which handles the attributes one after another, from left to right in the IDM, i.e. in order of their level of significance. First all alternatives are viewed with respect to the first attribute, then with respect to the next attribute, etcetera. Strategy V is also attribute-based. The difference with the former strategy is that alternatives are eliminated during the search process, according to their level of expected weighted additive value.

*Figure 6.1 Elimination patterns for the IDM (alternatives * attributes)*



We define four patterns of elimination (Strategies Va,Vb,Vc,Vd). These patterns differ with respect to the speed of elimination of alternatives. In strategy Va ('linear') alternatives are eliminated linearly. Ten percent of the alternatives is eliminated after ten percent of the attributes is considered. Half the number of the alternatives is being eliminated after half the number of attributes is considered; etcetera. Strategy Vb ('slow-quick-slow') eliminates alternatives at a slow rate in the beginning - when the most important attributes are handled - and at a high rate in the middle, to save some some information cells for the least important attributes at the end. In strategy Vc ('slow-quick-quicker') the elimination rate gradually increases and some of the attributes at the end remain unconsidered completely. In strategy Vd ('jump') none of the alternatives gets eliminated in the beginning, until at a certain stage an all-but-two elimination occurs. The two 'surviving' alternatives are then compared for the remaining attributes. The elimination patterns are graphically represented by the curves in Figure 6.1. The Figure shows the framework of an IDM: alternatives * attributes. The total area of the square represents the full amount of information, i.e. the total of N information cells. The area below each curve in the Figure equals 50% (0.5N) of the total area, reflecting the informational restriction of fifty percent. Each point on a curve gives the percentage of alternatives still being considered (i.e. not being eliminated) as a function of the percentage of attributes being handled.

For all strategies, after n cells the alternative with the highest expected weighted additive value ($\sum w_i * x_{ij}$) will be chosen, i.e. a linear compensatory decision-rule will be used. In calculating this additive value unknown information cells will be replaced by their expected value (i.e. 50). The use of the linear compensatory model as a decision rule is justified by the attributes being independent (Hogarth, 1987, p.73).

6.2.3 Empirical data

The empirical part comprehends a choice task in which 26 specialized chrysanthemum growers choose flower varieties. The task has been performed on a PC. In practice these growers can select out of a large number, in fact several hundreds, of possible varieties (known as cultivars). So, too many possibilities are available for knowing them all and it is realistic to assume that a grower will restrict the choice to maybe ten or twenty pre-selected cultivars. The breeder or the extension officer can do such a pre-selection. From interviews with growers and other experts is has become clear that non-economic considerations play a minor role in choosing varieties. The growers' main interest is choosing cultivar(s) that give a high expected financial margin, defined as the expected financial yield (price*quantity) minus variable costs.

Based on this knowledge an IDM was constructed that contains 15 alternatives and 11 attributes. The attributes have been chosen in consultation with experts. Criteria for selecting attributes are: economic impact, bias between varieties and a high degree of independence between attributes. The selected attributes are: color, speed of growth, experience, disease rate, quality, ease of harvesting, uniformity in growth, chemicals for growth regulation, plant density, license costs and price history. Together, these eleven attributes give a comprehensive picture of the relevant economic aspects. The contents of the attributes have been set in order to construct fifteen varied, fictive yet reasonable alternatives.

The task is set up in such a way that the decision makers can open at most half of the cells of the IDM, 83 cells out of 165, and then make a choice by allocating 10,000 m^2 of production area to the available varieties. Whether or not a decision maker will open cells to the maximum limit depends upon his/her estimated trade-off between the expected value of extra information and the mental effort of processing it (Payne et al., 1993).

Enough time is given for completing the task, so no time pressure is present for any participant. A sheet containing explanation of the attributes and the possible levels of the attributes is given as a handout for easy reference, together with a sheet that contains the 15*11 matrix structure of alternatives and attributes, which can be used for making notes and calculations.

After completing the choice task, each participant has given subjective weights to all 11 attributes by allocating approximately 100 points, in such a way that the relative amount of points given to an attribute reflects its importance. These weights have been re-scaled so that their sum equals 1 for each participant. Also, participants have given ratings to various attribute levels on a scale from 1 (very poor) to 100 (excellent). Based on these subjective weights and attribute values a weighted additive value can be calculated for alternatives and a check is possible whether or not the decision maker has chosen the alternative with the highest weighted additive value. The difference between the realized weighted additive value and the maximum weighted additive value will be defined as the subjective loss. It will be used as a quality measure of the final choice.

*Table 6.2 Characteristics of information search strategies; applied to the IDM (alternatives*attributes) with limited access to cells*

A. Amount of information acquired
1. Search depth: the relative amount of information cells requested
2. Reacquisition rate: the relative number of cells viewed more than once
B. Sequence of information acquisition
3. Cell transitions: relative amounts of type 1 (same row, same column), type 2 (same row, other column), type 3 (other row, same column) and type 4 (other row, other column) transitions
4. Search type: relative amount of intra-dimensional (type 3) versus inter-dimensional (type 2) transitions
C. Content of information acquired
5. Attribute focus: variation in opened cells between columns (attributes)
6. Alternative focus: variation in opened cells between rows (alternatives)
7. Choice focus: variation in opened cells between chosen and non-chosen alternatives
D. Time used
8. Searching information
9. Processing information

6.3 Measures of search strategies

Search strategies have been defined as guidelines for searching and processing of information. They can also be characterized in terms of their effects, i.e. in terms of what they accomplished. Several characteristics have been used to describe search processes in an IDM. In general they refer to one of four categories (Einhorn and Hogarth, 1981): (1) the amount of information acquired, (2) the sequence of acquisition, (3) the content of the information acquired and (4) the time spent on examining the information. These four categories are represented in Table 6.2. A quantitative illustration is given in Figure 6.2.

(1) Search order

	a	b	c	d
w_i	0.4	0.3	0.2	0.1
A	1	5	*	*
B	2	6	7	8
C	3	*	*	*
D	4	*	*	*

Search depth:
8/16
Reacquisition rate:
0/16
Cell transitions:
Type 1: 0/7
Type 2: 2/7
Type 3: 4/7
Type 4: 1/7
Payne index:
(2/7 – 4/7) / (2/7 + 4/7)
= -1/3
Search type: attribute-based with elimination

(2) Information acquired

	a	b	c	d	EV
w_i	0.4	0.3	0.2	0.1	EV
A	70	50	*	*	58
B	**60**	**90**	**60**	**70**	**70**
C	30	*	*	*	42
D	50	*	*	*	50

Distribution of cells opened:
Alternative focus:
$\{((2-2)^2+(4-2)^2+(1-2)^2+(1-2)^2)/4\}^{½}$
= 1.22
Attribute focus:
$\{((4-2)^2+(2-2)^2+(1-2)^2+(1-2)^2)/4\}^{½}$ = 1.22
Choice focus:
((4-2)/2) = 2.00

(3) Full information

	A	b	C	d	EV
w_i	0.4	0.3	0.2	0.1	EV
A	70	50	70	70	64
B	60	90	60	70	70
C	30	50	80	20	45
D	50	90	90	90	74

Quality of final choice:
Success (yes/no):
No
Subjective loss:
(74-70) = 4.0

Figure 6.2 *Illustration of characteristics for a given information search process of eight cells in an information display matrix with 4 alternatives (A,B,C,D) and 4 attributes (a,b,c,d) with given weights (w_i). The alternative is selected on the basis of expected weighted additive value (EV) and is represented in bold. Expected value of unknown cells equals 50.*

Within the first category, Devine and Kozlowski (1995) uses *choice search depth* and *contextual search depth*. The first refers to the relative number of cells accessed for allowable alternatives for choice and the latter for cells accessed for the context in which this choice must fit. Another measure that falls into this category is the *reacquisition rate* which gives the number of cells viewed at least twice divided by total number of cells (M) viewed (Lohse and Johnson, 1996).

With respect to the second category, the sequence of cells requested, four basic cell transitions can be distinguished: type 1 (same alternative, same attribute), type 2 (same alternative, other attribute), type 3 (other alternative, same attribute) and type 4 (other alternative, other attribute). A deliberate search will contain a relatively low number of transitions of type 1 and type 4. The relative amounts of type 2 and type 3 transitions are used to characterize attribute-based (intra-dimensional) searching and alternative-based (inter-dimensional) searching. Payne (1976) uses as an index $(M_2 - M_3) / (M_2 + M_3)$, where M_2 and M_3 are the number of type 2 and type 3 transitions respectively. Ball (1996), among others, raises some questions regarding the adequacy of this single-step measure and proposes more complex multiple-step transition types. However, for a robust analysis, single-step transitions seem to be adequate for the question: which type of searching (alternative-based or attribute-based) is likely to yield 'better' choices? In the empirical part of the research we will make a main classification between alternative-based and attribute-based search behavior, based on the difference between M_2 and M_3. If $(M_2 - M_3) / M$ is larger than 0.1 the decision-maker is classified in the group of alternative-based searchers. If $(M_2 - M_3) / M$ is smaller than -0.1 the classification will be attribute-based. Otherwise it will be labeled as mixed.

With respect to the third category - the content of the information acquired - it is important to see how the opened cells are distributed through the matrix. A random search process will lead to a non-biased distribution of cells. A deliberate search, which distinguishes between important and less important attributes, fruitful and less fruitful alternatives, leads to a biased or focused distribution of cells. We define the *attribute focus* as the standard deviation in the distribution of cells between columns: $(\Sigma_i(m_{i\bullet} - M/c)^2/c)^{1/2}$, where: $m_{i\bullet}$ is the number of cells opened for attribute (column) i, M the total number of cells opened and c the total number of attributes (columns). A search strategy that sharply distinguishes between important and less-important attributes generally leads to a high attribute focus. Likewise we define the *alternative focus* as $(\Sigma_j(m_{\bullet j} - M/r)^2/r)^{1/2}$; where: $m_{\bullet j}$ is the number of cells opened for alternative (row) j, M as before and r total the number of alternatives (rows). A search strategy that sharply distinguishes between fruitful and less-fruitful alternatives generally leads to a high alternative focus. A third measure within this category refers to amount of information acquired for the chosen alternative in relation to the non-chosen alternatives. We call this *choice focus*, defined as $(m_{\bullet c} - M/r)/ (M/r)$, where:

$m_{\bullet c}$ the number of cells acquired for the chosen alternative c, and M and r as before. In case of a random search, the choice focus will be close to 0.

With respect to the last category - time - a distinction should be made between time spent on examining the information (processing) and time used for orientation on which cell to open next (searching).

6.4 Quality measures of the final choice

Quality measures of the final choice can be purely objective (e.g. financial yield), purely subjective (e.g. expressed level of satisfaction with the decision), as well as something in between (e.g. a calculated level of utility based on subjective information). We will address these three categories in declining order of objectiveness.

Some constructions within the IDM-setting have been used in the literature to create an objectively 'best' alternative. Davidson (1996) uses a construction in which the decision makers (i.c. second and fifth grade children) can find the right solution if they carefully listen to a story in which the relevant clues are given. Devine and Koszlowski (1995) describe a sports event (basketball) in which a fifth team player has to be added to four already selected players. The stage in the game and the attributes of the players make one choice to be outstanding. In these cases accuracy can be (and has been) defined as the mean amount of times the *right* alternative has been chosen.

Often a partially subjective criterion will be more appropriate, using the individual preferences of the decision maker. Payne et al. (1993) uses the weighted additive value based on the decision maker's weights (of attributes) and ratings (given to levels of attributes) as a standard. This is also referred to as the multi-attribute utility score. Relative accuracy of a choice X is then defined as the distance between the weighted additive value of X and the maximum weighted additive value that could be reached (by choosing the subjectively best alternative). This distance will be indicated here as *subjective loss*. The use of the weighted additive value as a normative standard and the distance from it as a measure of relative accuracy is quite common (e.g., Doyle et al., 1995).

A third class of quality measures of choice consists of purely subjective criteria. Timmerman and Vlek (1996), who study the influence of multi-attribute evaluation for group decision-making, use attitudinal criteria like reported confidence and satisfaction with the decision on a scale from "1" (not confident/satisfied at all) to "7" (very confident/satisfied).

6.5 Hypotheses

In the light of the comparison between attribute-based and alternative-based search strategies the following hypotheses will be tested. These hypotheses will be tested in the Monte Carlo simulation and, if appropriate, the empirical part.

H1: Systematic search strategies, alternative-based or attribute-based, lead to better results than random searching.

H2: Attribute-based search strategies lead to better results than alternative-based strategies.

H3: Attribute-based searching improves when alternatives are eliminated during the process.

H4: Among the elimination strategies, the 'slow-quick-slow elimination' leads to the best results.

H5: Alternative-based searching improves when a minimum level of expected weighted additive value must be reached.

H6: The above hypotheses (1-5) hold for various dimensions of the IDM.

H7: The above hypotheses (1-5) hold for various dispersions of the attribute weights.

H8: The above hypotheses (1-5) hold for various levels of information accessibility.

H9: Search processes by decision-makers in practice are sub-optimal.

6.6 Simulation results

This section gives the results of the Monte Carlo simulation of various search strategies. At first the characteristics discussed earlier (see Table 6.2, categories A to D) will be presented. With respect to the amount of information acquired, each strategy tested in the basic simulation has the same search depth: 83 out of 165 cells (N=15*11) are opened. The reacquisition rate is zero for all strategies. With respect to the (computer) time needed, the program is written in Borland Pascal and 10,000 runs take about three minutes on a Pentium 200 MHz, 32Mb computer, irrespective of the strategy. This amount of time includes the random number generating routines for filling the IDM in each run. The other characteristics, the sequence of information acquisition (cell transition types 1, 2, 3 and 4) and the content of the acquired information (search focuses for alternatives, attributes and choice) are different for each strategy, see Table 6.3. This Table also gives the average quality of the final choice for each strategy. Firstly, the success rate of each strategy is given, defined as the percentage in which the right alternative is chosen. The right alternative is the one with the highest weighted additive value, based on full information, i.e. based on all (11) attribute weights and all (165) information cell-scores. Secondly, the average subjective loss, previously defined as the distance between the optimal and the realized weighted additive value is given.

Table 6.3 *Monte Carlo simulation results for five search strategies in a 15 alternatives *11 attributes IDM, when 83 cells are allowed to be opened (I = random search, II = alternative-based search, III = alternative-based search with minimum expected value S, IV = attribute-based search, V = attribute-based search with specified elimination pattern)*

Strategy	Cell transitions type: 1	2	3	4	Distribution of cells opened Altern. focus	Attrib. focus	Choice focus	Success rate	Subject. loss
I	0.0	6.0	8.6	85.4	1.57	1.79	0.08	38.4	4.90
II	0.0	91.5	0.0	8.5	5.31	0.50	0.87	51.6	3.15
III (S=50)	0.0	70.1	12.8	17.0	4.06	3.43	0.98	92.9	0.20
III (S=51)	0.0	65.1	16.6	18.4	3.89	3.71	0.97	93.3	0.19
III (S=52)	0.0	60.1	20.6	19.3	3.72	4.00	0.98	93.8	0.15
III (S=53)	0.0	55.2	24.9	19.9	3.55	4.27	0.98	94.1	0.15
III (S=54)	0.0	49.7	29.8	20.5	3.35	4.58	0.98	94.4	0.14
III (S=55)	0.0	45.4	34.8	19.7	3.21	4.79	0.98	93.7	0.15
III (S=56)	0.0	40.3	40.9	18.9	3.02	5.05	0.98	93.4	0.16
III (S=57)	0.0	36.3	46.6	17.2	2.89	5.25	0.98	92.9	0.17
III (S=58)	0.0	31.7	52.1	16.1	2.71	5.48	0.97	91.9	0.19
III (S=59)	0.0	28.3	57.4	14.4	2.56	5.66	0.97	91.0	0.22
III (S=60)	0.0	25.1	61.2	13.7	2.41	5.83	0.96	89.9	0.26
IV	0.0	0.0	93.9	6.0	0.50	7.15	0.08	70.0	1.05
Va (linear)	0.0	0.1	89.0	10.9	2.73	4.92	0.81	88.9	0.15
Vb (slow-quick-slow)	0.0	0.1	89.0	10.9	2.73	4.94	0.81	93.4	0.09
Vc (slow-quick-quicker)	0.0	0.1	91.5	8.4	1.71	6.05	0.45	82.4	0.33
Vd (jump)	0.0	0.7	90.2	9.1	1.36	6.84	0.63	78.2	0.65

After 83 cells, random searching for information (strategy I, Table 6.3) is dominated by cell transitions of type 4 (85.5%) and the focuses with respect to alternatives, attributes and choice are low (1.79, 1.59 and 0.06 respectively). This random searching generates a success rate of 38.4% and a subjective loss equal to 3.94. Pure alternative-based searching (strategy II) increases the success rate to 51.6%, whereas pure attribute-based searching (strategy IV) yields a success rate of 70.0%. A more critical way of alternative-based searching by introducing a minimum aspiration level (S) yields a substantial improvement: at its best (strategy III, S=54) the success rate increases to 94.4% and the average loss reduces to 0.14. In a similar way the attribute-based strategy becomes more effective when applying an elimination process. The best results of attribute-based searching are found in case of a *slow-quick-slow* elimination (strategy Vb). The success rate of this strategy is 93.4%, with an average loss of 0.09. So, strategy III has a slightly bigger chance of choosing the best alternative, but in those cases of missing the best one, the average loss incurred is somewhat higher.

When the quality measures are related to the characteristics of the search processes, the following remarkable results are obtained. Both strategy III, with S=54, as well as strategy Vb yield excellent results in terms of success rate and loss. However, they are based on entirely different search processes as shown by the sequence of acquisition. Strategy III, S=54, is essentially a horizontal strategy with 49.7% transitions of type 2 (same alternative, other attribute), whereas strategy Vb is dominated by type 3 - vertical - transitions (89.0% same attribute, other alternative).

With respect to the distribution of cells opened the random search strategy (I) leads to standard deviations of 1.57 (alternatives) and 1.79 (attributes). This can be seen as the normal variation. From Table 6.3 one can see that for generating better results, in terms of success rate and subjective loss, search strategies must have a higher focus for both alternatives and attributes. This means that strategies must distinguish more sharply between important and less important attributes and between fruitful and less fruitful alternatives. Strategies that do not distinguish with respect to one of these aspects (strategies II and IV) or both (strategy I) yield sub-optimal results. The successful strategies III and V combine both aspects and an optimal balance is found in the region where the focuses are about twice (for the alternatives) or thrice (for the attributes) as high as for the random strategy. So, given the specific structure of the IDM, the optimal attribute focus is higher than the optimal alternative focus. That means that in this case distinguishing between important and less important attributes during the information search is even more critical than between fruitful and less fruitful alternatives.

6.6.1 Varying the size of the IDM

Do the results described in the previous section stay valid when varying the size of the IDM, from 15*11 to 11*15, other things being equal? Table 6.4 gives the results for this case. It turns out that the strategies III, S=54 and Vb still generate the best results, although they perform slightly worse than before, in terms of success rate and subjective loss. Again, the optimal focuses are more than twice as high as for the random strategy. This means that for having good results distinguishing between important and less important attributes as well as between fruitful and less fruitful alternatives is crucial. Now, as can be seen from the relative scores, distinguishing between fruitful and less fruitful alternatives is as critical as distinguishing between important and less important attributes.

Table 6.4 *Monté Carlo simulation results for five search strategies (see Table 6.3) with different size of the IDM: 11*15*

Strategy	Cell transitions type: 1	2	3	4	Distribution of cells opened: Altern. focus	Attrib. focus	Choice focus	Success rate	Subject. loss
I	0.0	8.4	6.1	85.5	1.79	1.59	0.06	42.5	3.94
II	0.0	93.9	0.0	6.1	7.15	0.50	0.79	52.5	2.82
III (S=50)	0.0	71.5	10.9	17.6	5.43	2.59	0.96	91.6	0.22
III (S=51)	0.0	66.0	14.9	19.1	5.22	2.80	0.97	91.8	0.21
III (S=52)	0.0	59.7	19.6	20.7	4.94	3.06	0.97	91.8	0.20
III (S=53)	0.0	54.1	24.7	21.2	4.69	3.26	0.97	91.9	0.18
III (S=54)	0.0	49.1	30.3	20.6	4.46	3.45	0.96	92.2	0.17
III (S=55)	0.0	43.8	36.2	20.0	4.23	3.64	0.96	91.7	0.18
III (S=56)	0.0	39.5	42.6	17.9	4.03	3.78	0.96	91.2	0.18
III (S=57)	0.0	35.3	47.9	16.8	3.83	3.93	0.95	90.5	0.19
III (S=58)	0.0	31.1	52.8	16.1	3.58	4.10	0.94	89.7	0.22
III (S=59)	0.0	28.3	56.7	15.0	3.44	4.20	0.94	88.3	0.26
III (S=60)	0.0	24.8	60.9	14.3	3.22	4.32	0.94	87.5	0.29
IV	0.0	0.1	91.5	8.4	0.50	5.31	0.06	71.3	0.83
Va (linear)	0.0	0.2	84.2	15.6	4.29	3.22	0.86	90.7	0.14
Vb (slow-quick-slow)	0.0	0.3	84.1	15.6	3.89	3.52	0.86	91.7	0.12
Vc (slow-quick-quicker)	0.0	0.1	89.0	10.9	1.88	4.66	0.33	81.4	0.36
Vd (jump)	0.0	1.0	82.9	16.1	3.29	4.47	0.99	80.8	0.53

Table 6.5 *Characteristics of attribute weights (w_i) for three different levels of dispersion (high, middle and low)*

	w_1	w_2	w_3	w_4	w_5	w_6	w_7	w_8	w_9	w_{10}	w_{11}
High[a]	0.18 (±0.02)	0.17 (±0.02)	0.16 (±0.01)	0.16 (±0.01)	0.13 (±0.03)	0.09 (±0.03)	0.05 (±0.02)	0.03 (±0.01)	0.02 (±0.01)	0.01 (±0.01)	0.01 (±0.01)
Middle[b]	0.17 (±0.03)	0.15 (±0.02)	0.14 (±0.02)	0.12 (±0.01)	0.11 (±0.01)	0.09 (±0.01)	0.07 (±0.02)	0.06 (±0.02)	0.04 (±0.02)	0.03 (±0.01)	0.02 (±0.01)
Low[c]	0.16 (±0.02)	0.13 (±0.01)	0.12 (±0.01)	0.10 (±0.01)	0.09 (±0.01)	0.08 (±0.01)	0.08 (±0.01)	0.07 (±0.01)	0.06 (±0.01)	0.06 (±0.01)	0.05 (±0.01)

N.B. Generating mechanism for:

[a]High dispersion: 4 ∈ {random(0,20) + 80}, 3 ∈ {random(0,100)}, 4 ∈ {random(0,20)}

[b]Middle dispers.: 11 ∈ {random(0,100)}

[c]Low dispersion: 4 ∈ {random(0,120) + 40}, 3 ∈ {random(0,80) + 40}, 3 ∈ {random(0,40) + 40}

6.6.2 Varying the attribute weights

So far the attribute weights have been generated by random drawings from a uniform distribution (followed by re-scaling and re-ordering). This leads to an average distribution as shown as in the middle row of Table 6.5. The total weight of the first 50% of the attributes equals 73.5% of the total weight. What will happen to the effectiveness of the information search strategies when the dispersion in weights is varied? Two other generating mechanisms have been used to simulate a high and a low dispersion (see footnote Table

6.5). In case of a high dispersion the first 50% of the attributes represent 84.5% of the total weight and for the low dispersion this figure equals only 64.0%.

In general, the higher the dispersion of the attribute weights the better the results of a strategy in terms of success rate and subjective loss, see Tables 6.3, 6.6 and 6.7. Exceptions are strategy I (random search) and strategy II (pure alternative-based search) which yield higher subjective losses for an increasing rate of dispersion. For all dispersions, again, the strategies III (alternative-based with minimum level) and V (elimination) perform the best. Also, as before, among the elimination strategies, the 'slow-quick-slow' pattern (Vb) turns out to be the best. For strategy III, the optimal level of S varies with the rate of dispersion. In case of a low level of dispersion of attribute weights, S=52 generates the best results, for the standard (middle) level of dispersion, S=54 and for the high level of dispersion, S=58 (highest success rate) or even S=60 (lowest loss).

Table 6.6 *Monte Carlo simulation results for five search strategies (see Table 6.3) with different attribute weights (high dispersion)*

Strategy	Cell transitions type: 1	2	3	4	Distribution of cells opened: Altern. focus	Attrib. focus	Choice focus	Success rate	Subject. loss
I	0.0	6.2	8.4	85.4	1.58	1.80	0.10	38.2	5.28
II	0.0	91.5	0.0	8.5	5.31	0.50	0.86	51.8	3.40
III (S=50)	0.0	69.3	13.0	17.7	4.02	3.51	0.97	94.1	0.18
III (S=51)	0.0	64.7	16.3	19.0	3.86	3.77	0.97	95.0	0.14
III (S=52)	0.0	60.7	19.8	19.5	3.73	4.00	0.98	95.2	0.12
III (S=53)	0.0	55.7	24.2	20.1	3.57	4.26	0.97	95.8	0.11
III (S=54)	0.0	51.4	28.4	20.2	3.42	4.48	0.98	95.8	0.10
III (S=55)	0.0	48.0	32.3	19.7	3.33	4.64	0.97	95.9	0.09
III (S=56)	0.0	42.8	38.0	19.2	3.13	4.92	0.98	95.9	0.09
III (S=57)	0.0	39.0	42.7	18.3	3.01	5.10	0.97	96.1	0.09
III (S=58)	0.0	34.9	48.8	16.3	2.86	5.30	0.98	96.2	0.08
III (S=59)	0.0	31.4	53.7	14.9	2.72	5.48	0.97	96.1	0.08
III (S=60)	0.0	28.3	57.7	14.0	2.59	5.64	0.97	95.7	0.07
III (S=61)	0.0	25.1	61.4	13.4	2.44	5.81	0.97	95.1	0.08
IV	0.0	0.1	93.9	6.0	0.50	7.15	0.08	83.8	0.33
Va (linear)	0.0	0.1	89.0	10.9	2.73	4.92	0.81	94.8	0.06
Vb (slow-quick-slow)	0.0	0.1	89.0	10.9	2.73	4.94	0.81	97.3	0.03
Vc (slow-quick-quicker)	0.0	0.1	91.5	8.5	1.71	6.05	0.45	92.7	0.06
Vd (jump)	0.0	0.5	90.2	9.3	1.36	6.84	0.63	87.1	0.29

Table 6.7 *Monte Carlo simulation results for five search strategies (see Table 6.3) with different attribute weights (low dispersion)*

Strategy	Cell transitions type: 1	2	3	4	Distribution of cells opened: Altern. focus	Attrib. focus	Choice focus	Success rate	Subject. loss
I	0.0	6.2	8.4	85.4	1.58	1.81	0.10	38.3	4.56
II	0.0	91.5	0.0	8.5	5.31	0.50	0.89	50.5	3.07
III (S=50)	0.0	70.0	13.0	17.0	4.05	3.44	0.97	91.3	0.24
III (S=51)	0.0	64.3	17.0	18.7	3.84	3.78	0.97	91.5	0.22
III (S=52)	0.0	58.7	21.5	19.8	3.66	4.09	0.98	91.7	0.22
III (S=53)	0.0	52.6	27.0	20.4	3.44	4.43	0.98	91.5	0.22
III (S=54)	0.0	47.0	32.5	20.4	3.25	4.72	0.98	91.0	0.23
III (S=55)	0.0	41.9	38.4	19.7	3.08	4.98	0.98	89.6	0.26
III (S=56)	0.0	36.5	44.7	18.8	2.87	5.25	0.98	88.9	0.29
III (S=57)	0.0	32.0	51.5	16.6	2.70	5.47	0.97	87.6	0.34
III (S=58)	0.0	28.6	56.3	15.1	2.58	5.63	0.97	86.5	0.37
III (S=59)	0.0	24.6	61.6	13.8	2.39	5.85	0.96	83.7	0.47
III (S=60)	0.0	20.9	66.2	12.9	2.19	6.05	0.94	82.4	0.52
IV	0.0	0.1	93.9	6.0	0.50	7.15	0.08	58.5	1.82
Va (linear)	0.0	0.1	89.0	10.9	2.73	4.92	0.81	75.6	0.55
Vb (slow-quick-slow)	0.0	0.1	89.0	10.9	2.73	4.94	0.81	81.4	0.33
Vc (slow-quick-quicker)	0.0	0.1	91.5	8.5	1.71	6.05	0.45	68.1	0.95
Vd (jump)	0.0	0.7	90.2	9.1	1.36	6.84	0.63	66.7	1.15

6.6.3 Varying the levels of information

Table 6.8 gives the success rate and subjective loss of different strategies for various levels (n) of cells to open. The random search strategy (I) performs worst, except for small n, where it beats strategy II. The success rate of this pure alternative-based strategy (II) increases almost linearly with n, also visualized in Figure 6.3. The marginal increase in effectiveness of the other strategies is at its highest at the beginning and then gradually becomes smaller. At the end, n=N=165, when all information has been acquired, the results of all strategies are equal. The slope of the line of strategy IV (attribute-wise search) is not smooth because of the difference in additional value of information cells with a cycle of 11; i.e. for R=1,2,...,14 cell 11*R+1 is likely to generate more value than cell 11*R+2, which in turn provides more value than cell 11*R+3, and so on, till cell 11*R+11. The reason for this is that each column is handled in such a way that the so far best alternative is treated first, followed by the second best, third best, and so on (for details see *Appendix*).

Table 6.8 Success rate and average loss for five search strategies (see Table 6.3) for varying number (n)of cells to be opened

Success rate of strategy:	N=21	N=41	N=62	N=83	N=103	N=124	N=144	N=165
I	17.7	24.2	30.7	38.4	45.8	55.8	69.5	100.0
II	15.0	26.6	38.5	51.6	63.2	74.7	86.9	100.0
III (S=54)	38.0	63.7	83.1	94.4	98.4	99.8	100.0	100.0
IV	32.3	42.6	58.7	70.0	76.5	90.2	95.5	100.0
Vb (slow-quick-slow)	35.6	57.6	74.0	93.4	99.3	100.0	100.0	100.0
Subjective loss of strategy:	N=21	N=41	N=62	N=83	N=103	N=124	N=144	N=165
I	10.60	8.40	6.55	4.90	3.53	2.31	1.12	0.00
II	10.49	6.97	4.64	3.15	2.11	1.29	0.60	0.00
III (S=54)	4.88	1.75	0.56	0.14	0.03	0.00	0.00	0.00
IV	6.26	4.05	1.93	1.05	0.59	0.11	0.03	0.00
Vb (slow-quick-slow)	5.55	2.09	0.76	0.09	0.01	0.00	0.00	0.00

Among the elimination strategies the one with the slow-quick-slow pattern (Vb) turns out to be the best for all levels of n. Together with strategy III (alternative-based with minimum level S=54) this strategy performs the best. Comparing the success rate of both strategies for increasing n, it shows that strategy Vb gets behind first, then catches up and finally takes a small lead.

6.6.4 Summary of simulation results

Several information search strategies have been analyzed and compared under various conditions (size, weights and access to information) of the IDM. It shows that, in general, purely (naïve) alternative-based or attribute-based searching defeats random searching. Furthermore, under all conditions, attribute-based searching improves when alternatives are eliminated during the process. Several elimination patterns have been tested and the 'slow-quick-slow' elimination of alternatives turns out the best. Also, under all conditions, alternative-based searching improves when a minimum level of expected weighted additive value (S) is introduced. The optimal level of S, however, varies with the dispersion of attribute weights. Finally, one can not say in general that (modified) attribute-based searching generates better results than (modified) alternative-based searching. Both are capable of reaching excellent results, in terms of success rate and subjective loss. Some conditions (low dispersion of weights and a moderate level of access to information) are more favorable for alternative-based searching and others (high dispersion of weights, high level of access to information) for attribute-based searching. In short, we find support for hypotheses H1, H3, H4 and H5, under various conditions (H6, H7 and H8). No general support is found for H2 in the simulation part.

6.7 Decision strategies of flower producers; empirical results

The results of the task described earlier in *Method and material* are presented in Table 6.9. We refer to the search characteristics as described earlier (see Table 6.2). With respect to the search depth: a maximum information limit of 83 cells has been set, as in the simulation. Only two participants reach this limit. On average, 61 different cells are viewed, nearly 75% of the maximum limit. With respect to the sequence of information acquisition, it shows that type 3 (vertical, attribute-based) transitions occur most frequently (48% on average), followed by type 2 (horizontal, alternative-based) transitions (36%), type 4 (random) transitions (14.7%) and type 1 (repetition) transitions (1.1%). With respect to their search strategies, the participants have been classified into one of three head categories: alternative-based searching, attribute-based searching and mixed searching. A participant falls into the first category if the amount of type 2 transitions is larger than the amount of type 3 transitions by at least 10 percentage points. Likewise, classification into the second category follows when the amount of type 3 transitions is larger than the amount of type 2 transitions by at least 10 percentage points. Otherwise, a participant falls into the mixed category. According to this classification 9 participants have followed an alternative-based search strategy, 12 have followed an attribute-based strategy and 4 have followed a mixed strategy (and from one participant the information has been lost). When considering the focuses in cells opened, it shows that the average alternative focus is 3.35 and nearly equals the attribute focus (3.38). The average choice focus is 1.43, that means that the proportion of cells opened for any chosen alternative is 143% higher than for an arbitrary alternative.

How good are the final choices? *Subjective loss,* defined as the difference in weighted additive value of the optimal alternative versus the chosen alternative, will be used as the quality measure of final choice. Subjective weights and values, needed to calculate this measure, were taken from the individual participants' judgments (for details see *Method*). When a participant divides the available area (10,000 m^2) over more than one alternative the loss is calculated as a weighted average. The average subjective loss of all 26 participants equals 2.4. Classified by search strategy: the average loss of the (nine) participants using mainly alternative-based searching is 3.6, versus 1.5 for the (twelve) persons using mainly attribute-based searching and 2.0 for those (four) using a mixed strategy. In three cases (growers 3, 13 and 21), where they allocate their total area to their optimal alternative, the subjective loss equals zero. Ten growers allocate part, between 0.4 and 0.7, of their total area to their optimal alternative. The rest, 13 growers, do not seem to detect their best alternative and allocate their total production area to sub-optimal alternatives.

*Table 6.9 Characteristics of search processes of 26 growers in a 15*11 IDM, when 83 cells are allowed to be opened*

Grower	# Cells	Cell transitions type:				Search	Distribution cells opened:			Subj.
	opened	1	2	3	4	type	Altern.	Attrib.	Choice	Loss
1	49	0.0	47.9	20.8	31.3	Altern.	2.08	4.62	1.14	0.5
2	53	0.0	28.3	56.6	15.1	Attr.	2.75	3.93	1.51	0.4
3	52	1.9	28.3	49.0	20.8	Attr.	3.22	3.52	2.18	0.0
4	55	1.7	51.7	31.0	15.6	Altern.	3.34	3.62	1.72	3.5
5	52	1.9	76.9	15.4	5.8	Altern.	4.62	1.21	2.18	2.7
6	53	1.9	43.4	32.1	22.6	Altern.	3.03	3.24	1.55	2.7
7	56	1.8	32.1	51.8	14.3	Attr.	3.51	3.03	0.07	1.6
8	65	0.0	23.5	65.6	10.9	Attr.	2.84	4.40	1.42	3.6
9	72	0.0	66.2	22.5	11.3	Altern.	5.08	1.72	1.29	8.0
10	83	0.0	1.2	90.2	8.6	Attr.	2.22	5.53	0.54	0.1
11	56	1.7	36.2	48.3	13.8	Attr.	3.43	3.65	1.95	3.7
12	54	3.1	59.4	23.5	14.0	Altern.	3.18	2.35	1.50	7.1
13	83	0.0	12.2	81.7	6.1	Attr.	4.10	3.09	0.99	0.0
14	76	0.0	48.0	34.7	17.3	Altern.	3.00	4.34	1.17	3.7
15	58	4.8	38.1	46.0	11.1	Mix	3.46	3.02	1.84	1.2
16	26	3.8	38.5	46.2	11.5	Mix	2.41	2.01	2.47	4.3
17	48	0.0	25.5	51.1	23.4	Attr.	3.17	3.26	2.44	2.4
18	72	1.4	36.5	41.9	20.2	Mix	3.04	3.89	0.88	2.1
19	61	0.0	61.7	15.0	23.3	Altern.	3.49	3.29	1.24	1.8
20	82	1.2	8.5	81.8	8.5	Attr.	3.36	4.27	0.65	0.5
21	49	0.0	33.4	54.2	12.4	Attr.	2.77	3.82	2.06	0.0
22	70	*	*	*	*	*	4.32	2.10	1.36	3.9
23	73	0.0	39.7	42.5	17.8	Mix	3.30	4.48	1.26	0.4
24	80	0.0	3.8	87.3	8.9	Attr.	3.81	3.62	0.88	3.9
25	65	0.0	15.6	84.4	0.0	Attr.	4.71	2.87	1.54	2.1
26	47	2.0	48.0	27.1	22.9	Altern.	2.82	3.04	1.44	2.6
average	61	1.1	36.2	48.0	14.7		3.35	3.38	1.43	2.4

*) information was lost by erroneous computer handling

The average subjective loss is larger than 'necessary', as can be seen from a comparison with the Monte Carlo simulations. For instance, for N=83 losses can be close to zero and for N=62 losses can still be smaller than 1 (see, Table 6.8, strategies III and Vb). To see whether the cause may be a sub-optimal information search strategy, a comparison with the previous Monte Carlo simulation results now follows. The alternative focus lies in the region where optimal results can be expected, but the attribute focus is too small to generate optimal results, 3.4 versus 4.6 (strategy III, S=54) or 4.9 (strategy Vb) in the simulation. This means that participants in general do not distinguish between important and less important attributes as much as needed for generating optimal final results. Furthermore, the participants use relatively more information of the chosen alternative than in the best search strategies: choice focus 1.43 in the task versus 0.81 to 0.98 in the Monte Carlo simulation. This difference suggests either a sub-optimal search strategy in which too many information cells are used for confirmation of the right choice, or a sub-optimal choice strategy in which better known alternatives are preferred to less known alternatives, although the latter ones may have a higher expected value.

To further investigate the relation between the characteristics of the information search process and the quality of the final choice a regression analysis has been performed. Subjective loss is taken as dependent and search characteristics as independent variables. Only one variable (attribute focus) arises as significant in this multiple regression. A problem, however, is the multi-collinearity in the data. We therefore choose to reduce the regression model to one independent variable and follow it by a multivariate technique (factor analysis) to uncover the structure between dependent variables. After skipping the non-significant variables the (partial) correlation coefficient between subjective loss and attribute focus equals -0.56. This significant correlation means: the higher the attribute focus the lower the loss. Factor analysis shows the structure of coherence between the independent variables (see Table 6.10). According to factor 1 in Table 6.10, a high attribute focus correlates with a high number of cells opened, a large share of type 1 and type 3 cell transitions, a small share of type 2 cell transitions and a relatively low level of choice focus. Also, as can be seen from factor 2 in Table 6.10, a high level of attribute focus correlates with a low level of alternative focus and a relatively large share of type 4 cell transitions.

Table 6.10 *Factor loadings (correlations) between independent variables characterizing the search processes of 26 participants in an IDM*

Variable (% of variance)	Factor 1 (42.6)	Factor 2 (25.8)	Factor 3 (16.1)
# Cells opened	0.79	-0.26	-0.43
Cell transitions type 1	-0.57	-0.12	0.50
Cell transitions type 2	-0.85	-0.08	-0.47
Cell transitions type 3	0.86	-0.17	0.46
Cell transitions type 4	-0.39	0.79	-0.33
Attribute focus (columns)	0.65	0.71	-0.01
Alternative focus (rows)	-0.03	-0.91	-0.31
Choice focus	-0.65	-0.06	0.47

6.7.1 Summary of empirical results

Thirteen participants (50%) fail to detect their optimal alternative. The average subjective loss incurred is 2.4, which is higher than the optimal value in the Monte Carlo simulation. Average losses are found to be higher for persons using alternative-based searching versus persons using attribute-based searching. To explain differences in loss between participants a regression analysis has been performed. It shows that participants who have a small subjective loss also have, in general, a high level of attribute focus, i.e. make a sharp distinction between important and non-important attributes. This generally goes together with a high number of information cells opened (search depth) and a high percentage of type 3, attribute-wise, cell transitions. Participants facing a higher loss seem to focus more on alternatives instead of attributes. Their percentage of type 2, alternative-wise, cell transitions is higher. Also their choice focus is higher, suggesting that in their search strategy they are led by finding confirmation and/or in their choice strategy they are led by avoid promising, yet less well-known (i.e.risky) alternatives. Referring to the hypotheses, H2 and H9 find support in this empirical part. The other hypotheses can not be tested here.

6.8 Conclusion and discussion

Information display matrices (IDMs) have been used in many studies to analyze decision-making processes. It is a well-known fact from these empirical settings that some people search for information in mainly an alternative-based way, while others search mainly attribute-wise. This study has been addressing the question why attribute-based searching for information is likely to generate more rational choices than alternative-based searching. This general question has been explored in a Monte Carlo simulation as well as in an empirical setting.

First several search strategies have been defined, from purely alternative-based and attribute-based to various hybrids. Then, indicators have been defined to characterize these strategies. These have been partly taken from literature, like the search depth to represent the amount of information acquired and the four types of cell transitions to represent the sequence of information acquisition. Also three new indicators have been introduced: attribute-focus, alternative-focus and choice-focus. These characterize the distribution of opened cells in the IDM. They turn out to be a useful device in detecting strengths and weaknesses of search strategies.

The Monte Carlo simulation shows that both alternative-based and attribute-based searching are capable of generating excellent results in terms of success rate and subjective loss. The empirical part, however, shows subjective losses that are (1) higher on average and (2) different between the search strategy used. Participants using mainly attribute-based searching incur a lower loss than persons using mainly alternative-based searching.

The following considerations seem to be relevant in explaining these results. Firstly, subjective loss was based on the weighted additive value ($\sum w_i * x_{ij}$). Participants may have other concerns, which are not captured by this decision rule. Especially risk considerations seem to be present, leading participants to choosing more than one alternative, thereby deliberately decreasing both the mean and the variance of the expected value. Secondly, a correlation has been found between the level of loss and the level of attribute focus, indicating that participants who make a sharp distinction between important and less-important attributes incur a smaller subjective loss. It seems that some participants start searching through the IDM before considering first what weight they would attach to various attributes. They are inclined to search alternative-wise, in order to find a reasonable, satisfying, not necessary optimal, solution. Others first consider which attributes are most important to them and then start searching for information. They are inclined to search attribute-wise, and they probably have a higher motivation to find the optimal solution.

Future research may focus on further improving and testing of search strategies. Within the class of attribute-based strategies, the pattern of elimination of alternatives has been fixed to one of four patterns. However, a further modification may be to vary the speed of elimination, depending on the weights drawn in each simulation. Also, the power of various search strategies may be tested under less well-defined assumptions. As an example one can think of other distributions of cell scores. Here they have been drawn from a uniform distribution on (0,100). But, since in reality the underlying distribution(s) will often be unknown, it seems worthwhile to follow a two-step procedure: (1) randomly generate a distribution from a set of distributions, (2) randomly generate a cell score form this 'underlying' distribution.

In the field of decision support, further research may focus on how decision-makers can be helped to improve their information search strategies. The results from this paper suggest that decision-makers may improve their search strategies, followed by more rational final choices, when they first consider the relevant attributes and their relative importance. Simple exercises ("divide 100 points among these attributes...") can be used to stimulate this process of awareness. The effects can be measured in an experiment in which some participants are presented an IDM straightaway, and others get some exercises first.

6.9 Appendix 1 Detailed description of search strategies

(Note: Best and next-best alternative are measured in terms of expected weighted additive value (the product of attribute weights and expected cell scores: $EV = \sum w_i * x_{ij}$))

Strategy I: random search
(Note: stop searching if n cells have been opened)
1. randomly open a cell
2. continue as in 1
3. choose the alternative with the highest EV

Strategy II: Alternative-based search
(Note: stop searching if n cells have been opened)
1. open cell (A,1)
2. move horizontally until all cells of this row have been opened
3. switch to the next row (and continue as in 2)
4. choose the alternative with the highest EV

Strategy III: Alternative-based search with minimum expected value
(Note: stop searching if n cells have been opened)
1. open cell (A, 1)
2. move horizontally from one cell to the other as long as the EV of this alternative at least equals S (e.g. S = 55)
3. if the EV falls below S switch to the first unopened cell of the next best alternative (and continue as in 2)
4. if all cells of an alternative are opened, go to the first unopened cell of the next best alternative (and continue as in 2)
5. if all rows are handled, lower S (e.g. S := S - 1) and switch to the best alternative (and continue as in 2)
6. choose the alternative with the highest EV

Strategy IV: Attribute-based search
(Note: stop searching if n cells have been opened)
1. open cell (A,1)
2. move vertically until all cells of the first column have been opened
3. switch to the next column, move vertically, start with the best alternative, then the second best alternative, and so on, until all cells of the column have been opened
4. continue as in 3
5. choose the alternative with the highest EV

Strategy V: Attribute-based search with elimination
(Note: stop searching if n cells have been opened)
1. open cell (A,1)
2. move vertically until all cells of the first column have been opened
3. eliminate q_i alternatives with the lowest EV
4. switch to the next column, move vertically, start with the best alternative, then the second best alternative, and so on, until all cells except for the eliminated alternatives are opened
5. (i := i + 1) and continue as in 3 and choose the alternative with the highest EV

References

Ball, C. (1997). A comparison of single-step and multiple-step transition analyses of multi-attribute decision strategies. *Organizational Behavior and Human Decision Processes* 69, 195-204.

Bettman, J.R. (1979). *An information processing theory of consumer choice*. Reading Massachusetts: Addison-Wesley Publishing Company.

Davidson, D. (1996). The effects of decision characteristics on children's selective search of predecisional information. *Acta Psychologica* 92, 263-281.

Devine, D.J. and Kozlowski, S.W.J. (1995). Domain-specific knowledge and task characteristics in decision making. *Organizational Behavior and Human Decision Processes* 64, 294-306.

Doyle, J.R., Green, R.H. and Cook, W.D. (1995). Upper and lower bound evaluation of multi-attribute objects: comparison models using linear programming. *Organizational Behavior and Human Decision Processes* 64, 261-273.

Einhorn, H.J. and Hogarth, R.M. (1981). Behavioral decision theory processes of judgement and choice. *Annual Review of Psychology* 32, 52-88.

Hogarth, R.M. (1987). *Judgement and choice: The psychology of decision (2nd ed.).* Chichester: John Wiley and Sons.

Jacoby, J., Chestnut, R.W., Weigl, K.C., and Fisher, W. (1976). Pre-purchase information acquisition: description of a process methodology, research paradigm, and pilot investigation. *Advances in Consumer Research* III, 306-314.

Kleindorfer, P.R., Kunreuther, H.C. and Schoemaker, P.J.H. (1993). *Decision sciences: an integrative perspective*. Cambridge: Cambridge Univ. Press.

Lohse, G.L. and Johnson, E.J. (1996). A comparison of two process tracing methods for choice tasks. *Organizational Behavior and Human Decision Processes* 68, 28-43.

Payne, J.W. (1976). Task complexity and contingent processing in decision making: an information search and protocol analysis. *Organizational Behavior and Human Performance* 16, 366-387.

Payne, J.W., Bettman J.R. and Johnson E.J. (1993). *The adaptive decision maker*. Cambridge: Cambridge Univ. Press.

Plous, S. (1993). *The psychology of judgment and decision making*. New York: McGraw-Hill.

Simon, H.A. (1982). *From substantive to procedural rationality. Models of bounded rationality, vol. 2*. Cambridge: MIT Press, 424-443. (First published in 1976)

Timmermans, D. and Vlek, Ch. (1996). Effects on decision quality of supporting multi-attribute evaluation in groups. *Organizational Behavior and Human Decision Processes* 68, 158-170.

Van Raaij, W.F. (1976). *Consumer choice behavior: an information-processing approach*. Tilburg: Tilburg University Press. (PhD-thesis)

7 General discussion

7.1 Introduction

The main objective of this study, as described in Chapter 1, was to gain insight into the management processes of the greenhouse growers. A homogenous group of 26 specialized chrysanthemum growers participated in this research. The growers met in an off-farm workshop in which their decision making with respect to production planning and cultivar choice was analysed. The participants completed several tasks, one of which was a cultivar choice game. Furthermore, the growers agreed to participate in a follow-up year, consisting of bimonthly on-farm visits. During this follow-up, interviews were held and data were collected on firm structure, sales, prices, production, information use, computer use, et cetera. A quantitative analysis was done to estimate firm efficiencies and to estimate the effects of the quality of the decision-making process.

This final chapter contains a discussion of the methods used (7.2). Furthermore, an outlook on management support (systems) is included (7.3).

7.2 Methodological issues

7.2.1 Measuring firm performances

One of the research questions (see Chapter 1) of this study was to find an explanation for why some growers are more effective than others, especially with respect to production planning and cultivar choice. The technique of the stochastic frontier production function was used to estimate firm (in)efficiencies (Chapter 3). For the past few decades this method has been widely used in studies that compared efficiencies (see Chapter 2). The concept of the frontier fits nicely within the definition of the production function in terms of the *maximum* output that can be produced from a specified set of inputs, given the existing technology available (Battese, 1992). Traditional least-squares (OLS) regression techniques would not generate a production function as described above, but a function that could be more appropriately described as a response (or *average*) function (Battese, 1992). However, it is interesting to compare both methods. We therefore use the (traditional) multiple OLS regression technique as an alternative method for deriving firm-specific performances. An advantage of the OLS technique is that it can easily generate decomposed performances of turnover into a quantity and price effect. From a management perspective such decomposed performance indicators are important, since they supply more detailed information on what goes well and what can be improved.

Table 7.1 gives the results of a loglinear regression of turnover per m² (T) on the firm-structural variables construction year of the glasshouses (CY), labour input (LA) and area of supplementary lighting (SL) for the 26 firms. These firm-structural variables are the same as in the stochastic frontier production function (Chapter 3). Also the loglinear form of the model is similar to the one in Chapter 3. The parameters in Table 7.1 were estimated by using Ordinary Least Squares (OLS).

Table 7.1 *Parameter estimates and standard errors for the multiple loglinear regression models of turnover, price and quantity on firm-structural variables*

Independent variables	Dependent variable		
	Turnover Ln(T)	Price Ln(P)	Quantity Ln(Q)
Constant	-137.09**	-96.71**	-40.83
	(47.30)	(42.30)	(37.73)
Construction year; Ln(CY)	18.372**	12.437**	5.993
	(6.191)	(5.537)	(4.939)
Labour input; Ln(LA)	0.2323*	0.1670	0.0661
	(0.1497)	(0.1339)	(0.1194)
Supplementary lighting; SL (0/1)	0.199**	0.185**	0.014
	(0.046)	(0.041)	(0.037)
	R^2=0.53**	R^2=0.52**	R^2=0.07

** = highly significant, * = moderately significant

The estimation for turnover (T) can be split into an estimation for price (P) and quantity (Q), see Table 7.1. Since T= P*Q by definition, and therefore Ln(T) = Ln(P) + Ln(Q), the estimated coefficients for the price and quantity equation add up to coefficients in the turnover equation. From these regressions, expected individual levels of turnover, price and quantity can be calculated for each firm, given its firm-structural input, i.e. given its construction year of the glasshouse, labour input and whether or not it uses supplementary lighting. These levels tell farmers what turnover, price and quantity they can expect on average, given their firm structure. If the real turnover is higher than the expectation, we say that *performance* is better than average. As an example, firm 3 (CY=1990.5, LA=6010, SL=1) has an expected turnover of NLG 108 per m^2, yet the real turnover was NLG 126 per m^2, i.e. 17% higher. This total effect can be divided into a price effect, +6% higher than the average norm, and a quantity effect, +10% higher than the expected average[1]. Knowledge of these performances is important from the grower's management control perspective.

From Table 7.1 it can be seen that turnover and price depend for slightly more than fifty percent on firm-structural variables, whereas quantity depends on the structural variables for only seven percent. So slightly less than fifty percent of the differences in turnover and price and almost all the variation in quantity remain to be explained by other factors. This is the scope for management capacity at the tactical level. Here the growers/managers will apply their personal talents to make the right decisions for using the available resources and to optimize farm results (Figure 2.1, Chapter 2). One should realize, however, that growers/managers are operating in an uncertain environment that partly lies beyond their control (e.g. weather conditions) and beyond their ability to predict (e.g. price fluctuations; see also Chapter 4). So it can reasonably be assumed that differences in results among growers are also partly accidental.

The estimated turnover performances by the regression technique can be compared with the estimated efficiencies by the stochastic frontier production function approach in Chapter 3. They turn out to be highly correlated. The correlation between both estimates is nearly perfect (Pearson correlation coefficient 0.99; Spearman rank correlation 0.98). From a theoretic point of view the frontier technique is superior, since it is compatible with the definition of the production function as the maximum output, given the available inputs. However, for practical purposes the estimated performances from the OLS regression technique are preferred. The main advantagesare (1) the possibility of further decomposition of the turnover performance into quantity performance and price performance[2] and

[1] Similar results were found in the frontier analysis. The estimated efficiency in the frontier analysis of firm 3 was 0.957 (see Chapter 3, table 6), 14% higher than the mean efficiency.

[2] A further decomposition of the price performance can be made. Price benefits can be the result of a better understanding of the market (predictions of supply and demand, contacts with buyers, et cetera) or the result of a successful quality policy (uniformity, weight, free of damage, et cetera) of the grower. The former, labelled as market performance, can be estimated by comparing the auction price of the cultivar chosen with the overall auction price. That means, the market performance of firm X, producing cultivar x, can be calculated as P(x) /P, where P(x) is the average price of all firms producing cultivar x and P is the average price of all firms producing chrysanthemums. The quality performance can be calculated as the residual between overall price performance and market performance. For instance, the overall price performance of firm 3, estimated as 1.06 (i.e. +6%) can be decomposed into a market performance of 1.05 (i.e.+5%) and a quality performance of 1.01 (i.e. +1%). This means that firm 3 was successful in all three aspects (quantity, market and quality).

(2) the ease of interpretation as relative performances.[3] This makes them more suitable as management tools for growers and their advisers.

7.2.2 Measuring management capacity

Management can be defined as making the best possible use of available scarce resources to achieve the objectives set (Turner and Taylor, 1998:1). Simple in definition, yet complex in nature, and for measuring management capacity a more elaborate model is needed. Such a model was introduced in Chapter 2. It distinguishes (1) the manager as a person (his/her drives and motivations, abilities and personal biography and background), (2) the dynamic decision-making processes (along the line of planning, implementation and control), (3) the technical and biological processes, (4) the results of the firm and (5) the environment in which the decision making takes place. When management capacity is measured, usually some of these aspects are taken into account. However, as argued in Chapter 2, studies to explain differences in firm results, in terms of technical or economic efficiency, usually do not go further than adding one or more biographical aspects (e.g. age and level of education). A next step would be to include aspects of the decision-making process and other (personal) aspects of management capacity. However, these aspects are difficult to quantify and little to no standardization has been established in this field. Measuring management capacity, including the quality of decision making, is therefore subjective to a large extent. Alleblas (1987) measured management capacity of 63 horticultural growers by means of a model consisting of three management areas (strategic level, tactical production planning and operational level) and three other areas (level of education, firm modernity and social aspects, such as working facilities for personnel). Scores were derived from interviews. Alleblas combined all aspects to measure an overall management score. A factor analysis was used by Alleblas to analyse existing associations between variables. Bots (1991) used a list of management items for scoring and measuring the complexity of a firm as well as its quality of the decision making. Eight pot plant nurseries were scored by an interview. The items focused on tactical and operational production planning and contained issues such as frequency of planning, use of (written) information sources, regular control, et cetera. Multiple regression and path analysis were used to estimate the (inter)relations

[3] A message stated as "Your turnover lies x% above the average level of turnover of comparable firms with similar technology input" is easier to interpret than "Your firm efficiency lies y% below the maximum attainable efficiency, i.e. z% above the mean efficiency". This is partly because the first statement can be givenin meaningful units (money), whereas the second statement is dimensionless, and partly because of the frontier being an artificial concept of what might be (Müller, 1974).

among complexity, quality of decision making and the firm's financial result. Ziggers (1993) added personal characteristics to this framework for measuring management capacity, such as performance motivation on the positive side, and social fear and fear of failure on the negative side. He used path analysis as a technique to estimate the impact of complexity, personal characteristics and quality of decision making on financial results of 39 pot plant producers. All these studies showed some relation between measured management capacity and firm's financial yield. The variation in results explained by management aspects lay around 30% (Alleblas, 1987:139) to 45% (Ziggers, 1993: 102), indicating that a large part of the differences in results could not be attributed to the measured level of management capacity.

Point of discussion is what to include in a management or decision-making score. In line with our sequential model of management capacity (person → decision making → physical firm processes → firm results, Chapter 2), we advocate to separate elements from different steps. The idea behind the model is that favourable personal characteristics (e.g. high level of intelligence) do not directly lead to better firm results. Only through an improved quality level of decision making and through changes in the physical processes can these personal characteristics have an impact on the firm's (financial) results. By the same token, interpreting the model in reverse order, differences in firm results (prices, quantities, waste, vacancy, et cetera) can be fully explained by the underlying physical processes (planting, crop growth, development of diseases, crop treatments, harvesting, post-harvesting, et cetera) without taking into account the human management factor. Such a technical model, however, is not satisfying from a management point of view. Therefore, one can take into account the quality level of decision making (with respect to cultivar choice, production planning, quality policy, et cetera). Again, differences in decision making could explain everything, without necessarily having to rely on personal aspects (motivation, level of intelligence, level of education, et cetera).[4] Finally, if one is interested in a deeper layer of explanation, one can include the personal aspects in the analysis and try to find out which characteristics have a significant influence, through the decision-making and the physical processes, on the final results. In summary, each layer in the model could explain the differences in results; however, the deeper the layer, the more helpful for explaining and improving the management process.

---

[4] That is in theory, since in practice there will be disturbances from the outside environment that are beyond the control and circle of awareness of even the most prescient decision maker.

7.2.3 Future research

For analysing decision processes, which are dynamic in nature, it is important to enter into a sustained contact with the decision makers. Only then is it possible to observe the whole cyclical process of planning-implementation-control. Furthermore, by establishing a basis of trust between researcher and the decision maker observed, less desirable facts which the decision maker would otherwise cover up, can be brought to the surface. For example, when asked about on-farm computer use for management purposes during the first session, many growers gave a positive impression. However, during the year of observation things turned out to be less positive for some of them. Some growers admitted that their computer was not used at all. Some said that the computer was predominantly used by the kids for playing games. Others said they had recorded many data in the past, but had quit doing so because of the huge amount of time needed for it and the relatively small benefits. Only a few were actually using the computer for planning and evaluation purposes. One danger of sustained contact between researcher and decision maker is that the latter may (gradually) change his/her decision making because of learning effects through the research. This means that the researcher must be cautious and ask questions in a neutral way and must not give feedback on the process until the research period is over. But even then, learning effects during the research period cannot be totally excluded.

For future research we recommend the further use of a longitudinal set-up. An important improvement within this framework would be the use of (already existing) farm accounting data. An interesting moment for research on management processes would be, when the software industry launches a new product. The rate of adoption and diffusion could then be analysed in relation to the existing decision-making processes.

Also it would be worthwhile to develop standardized instruments to measure management capacities. One general indicator of management is not very likely to be sufficient. Considering the many different tasks of management, several indicators for several tasks should be developed.

7.3 Outlook on management support

In line with our model of management ability, we distinguish two basic ways of management support: (1) through supporting the personal skills of the manager (2) through directly supporting the decision-making processes of planning-implementation-control. Since the focus of this study has been on the quality of the decision-making process, we will limit the discussion to this subject, after having noted that persistent improvement of the decision making can only be realized when the entrepreneur's competence is sufficient. That means that the growers' willingness to evaluate and criticize theirown decisions as well as their learning ability are crucial in keeping the firm profitable (e.g. Hedges, 1963, Zachariasse, 1974).

With respect to supporting the decision-making processes we will discuss (1) the hierarchic level of decision making (strategic, tactical, operational) and (2) the phase of the process (planning, control). First, the distinction of decision making into several levels has been well-established in management theory. Leutscher (1995) gives a concise summary of farm management concepts and shows that the management concept of strategic-tactical-operational level, introduced by Anthony (1965), has seen many variations. However, the basic idea is similar: some (strategic) decisions with long-term consequences define the space for the lower-level, medium-term and short-term (tactical and operational) decisions. Our study was focused on cultivar choice and production planning, medium-term (tactical) decisions that do not lay down things for many years, but clearly go beyond the day-to-day level. That means that the effect on firm results at this level of decision making also depends on the quality of both the strategic decisions already made and the operational day-to-day work yet to come. An improvement in production planning, a more careful cultivar choice, for instance, should take into account the strategic choices ((re)investment policy, personnel recruitment policy, use of artificial lighting, et cetera) and also the possibilities of improving the day-to-day work (work motivation, quality care, disease control, et cetera).

7.3.1 Planning phase: (1) stating the objectives

The decision-making process starts with the specification of objectives and goals. This may be seen as a part of the planning phase, but its importance justifies a separate treatment. Kay and Edwards (1994) stress the role of goals as gauges to determine the effectiveness of the management and, therefore they should be clear, written, specific, measurable and time-scheduled. In this study we found that in practice growers do not meet this ideal picture. Their goals are usually stated in general terms ("high income", "maximum turnover") and not made specific and not written down. Furthermore, consistency in time with respect to critical success factors ("the few key issues that must be done exceedingly well to be succesful" - Rockart, 1979) was low (see Chapter 3). The same is true for consistency in level of importance of cultivar attributes, measured in two tasks on the same day (see Chapter 5). This means that growers in general do not have fixed ideas on what matters most. They easily change their minds. This attitude is not necessarily bad, it may reflect an amount of flexibility that facilitates coping with unexpected problems and facing new challenges. On the other hand, if it is an expression of lack of vision, it may lead to ad hoc policies and jeopardize the firm results. Management support with respect to formulating the objectives may be supplied by regularly, at least once a year, asking entrepreneurs to state their priorities for the next period. Simple exercises (e.g. "divide 100 points among the following items..." and "add three other important items to the list...") can be used to stimulate the process of awareness. The concept of critical success factors may be helpful to translate high level, general objectives into lower level, operational goals.

7.3.2 Planning phase: (2) product choice

A substantial part of this research was concerned with the cultivar choice process of growers. The concept of multi-attribute utility (MAU) was used to analyse and quantify the level of rationality of choice (see Chapters 5 and 6). One of the research questions of this study was to seek for possibilities in the area of management support (systems). Therefore, the potential use of the MAU-model as a framework for decision support was discussed (Chapter 5). It was concluded that the model can be a useful tool for those growers, approximately one fourth of the population, who are interested in some sort of rational test against their intuitive choice. A practical introduction of the MAU-model, however, would also depend on the availability of up-to-date, reliable information on cultivars. Breeders should transmit the information on the relevant attributes (quality, response time, susceptibility to pests and diseases, uniformity, et cetera) for their new varieties as soon as possible to some accessible medium, e.g. the Internet, in a uniform standard. If coordination of such a dataset was in the hands of an objective authority (e.g. research station), guaranteeing reliability and regular updating, this would be a valuable source for growers.

7.3.3 Planning phase: (3) production planning

Once the cultivars have been chosen, production planning is needed to efficiently use the available resources (greenhouse space, labour, et cetera). With respect to this tactical planning, we found that it was far less accurate than the growers had indicated in advance (see Chapter 3). Deviations, mostly delays, in harvest and (next) planting were often greater than ten days, whereas growers claimed in advance these would be smaller than one week (in winter) and usually just a couple of days (in summer). Here, various tools could be used to improve the planning. These tools can be simple (e.g. use of handwritten cultivar cards) or more advanced, e.g. computer programs taking into account various aspects, such as expected response time, expected duration of vegetative growing, effect of time of year and effect of plant density. Some initiatives for computerized planning systems in greenhouse horticulture, especially pot plant production, have been developed in the 1990s. Hofstede (1992) describes various tools that can be used for computerized planning. The simplest version seems to be the most promising. This version, called "proplan hand", consists of a matrix representing time (horizontal axis) and greenhouse space (vertical axis). The grower/planner can use the matrix for visualizing the planning on screen and simulating the effects of different cultivation plans. Also other aspects of the production planning of pot plant growers have been simulated in a way that could lead to computerized support. Among these are various operational strategies of product delivery (Leutscher, 1995) and algorithms aimed at decreasing the internal transport movements of pot plants through the greenhouse (Annevelink, 1999).

Despite these initiatives the use of advanced (computerized) tools for production planning is still in its infancy. The majority of growers do not see enough potential benefits to be really interested in this kind of management support. Growers who do see the potential benefits face programs that do not meet their specific needs. This explains why further development and introduction of computerized planning systems is proceeding very slowly. Unless the software industry finds a solution, i.e. a product that attracts interest from a larger share of growers, the use of planning tools will be restricted to those (bigger) firms, which have the competence to buy or build a tailor-made instrument themselves.

7.3.4 Control phase

The results of this research indicate that high levels of data recording and firm evaluation are positively associated with overall firm efficiency and performance. Firm control is supported by clear, specific measures of performance. In the previous section the overall performance with respect to turnover was split into partial performances with respect to price, quality, market feeling and quantity. These kinds of advanced measures for evaluation could be given to growers as management support, preferably in a study group setting with similar firms.

7.3.5 Future use of management support systems

New tools for improving decision making may be aimed at communication and learning. One may think of computer programs and high-quality printers generating graphical means to be used as discussion tools and means of communication.

It is hard to say what the future of management support systems will be like. Previous attempts to develop and introduce on-farm management support systems seem to indicate that growers are not much interested in computer programs that provide optimal solutions for partial problems. Growers seem to be more interested in tools that mirror part of their firm and which can be used for communication, discussion and learning. An interesting line of research in this respect is the meta-level of decision making, i.e. the way managers direct their decision making. Studies on how managers spend their time, how they distinguish between crucial and less crucial decisions, how they distinguish between urgent and less urgent decisions, et cetera, may be, in the end, a necessary condition for a breakthrough in the area of management support (Renkema, 1998).

References

Alleblas, J.T.W. (1987). *Management in de glastuinbouw: een zaak van passen en meten*. Den Haag: Landbouw-Economisch Instituut. (Onderzoekverslag 34, in Dutch).

Annevelink, E. (1999). *Internal transport control in pot plant production*. Wageningen: Wageningen Agricultural University. (PhD-thesis)

Anthony, R.N. (1965). *Planning and control systems; a framework for analysis*. Boston: Harvard University.

Battese, G. (1992). Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics. *Agricultural Economics* 7, 185-208.

Bots, J.M. (1991). *De besturing van het primaire agrarische bedrijf: een toepassing van de Wageningse Besturings Benadering in een voorstudie met betrekking tot potplanten bedrijven*. Wageningen: Wageningen Agricultural University. (PhD-thesis, in Dutch)

Hedges, T.R. (1963). *Farm management decisions*. Englewood Cliffs: Prentice-Hall.

Hofstede, G.J. (1992). *Modesty in modelling: on the applicability of interactive planning systems with a case study in pot plant cultivation*. Wageningen: Wageningen Agricultural University. (PhD-thesis)

Kay, R.D. and Edwards, W.M. (1994). *Farm management*. New York, etc.: McGraw-Hill. *(3rd ed)*

Leutscher, K.J. (1995). *Operational management in pot plant production*. Wageningen: Wageningen University. (PhD-thesis)

Müller, J. (1974). On sources of measured technical efficiency: the impact of information. *American Journal of Agricultural economics* 56, 730-738.

Renkema, J.A. (1998). *Agrarische bedrijfseconomie: "een kwestie van halen en brengen"*. Wageningen: Wageningen Agricultural University. (Valedictory speech in Dutch).

Rockart, J.F. (1979). Chief executives define their own data needs. *Harvard Business Review* 57, 81-93.

Turner, J. and Taylor, M. (1998). *Applied farm management*. London, etc.: Blackwell Science. (2nd ed.)

Zachariasse, L.C. (1974). *Boer en bedrijfsresultaat: analyse van de uiteenlopende rentabiliteit van vergelijkbare akkerbouwbedrijven in de Noord-Oost-Polder*. Wageningen: Wageningen University. (PhD-thesis, in Dutch)

Ziggers, G.W. (1993). *Agrarisch ondernemerschap in een bedrijfskundig perspectief*. Wageningen: Wageningen University. (PhD-thesis, in Dutch)

Summary

Introduction

Within Dutch agriculture, greenhouse horticulture stands out as a growing sector. Whereas the total agricultural production value remained at a constant level of about NLG 36 billion, the production value of greenhouse horticulture increased from NLG 6.2 billion in 1985 to NLG 10.4 billion in 1998. In such circumstances of growth and innovation, one would expect a fast development, acceptation and diffusion of management support systems. However, apart from computerized climate control, which is standard in greenhouse horticulture, the role of computerized support systems for management purposes is still very limited. To explain this low level of computerized support system use, more insight is needed into the underlying decision-making processes. This has been the main reason to start the current research project on existing management practices of greenhouse growers. The emphasis has been on two important decisions, cultivar choice and product planning, which are at the heart of the growers' tactical management.

The main objective of this study was to get insight into the decision-making processes of greenhouse growers. From a descriptive point of view, it seeks to investigate: how growers plan, how they make choices, how they evaluate their results, and, from a normative point of view, it tries to detect the weak spots in the decision making. Based on the descriptive and normative parts, the study seeks for possibilities in the area of management support (systems).

Insight into the decision making was gained by observations of firms. A group of 26 specialized, comparable chrysanthemum growers was followed during a one-year period 1993/94, comprising over four production rounds. Interviews were held and data were collected on firm structure, sales, prices, production, information use, computer use, et cetera. Prior to these bimonthly observations, the group had met in November 1993 to participate in a research workshop. The workshop consisted of several tasks aimed at measuring the individual quality of the decision-making process.

Analysing decision-making processes

First, a literature analysis was performed to investigate the ways in which management

capacity and decision-making processes can be studied (Chapter 2). A sequential model of management was extracted: person (management capacity) → decision making → physical firm processes → firm results. Empirical studies show an influence of management capacity on farm results, for instance, a relation between personal characteristics and economic results. Overall, the proportion of variance in the dependent (result) variables that is explained by the independent (management) variables differs from 7% to 40% between the studies reviewed. However, these values are hard to compare, due to differences in the way management capacity is defined in these studies, differences in independent variables that are included, and differences in definition of farm results.

Most empirical studies on management capacity of farmers, in relation to farm results, use questionnaires and interviews for data collection. These are usually executed without repetition, leading to single measurements. To effectively analyse the role of all aspects of management capacity, other methods can be useful. On-farm investigations, with regular repetition, are more appropriate to study management capacity of farmers. Such longitudinal observations are more in line with the dynamic nature of decision-making processes. Also, they give opportunities for verification and are therefore likely to give a more realistic picture. Off-farm experiments with farmers, e.g. in a computer laboratory, can be used to simulate decision-making processes, to assess certain abilities and capabilities of the farmers and to find out about their drives and motivations and their attitude, for instance, toward risk. However, there is considerable evidence to suggest that the external validity of decision-making research that relies on laboratory simulations of real-world decision problems is rather low. To provide evidence on validity of different methods, the need for multimethod approaches is generally acknowledged.

It can be concluded that the decision-making process is underexposed in empirical research. This is especially the case for studies using the production frontier approach. The decision-making process can only be measured by longitudinal data, for instance, structured farm observations/visits in time, to follow the planning, implementation and control on the farm. This kind of studies can lead to a better understanding of differences in success among farmers and can serve as a basis for support and improvement of their farm results.

Firm (in)efficiencies

To measure the level of firm inefficiency, the variance among firms and the relationship with aspects of the decision making, the stochastic production frontier approach was applied (chapter 3). The frontier estimates the maximum output given a certain level of input (physical inputs as well as the non-physical quality of decision making) and given the current state of technology. The level of firm inefficiency is measured as the distance between the actual output and the potential (frontier) estimate. Turnover per m^2 was taken as a measure of output. Frontier estimates of turnover were based on age (construction year) of the glasshouse, labour input and the use of supplementary lighting. The quality of the decision making was measured along the line of (1) goal setting, (2) planning, (3) data recording and (4) evaluating. For each step in the decision-making process an operational variable was defined, suitable for quantification. Data and measurements on these variables were collected for the 26 participating firms during a one-year period.

The results show statistically significant associations between some aspects of the decision-making variables and the efficiency of firms. Especially the aspects of data recording and evaluation were found to be of importance. Firms with a high intensity of data recording and a high level of firm evaluation had smaller inefficiencies. The aspects of goal setting and planning were not found to be associated with the level of efficiency.

Some remarks should be made with respect to these results. First, the transformation from decision-making concepts into operational variables is necessarily arbitrary to some extent and further research and development are needed to achieve standard quality indicators of management. Second, one phase of the decision-making process could not be included into the analysis. This is the stage of implementation, where appropriate actions are needed to bring plans into action and a skilful, practical attitude ('green fingers') is needed to work with the resources available. We did not find a satisfactory way to measure the quality level at this stage. By including this phase, the level of variation in efficiency one can expect to explain might increase.

Growers as price predictors

Since prices play a major part in causing differences in turnover among growers, the price predicting ability of growers was tested and compared (Chapter 4). The main question addressed in this chapter was: to what extent can price predicting by flower producers be considered a skill. For the purpose of answering this question a survey was held among the 26 participating chrysanthemum growers, who predicted prices for several periods in the year 1994. At first, actual prices were analysed and statistically tested for non-randomness. It turned out that price variations over time and price variations among cultivars follow, indeed, non-random patterns.

Little evidence, however, was found that predicting absolute price levels is a skill rather than just coincidence. Growers who predicted well for one period did not necessarily do so for other periods. Only occasionally positive significant correlations were found between prediction errors of different periods. Growers were more consistent in predicting *relative* price positions. We introduced two relative indicators: (1) market position of the cultivar grown (relative to other cultivars) and (2) quality position of the firm (relative to other firms producing the same cultivar). It turned out that estimating the relative market position can be considered a skill, i.e. some growers predicted these positions consistently better than others. With respect to the relative quality position the evidence is less clear.

Future research may look at ways in which growers can improve their price predictions, based on probability judgements. It can also be directed at including other (cost-related) factors in the decision-making with respect to product choice and product differentitaion. A multi-criteria decision-making model including price expectations and other cost-related factors which are less subject to variation, such as growing time, harvest labour and plant density, may be helpful in understanding and supporting the product choice.

Cultivar choice

Choosing among cultivars is a multi-attribute decision. Each cultivar comprises a set of unique biological and economic characteristics (attributes), such as response time, pests/diseases, uniformity and market perspective. The choice problem for each grower is to select a package of attributes that gives the highest level of satisfaction. An off-farm workshop on cultivar choice was organized aimed at measuring the individual quality level of the decision process. Three general aspects of the quality of decision making that emerge from the literature (e.g. Simon) - level of consciousness/awareness, level of (economic) rationality and level of consistency - were analysed. To determine these levels, several tasks have been developed and presented to the group of 26 growers.

The main part of the workshop consisted of a cultivar choice simulation game, played by means of a computerized information display matrix (IDM). This is a technique for studying decision making that has been applied in consumer research and research on organizational behaviour. In chapter 5 the technique was introduced for farmers' decision making. The IDM consisted of 15 alternatives (rows) and 11 attributes (columns), i.e. 165 information cells. By opening the information cells the decision maker can observe the specific information. The individual task of each grower in the IDM was to open information cells up to a maximum of 83, i.e. fifty percent of the total information, and then to make a choice by allocating 10.000 m^2 of glasshouse area to the available alternatives. Information search and final choices were recorded for each participant.

When the weighted additive multi-attribute utility (MAU-) model was used as a measure for (subjective) optimality, it turned out that thirteen participants (50%) did not choose their optimal - in MAU sense - cultivar. The main explanation for this is that they use decision heuristics instead of the more demanding weighted additive MAU-model. All in all, the differences among growers with respect to their level of consciousness/awareness, (economic) rationality and consistency turned out to be substantial.

The results of this study also indicated some statistical significant relations between the experiment and real life. Participants demonstrating a high level of awareness in the experiment scored, on average, a higher normative turnover per m^2 and also a higher yield per m^2 (actual as well as normative); however, not a higher price. The same relations between experiment and real-life held for the level of rationality: less subjective loss in the IDM-game went together with a higher performance as to turnover and yield, not as to price. Finally, no relations were found between level of consistency and real-life performances.

This means that the experimental findings had some predictive power for the real-life performances as to turnover and yield. Yet, the variation in performances 'predicted' by the experimental findings in terms of R^2 was small, limited to approximately 20% (R^2). No price variation could be predicted by the experimental findings. The reason for this might be that prices were more influenced by accidental market fluctuations, whereas yields were within the management influence of the grower.

One may wonder if the MAU-model can be used as a framework for decision support. Therefore, we explained the concept of MAU to the growers and asked them to give their opinions on the potential use of such a MAU-model as a decision support for their cultivar choice. Six growers (23%) were highly interested; they rated the potential use of a MAU-model as a decision aid higher than 80 (on the scale from 0-100). For these growers the MAU-model can serve, as one participant put it, "to check your own feeling", i.e. serve as a rational test.

Information search behaviour

One aspect of the IDM experiment (previous section) is the information search behaviour. Some people search for information in mainly an alternative-based way, while others search mainly attribute-wise. In line with previous studies, the attribute-based way of searching was found to generate better choices - in terms of MAU-values - than the alternative-based way of searching. Characteristics of the information search were more deeply analysed in Chapter 6. In addition to established search characteristics, three new indicators were introduced: attribute-focus, alternative-focus and choice-focus. These turned out to be useful in detecting strengths and weaknesses of search strategies. The analysis showed that higher economic losses were incurred by decision makers who did not distinguish sharply enough between important and less-important attributes, i.e. whose attribute-focus was relatively low. This result suggests that decision making with respect to cultivar choice can be improved by increasing awareness of attributes and their relative importance.

Main conclusions

- The circumstances of growth and innovation during the past few decades in greenhouse horticulture have not led to a fast development, acceptation and diffusion of management support systems. Apart from computerized climate control, which is standard in greenhouse horticulture, the role of computerized support systems for management purposes (planning/evaluation) is still very limited.
- A sequential model of management: person (management capacity) → decision making → physical firm processes → firm results, represents best the different layers in analysing firm results. Differences in firm results can be fully explained by the underlying physical processes. A next layer of explanation is the (quality of) decision making. Finally, one can include the last layer, formed by the personal aspects (motivation, intelligence, level of education, et cetera), in the analysis and try to find out which characteristics have a significant influence, through the decision making and the physical processes, on the final results.
- Longitudinal on-farm observations are useful for studying the dynamic aspects of the decision-making processes (planning, implementation, control).
- The quality of the decision-making process shows positive associations with the level of firm efficiency. In this study with 26 specialized chrysanthemum firms a positive influence was found for the control phase (data recording and firm evaluation).
- Predicting absolute prices by growers must be considered a lottery. Growers who predict well for one period do not have a higher chance of predicting well for other periods. With respect to predicting relative price positions (relative to other cultivars or other firms) evidence was found, however, that this is a skill.
- Off-farm experiments are a useful additional means for both analysis and detection of weak spots in the decision making. For analysing choices among several alternatives the Information Display Matrix (IDM) is a powerful instrument.
- Some growers search for information in a more effective way than others. Suboptimal choices were found for those decision makers who did not distinguish sharply enough

between important and less important attributes, i.e. whose attribute-focus was relatively low.

- Decision making with respect to cultivar choice can be improved by increasing awareness of attributes and their relative importance. A multi-attribute utility (MAU-) model can be a useful management support tool for those growers who are interested in some sort of rational test.
- Awareness, rationality and consistency are the three main aspects of the quality of decision making.
- The experimental findings with respect to awareness and rationality have some predictive power for real-life performances.
- In the discussion is hypothesized that previous attempts to develop and introduce on-farm management support systems seem to indicate that growers are not much interested in computer programs that provide optimal solutions for partial problems. Growers seem to be more interested in tools that mirror part of their firm and which can be used for communication, discussion and learning.

Samenvatting

Inleiding

De Nederlandse glastuinbouw staat bekend als een groeiende en innovatieve sector. Terwijl de totale landbouwproductie in guldens gedurende de laatste vijftien jaar constant bleef (ongeveer 36 miljard gulden), nam de productiewaarde van de glastuinbouw toe van 6,2 miljard in 1985 tot 10,4 miljard in 1998. Gezien het klimaat van groei en innovatie zou men verwachten dat de ontwikkeling van computermatige managementondersteunende programma's een snelle vlucht zou nemen. Maar afgezien van geautomatiseerde klimaatsturing en als instrument in de communicatie met de veiling is de rol van de computer voor managementdoeleinden nog vrij beperkt. Om dit te verklaren is meer inzicht nodig in de werkwijze en het achterliggende denken van de tuinders. Dit vormde de aanleiding voor dit onderzoek naar het management van glastuinders. Het accent ligt hierbij op twee beslissingen die regelmatig door de teler moeten worden genomen: welke rassen (cultivars) ga ik telen en hoe plan ik mijn productie. Deze beslissingen vallen onder het zogenaamde tactisch niveau van management.

De hoofddoelstelling van dit onderzoek was het verkrijgen van inzicht in het besluitvormingsproces. Het onderzoek wil beschrijven: hoe maken telers keuzes, hoe maken ze een planning, hoe evalueren ze hun bedrijfsresultaten. Verder probeert het zwakke punten in de besluitvorming bloot te leggen en mogelijkheden aan te geven voor verbetering, in de vorm van management ondersteuning, al dan niet computermatig.

Inzicht in de besluitvorming werd verkregen door bedrijfsobservaties. Een groep van 26 gespecialiseerde chrysantentelers werd gedurende één jaar in 1993/94 gevolgd. In deze periode konden (ruim) vier productieronden plaatsvinden. Gegevens werden verzameld over de productie, prijzen, cultivarkeuze, planning, informatiegebruik en computergebruik. Eens per twee maanden werd een interview afgenomen.

Voorafgaand aan het jaar met bedrijfsobservaties kwam de groep telers in November 1993 bijeen om mee te doen aan een onderzoeksworkshop. Tijdens de workshop werden taken uitgevoerd om het kwaliteitsniveau van besluitvorming te bepalen, met name gericht op de productieplanning en cultivarkeuze.

Literatuurstudie naar besluitvorming

Uit de literatuur over besluitvorming en het meten hiervan, werd het volgende *sequentiële* model gedestilleerd: 1. persoon (inclusief management capaciteiten) → 2. besluitvorming → 3. fysieke bedrijfsprocessen → 4. (financiële) bedrijfsresultaten. Het merendeel van het empirisch onderzoek is gericht op het leggen van verbanden tussen enerzijds stap 1 en anderzijds stap 3 en 4. Hiervoor worden voornamelijk eenmalige vragenlijsten voorgelegd aan de managers en/of interviews afgenomen. Om echter meer recht te doen aan het gehele proces, inclusief stap 2., zou het wenselijk zijn om metingen te herhalen in de loop van de tijd. Verder is het van belang te kijken wat er zich werkelijk afspeelt op het bedrijf. Zulke longitudinale bedrijfsobservaties passen beter bij het dynamische karakter van de besluitvorming.

Een andere, nog weinig gebruikte onderzoeksmethodiek in de landbouweconomie, is het simuleren van de besluitvorming in een laboratoriumsituatie. Op deze manier kunnen verschillende elementen van de kwaliteit van de besluitvorming worden onderzocht, bijvoorbeeld het informatiezoekgedrag en de houding ten aanzien van risico. Wel moet worden opgemerkt dat de externe validiteit van de gevonden resultaten vaak vrij laag is, dat wil zeggen de resultaten uit het laboratorium mogen niet zonder meer worden vertaald naar de werkelijkheid.

De conclusie luidt dat het dynamische besluitvormingsproces te weinig aandacht krijgt in het empirische onderzoek. Wil men recht doen aan het dynamische karakter ervan, dan zullen longitudinale waarnemingen, bijvoorbeeld in de vorm van gestructureerde bedrijfsbezoeken, moeten worden verricht. Op deze manier kan een beter inzicht worden verkregen in de cyclus van planning, uitvoering en evaluatie van beslissingen. Inzicht dat kan leiden tot een beter begrip van verschillen in succes tussen ondernemers en uiteindelijk de bedrijfsefficiëntie op een hoger peil kan brengen.

Efficiëntie in de bedrijfsvoering

Voor het schatten van de efficiëntie van de bedrijfsvoering is de stochastische productiefrontiermethode (*stochastic frontier approach*; Hoofdstuk 3) toegepast. Deze methode schat de maximaal haalbare productie op een bedrijf, gegeven de gebruikte productiemiddelen en gegeven de stand van de techniek. De efficiëntie op een bedrijf wordt gemeten aan de hand van het verschil tussen de geschatte maximaal haalbare productie en de feitelijke productie.

Als maatstaf voor de productie is gekeken naar de jaaromzet per m^2 kasoppervlakte. De maximaal haalbare omzet per m^2 werd geacht afhankelijk te zijn van enerzijds structurele variabelen (het bouwjaar van de kas, de arbeidsinzet per m^2 en het al dan niet gebruiken van assimilatiebelichting) en anderzijds variabelen gericht op de kwaliteit van de besluitvorming (doelstelling, planning, informatieverzameling en evaluatie). De fasen uit het besluitvormingsproces werden hiertoe uitgedrukt in kwantificeerbare variabelen en metingen werden verricht voor de 26 deelnemende chrysantenbedrijven gedurende het jaar van onderzoek.

Uit de schattingsresultaten blijkt een statistisch significante relatie tussen enerzijds de bedrijfsefficiëntie en anderzijds de kwaliteit van de besluitvorming. Deze relatie kon met name worden aangetoond voor de informatieverzameling en de evaluatie. Bedrijven die gericht hun informatie bijhouden en goed op de hoogte zijn van hun bedrijfsresultaten (in verhouding tot de bedrijfsresultaten van collega's) scoren gemiddeld een hogere efficiëntie. Hun jaaromzet per m^2 is gemiddeld hoger dan verwacht mag worden op basis van alleen de structurele variabelen (bouwjaar, arbeid en assimilatiebelichting). Een soortgelijk verband kon niet worden gelegd voor de aspecten doelstelling en planning.

Enkele kanttekeningen bij deze resultaten zijn op hun plaats. Ten eerste, de omzetting van kwalitatieve begrippen (doelstelling, planning, informatieverzameling en evaluatie) naar kwantificeerbare variabelen is noodgedwongen een deels arbitraire zaak. Vervolgonderzoek is nodig om te komen tot gestandariseerde, breed geaccepteerde indicatoren voor de kwaliteit van de besluitvorming. Ten tweede, een belangrijke fase uit het besluitvormingsproces kon niet worden meegenomen in de analyse. Dit is de fase van de *implementatie* van beslissingen, waarin het vakmanschap op de werkvloer onderscheidend is; oftewel de fase waarin blijkt of de tuinder en het personeel 'groene vingers' hebben? We vonden geen bevredigende variabele om de kwaliteit in deze fase te meten.

Prijsvoorspellingen door tuinders

Prijsverschillen spelen een belangrijke rol in de verklaring van omzetverschillen tussen telers. Daarom is gekeken naar het vermogen van tuinders om prijzen te voorspellen (Hoofdstuk 4). De hoofdvraag in dit hoofdstuk luidde: zijn (goede) prijsvoorspellingen gebaseerd op toeval of mogen we spreken van een speciaal talent (bijvoorbeeld gebaseerd op een betere kennis van de markt). Om deze vraag te beantwoorden werden de deelnemende tuinders gevraagd prijsvoorspellingen te geven voor diverse tijdvakken van het jaar 1994.

Uit de analyse blijkt dat er weinig tot geen reden bestaat het voorspellen van *absolute* prijzen toe te schrijven aan een specifiek talent. Het blijkt dat telers die goed voorspellen voor de ene periode, in de regel, slechts gemiddeld voorspellen voor een andere periode. Slechts incidenteel is er sprake van een positieve, statistisch significante, correlatie tussen voorspelfouten in de ene en de andere periode. Echter, een ander beeld ontstaat wanneer we kijken naar het voorspellen van *relatieve* prijzen. We definieerden twee relatieve prijsindicatoren: (1) de marktpositie van de cultivar (prijs ten opzichte van andere cultivars) en (2) de kwaliteitspositie van het bedrijf (prijs ten opzichte van bedrijven met dezelfde cultivar). Het blijkt dat het voorspellen van de marktpositie een talent is, waar sommige tuinders aanhoudend beter in zijn dan anderen. Met betrekking tot het voorspellen van de kwaliteitspositie zijn er aanwijzigingen in beide richtingen: talent en toeval. Vervolgonderzoek kan ingaan op de vraag hoe tuinders hun prijsvoorspellingen zouden kunnen verbeteren.

Cultivarkeuze

Een cultivar is op te vatten als een pakketje biologische en economische eigenschappen (attributen), zoals verwachte teeltduur (waaronder reactietijd), ziektegevoeligheid, uniformiteit en marktperspectief. Het keuzeprobleem voor de tuinder is daarmee terug te voeren tot het kiezen van het pakketje eigenschappen dat naar verwachting het hoogste nut zal opleveren. In een workshop met de deelnemende telers is dit keuzeproces ontleed en is het kwaliteitsniveau van het keuzeproces gemeten (Hoofdstuk 5). Hierbij zijn drie aspecten bekeken: kennis van zaken, rationaliteit en consistentie. Om deze niveaus te meten zijn er meerdere taken ontwikkeld en voorgelegd aan de 26 tuinders.

Het grootste deel van de workshop bestond uit het cultivarkeuzespel. Dit spel werd gespeeld op een PC en was gebaseerd op een *information display matrix* (IDM). Dit is een techniek voor het bestuderen van keuzeprocessen, voornamelijk toegepast op de terreinen van consumentengedrag en organisatiepsychologie. In Hoofdstuk 5 wordt de techniek toegepast op de besluitvorming van tuinders met betrekking tot de cultivarkeuze. De IDM bestaat daar uit 15 keuzealternatieven (cultivars, weergegeven als rijen in de matrix) en 11 attributen (eigenschappen, weergegeven als kolommen in de matrix), oftewel 165 informatiecellen. Door informatiecellen te openen kan de deelnemer de specifieke informatie bekijken. De taak van elke tuinder bestond eruit om maximaal 83 cellen te openen (50% van de totale informatie) en vervolgens een keuze te maken door 10.000 m^2 kasruimte te verdelen over de beschikbare alternatieven. Het informatiezoekgedrag en de uiteindelijke keuze werd vastgelegd voor elke deelnemer.

Uit de analyse blijkt dat 13 deelnemers (50%) niet de optimale cultivar kiezen. Hierbij is "optimaliteit" gedefinieerd aan de hand van de gewogen multi-attribuut score (MAU), waarbij de weging gebaseerd is op de subjectieve voorkeur van de deelnemer zelf. De belangrijkste verklaring voor het niet selecteren van de beste cultivar is het toepassen van zogenaamde heuristieke beslissingsregels en bijbehorende informatiezoekpatronen in plaats van het meer complexe MAU-model.

Uit de resultaten kunnen ook enkele statistisch significante verbanden tussen spel en werkelijkheid worden getrokken. Deelnemers die in het spel een grote mate van kennis van zaken laten zien, scoren in de werkelijkheid, gemiddeld, een betere prestatie met betrekking tot de omzet en de hoeveelheid, niet met betrekking tot de prijs. Dezelfde verbanden tussen spel en werkelijkheid gelden voor de mate van rationaliteit: een rationele keuze in het spel kwam, gemiddeld, overeen met een betere prestatie ten aanzien van omzet en hoeveelheid in de werkelijkheid, en niet ten aanzien van prijs. Geen verbanden, tenslotte, konden worden gelegd tussen de mate van consistentie in het spel en de prestaties in de werkelijkheid.

Dit betekent dat de resultaten in het spel enige voorspellende waarde hebben ten aanzien van de prestaties in de werkelijkheid. Maar de verklaarde variatie in omzet en hoeveelheid op basis van het spel is beperkt tot ongeveer 20% (R^2). Terwijl van de variatie in behaalde opbrengstprijzen niets kon worden voorspeld op basis van het spel. De reden hiervan kan zijn dat de prijzen in werkelijkheid vooral worden bepaald door toevallige marktschommelingen, terwijl de hoeveelheid binnen de invloedsfeer van de tuinder ligt.

Men kan zich afvragen of het MAU-model kan dienen als een middel voor beslissingsondersteuning. We legden het concept uit aan de deelnemers (op een later tijdstip) en vroegen hun een oordeel te geven over het mogelijk gebruik als beslissingsondersteunend middel bij de cultivarkeuze. Zes telers (23%) waren zeer geïnteresseerd; ze scoorden het nut ervan hoger dan 80, op een schaal van 0-100. Voor deze telers kan het MAU-model dienen als een rationeel keuzemiddel, of zoals een van de telers het uitdrukte, "een check op je gevoel".

Informatiezoekgedrag

Een aspect van het IDM-spel (zie vorige paragraaf) is het informatiezoekgedrag. Sommigen zoeken informatie voornamelijk alternatiefsgewijs (rijgewijs) en anderen voornamelijk attribuutsgewijs (kolomsgewijs). Uit de analyse blijkt - in overeenstemming met eerder onderzoek - dat het attribuutsgewijze zoeken in de regel leidt tot betere keuzes, in termen van MAU-waarde. Het informatiezoekgedrag is in Hoofdstuk 6 verder onderzocht. In aanvulling op bekende karakteristieken zijn drie nieuwe indicatoren geïntroduceerd:

attribuutgerichtheid (attribute-focus), alternatiefgerichtheid (alternative-focus) en keuzegerichtheid (choice-focus). Deze indicatoren bleken nuttig in het beschrijven van de sterke en zwakke punten van het informatiezoekgedrag. Uit de analyse bleek dat minder goede keuzes (in termen van MAU-scores) vooral werden gemaakt door deelnemers die geen scherp onderscheid maakten tussen belangrijke en minder belangrijke attributen, oftewel wier attribuutgerichtheid relatief laag was. Dit resultaat suggereert dat de besluitvorming ten aanzien van de cultivarkeuze verbeterd kan worden door een scherper onderscheid in belangrijke en minder belangrijke eigenschappen.

Hoofdconclusies

- Ondanks groei en innovatie in de sector is de rol van management ondersteunende systemen in de glastuinbouw nog zeer beperkt. De computer wordt gebruikt voor klimaatsturing en voor communicatie met de veiling en de bank (telebankieren), maar nauwelijks voor planning en evaluatie.
- Een sequentieel model van management: 1. persoon (inclusief management capaciteiten) → 2. besluitvorming → 3. fysieke bedrijfsprocessen → 4. (financiële) bedrijfsresultaten, geeft een goede beschrijving van de verschillende lagen die kunnen worden onderscheiden. Verschillen in bedrijfsresultaat kunnen volledig worden verklaard door middel van de fysieke bedrijfsprocessen. Een diepere laag in de verklaring wordt verkregen door de analyse van de besluitvorming. Tenslotte kan men in de analyse teruggrijpen op de persoonlijke kenmerken (motivatie, intelligentie, ervaring, scholing, etcetera) om te ontdekken welke eigenschappen een significante invloed hebben op de resultaten, via het besluitvormingsproces en de fysieke processen.
- Longitudinale waarnemingen zijn nuttig voor het bestuderen van de dynamische aspecten van het besluitvormingsproces (planning, implementatie en evaluatie).
- Er bestaat een positief verband tussen enerzijds de bedrijfsefficiëntie en anderzijds de kwaliteit van de besluitvorming. Met name de informatieverzameling en de evaluatie bleken in dit onderzoek, gebaseerd op 26 gespecialiseerde chrysantenbedrijven, van invloed op de bedrijfsresultaten.
- Prijsvoorspellingen zijn niet gebaseerd op een specifiek talent of marktinzicht. Telers die goed voorspellen voor de ene periode, blijken slechts gemiddeld te voorspellen voor een andere periode. Echter, het voorspellen van relatieve prijzen (relatief ten opzichte van andere cultivars of andere bedrijven) blijkt wel gebaseerd op inzicht.

- Laboratorium experimenten zijn een nuttige aanvulling voor de analyse van besluitvorming en ook voor het blootleggen van de zwakke punten in de besluitvorming. Voor de analyse van keuzeprocessen is de *information display matrix* (IDM) een geschikt middel.
- Sommige telers vertonen een effectievere manier van informatie zoeken dan anderen. Minder goede keuzes worden vooral gemaakt door deelnemers die geen scherp onderscheid maken tussen belangrijke en minder belangrijke attributen (van het te kiezen object).
- De cultivarkeuze kan worden verbeterd door een sterker onderscheid in relatief belangrijke en onbelangrijke cultivareigenschappen. Een multi-attribuut score (MAU) kan dienen als een rationele toets op intuïtieve keuzes.
- Kennis van zaken, rationaliteit en consistentie zijn de drie belangrijkste aspecten van de kwaliteit van besluitvorming.
- De in spelvorm gemeten waarden met betrekking tot kennis van zaken en rationaliteit hebben enige voorspellende waarde voor de bedrijfsprestaties in de werkelijkheid.
- In de discussie wordt als hypothese naar voren gebracht: dat pogingen tot het ontwikkelen en invoeren van managementondersteunende systemen op het bedrijf aangeven dat tuinders niet zozeer zijn geïnteresseerd in computerprogramma's die optimale oplossingen berekenen voor partiële problemen. Tuinders lijken meer geïnteresseerd in instrumenten waarmee ze inzicht in het bedrijf krijgen en waarmee de communicatie zowel binnen het bedrijf als met schakels buiten het bedrijf wordt versterkt.

Curriculum Vitae

Geert Trip werd geboren op 3 juni 1961 in Nieuw Buinen (Drenthe). In 1979 behaalde hij het Atheneum-diploma aan het Ubbo Emmius Lyceum in Stadskanaal. In september van dat jaar begon hij de studie Econometrie aan de Rijksuniversiteit Groningen, met als hoofdrichting operationele analyse. Deze studie werd in maart 1986 met succes afgerond. Vanaf 1 maart 1986 was hij in dienst als Wetenschappelijk Medewerker bij de afdeling tuinbouw van het Landbouw Economisch Instituut in Den haag. Hier heeft hij gewerkt aan het opzetten van kwantitatieve modellen voor de schatting van vraag- en aanbodontwikkelingen in diverse tuinbouwsectoren. Met ingang van 1 juli 1990 verruilde hij deze functie voor een aanstelling als Universitair Docent bij de leerstoelgroep Agrarische Bedrijfseconomie van (thans) Wageningen Universiteit. Binnen deze functie is hij verantwoordelijk voor de opzet en uitvoering van enkele onderwijselementen, begeleiding bij afstudeervakken en is hij verder actief in commissies op het gebied van onderwijskwaliteit en PR & werving. Een oriëntatie op het management in de tuinbouw leidde begin 1993 tot het voorstel voor dit promotieonderzoek.