Strategic Decision Making and Firm Development in Dutch Horticulture

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Strategic Decision Making and Firm Development in Dutch Horticulture

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Abstract

Successful embedding of policy processes in entrepreneurial behaviour requires that policy makers understand how entrepreneurs behave and make decisions. Besides, empirical evidence about the impact of legislation on firm processes will help greenhouse growers to improve their decision making. In this study, the impact of firm performance, firm characteristics, perceptions and strategies on firm development and the consequences of firm development for firm performance are investigated. Two data sets used in this research combine data at the firm level of the Farm Accountancy Data Network and management information collected by an oral survey. Several statistical methods (e.g. Probit, Tobit, OLS), Cluster Analysis and Data Envelopment Analysis are used to identify relationships. The results suggest mutual relationships between firm performance and firm developments like innovation and firm growth. This creates a loop with a positive feedback: firm developments increase firm performance whereas a high performance induces firm developments. This loop has also a long term version: the family-firm life cycle. If future perspectives disappear, either by bad performances, or by lack of successors, firm developments like firm growth and innovation do not take place and the entrepreneur withdraws money from the firm in the exit stage. Objectives and strategies are consistent with the life cycle stage and the firm performance. The general conclusion about the relation between perceptions and firm developments is that the perception to what degree firm characteristics or consequences of external developments are within the entrepreneur's control determines his or her optimism about firm characteristics and external developments. However, the indirect relationship between perceptions and strategies indicates that perceptions at least partly represent the attitude of the entrepreneur rather than the evaluation of characteristics and external developments.

Key words: perceptions; strategic management; innovation; firm growth; strategies; decision making; greenhouse horticulture; farm accountancy data network

Voorwoord

Het boekje is af! Het klaren van een klus heeft me zelden meer opgelucht. De lange periode die aan deze opluchting is voorafgegaan heeft zich gekenmerkt door pieken en dalen. Het begint met een piek, wanneer met een overmaat aan enthousiasme het onderzoek begonnen wordt. Het wordt anders wanneer bij het inlezen het aantal mogelijke benaderingen waaruit een keuze gemaakt moet worden legio blijkt te zijn. Het dal wordt verlaten wanneer begonnen wordt met het verzamelen van gegevens, en de productie zichtbaar wordt. Een nieuw dal wordt ingegaan wanneer analyses vervolgens geen interpretabele uitkomsten geven. De ervaring die volgt wanneer dit niet het gevolg van slecht voorwerk is, maar van een bug in de software is in termen van pieken en dalen moeilijk onder woorden te brengen. Dat is gelukkig niet het geval wanneer het eerste hoofdstuk af is, en nieuwe hoofdstukken in steeds hoger (minder laag) tempo worden toegevoegd. Het inleveren van het manuscript is zonder twijfel een hoogtepunt.

Dit proefschrift had niet tot stand kunnen komen zonder de stimulerende begeleiding die ik al die tijd heb genoten. Allereerst professor Ruud Huirne, jouw gedrevenheid, toegankelijkheid en planmatige wijze van werken hebben er in belangrijke mate toe bijgedragen dat dit proefschrift er is gekomen. Jij verstaat de kunst om een vastgelopen proces op een motiverende manier vlot te trekken, een eigenschap die je nog veel nodig zult hebben! Professor Alfons Oude Lansink, ik heb veel opgestoken van jouw econometrische inzichten en ben je dankbaar voor je enthousiasme bij het vormgeven van de papers, het opzetten van de statistische modellen en het becommentariëren van papers. Dat jullie erin geslaagd zijn om in de tussenliggende periode beiden hoogleraar te worden zegt hopelijk meer over jullie capaciteiten dan die van mij. Professor Vinus Zachariasse, jij hebt me laten zien hoe belangrijk promoveren kan zijn, en hoe de gevolgen van de promotie je nog lange tijd op een positieve manier kunnen achtervolgen. Tevens wil ik je bedanken voor de ruimte die je me geboden hebt om mijn eigen keuzes te maken. Willy Baltussen, jouw pragmatisme stelde me regelmatig in staat om knopen op te lossen. Je advies om regelmatig parallellen te ontlenen aan voorbeelden die aansluiten bij eigen ervaringen is meerdere malen bijzonder bruikbaar gebleken. Dank daarvoor!

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1 General introduction

1.1 Introduction

Dutch greenhouse growers are subject to changing production and market conditions. Since the nineties of the twentieth century several developments threaten the international leading position of Dutch greenhouse horticulture. A bad environmental image of Dutch vegetable products like tomatoes resulted in dramatically dropping prices in the early nineties. Emerging production areas abroad, especially Mediterranean countries like Spain with low labour costs and more favourable climatic conditions, took advantage by increasing their market share. However, these threats for Dutch horticulture induced a range of developments. The majority of Dutch vegetable producers combined market power by merging the existing auctions into one organisation, which is able to provide a continuous stream of large quantities of uniform products to supermarkets. Others united in grower unions, focussed at specialty products with a high quality. Also, product innovations played an important role. E.g. the bulk product 'tomatoes' differentiated to special products like bunched tomatoes, cherry tomatoes and plum tomatoes. The increasing competition and the subsequent developments had a large impact on the structure of the horticultural sector. Firm size increased and the number of firms decreased. From 1990 until 2000 the number of vegetable producers decreased by 50%; the remaining firms doubled firm size, on average (Anonymous, 2003). The increasing firm size increased the scope for the application of strategic management concepts.

Although less pronounced, producers of cut flowers and pot plants operate in a comparable environment. They suffer from competition from countries like Kenya, Israel and Ecuador, which are able to produce product of a comparable quality at a lower price.

Nowadays, greenhouse producers face major political changes, among which regulations regarding energy are prominent. Liberalisation of the energy market separates costs of energy from costs of the technical infrastructure, which are based on the delivery capacity. The required capacity has to be based on peak loads in demand for heat, i.e. during heavy frost. The unequal demand for heat results in rising costs for infrastructure. In the future, greenhouse growers are faced with regulations,

which limit the use of energy to a large extent (Anonymous, 2002). The greenhouse industry made a covenant with the Dutch government to improve the energy efficiency by 65% in 2010 compared to the level of 1980. In 2002 the covenant has been upgraded by a new regulation requiring firm specific targets for reduction of energy use (Anonymous, 2002).

The continuously decreasing number of firms coupled with the increasing firm size in greenhouse horticulture provide empirical evidence that greenhouse growers need to understand external processes in order to adjust the firm strategy. Strategic management concepts include analysis of the external environment from a normative perspective in the decision making process (Grant, 1998; Lynch, 2000; David, 2001). Most empirical studies focus on large firms, where strategic decision making is an organizational process involving several persons. Therefore, a large body of empirical studies focus at least partly on organizational aspects of strategic decision making. E.g. Ireland et al. (1985) support the thesis that a positive relationship exists between the use of strategic planning processes and firm performance. The importance of strategic planning processes increases when a firm is confronted with inefficient markets, high degrees of uncertainty, major environmental changes and highly complex operations. The identification of a firm's internal strengths and weaknesses and its external opportunities and threats is a critical component of that process. The perceptions of strengths and weaknesses depend on the individual's basic cognitive properties like age, education and personal experience. Because of the existence of a relationship between these characteristics (e.g. age) and the level of management a person belongs to, perceptions differ over management levels.

Although firm size increases, horticulture is still dominated by family-firms operated by one or two entrepreneurs, who are personally involved in the whole strategic decision making process. So, in contrast to large firms the family-firm life cycle is a dominant concept in strategic decision making. A second difference between this thesis and the main stream of empirical studies is that most empirical studies focused at strategic decision making involve a limited number of large firms ruling out the potential for statistical analysis. The structure and developments of greenhouse horticulture makes this branch attractive for testing strategic management concepts statistically. Comparison makes sense if structure of firm and branch like other small and medium sized enterprises and research approach correspond.

Entrepreneurs in horticulture have to evaluate firm and entrepreneurial qualities to know whether they are able to face the external changes. Besides, the government is increasingly aware that legislation which restricts entrepreneurial freedom harms the international competitive position. At present, one of the intentions of the Dutch government is to tune policy processes to entrepreneurial processes. This implies deregulation of topics which can be left to the responsibility of the entrepreneurs. It also implies the choice of a suitable set of policy instruments and facilitating measures which enable the entrepreneurs to comply with future policy objectives, that cannot be left to the responsibility of the entrepreneurs. To perform this change in the political strategy, policy makers need knowledge about the decision making process of greenhouse growers. Also they have to know whether how they evaluate policy decisions concerning greenhouse horticulture. Both entrepreneurs and policy makers benefit from knowledge of the relation between external developments and the decision making process.

The decision making process of greenhouse growers has been studied in several ways. Alleblas (1988) investigated the impact of management on profitability in greenhouse horticulture. He concludes that the variation in management explains more than 50% of the profitability. Main determinants are the modernity and level of technical equipment, the interrelationship between age, education, firm size and external orientation, the attention for planning and control of the production process and commitment of employees. Trip (2000) investigated the decision making process regarding cultivar choice and price predictability. Both studies are focused at the management process within the firm, although Alleblas (1988) stresses the importance of the external environment for decision making.

1.2 Research model and objectives

Successful embedding of policy processes in entrepreneurial behaviour requires that policy makers understand how entrepreneurs behave and make decisions. Besides, empirical evidence about the impact of legislation on firm processes will help greenhouse growers to improve their decision making. The studies in horticulture mentioned before ignore either the relation between external processes, decision making and firm development (Alleblas, 1988; Trip, 2000). The general objective of

this study is to investigate the impact of firm performance, firm characteristics, perceptions and strategies on firm development and the consequences of firm development for firm performance. Firm development include strategic changes and innovation.

The following research questions are distinguished to realize the objective:
1. What are the effects of characteristics of the farmer, farm structure and performance on the firm developments?
2. What is the impact of the firm operator's perceptions, firm structure and firm developments on performance of the firm.
3. What is the impact of the family-firm life cycle, determined by firm structure and personal characteristics on the strategic decision making process.
4. What is the impact of entrepreneurial strategies, and perceptions of external developments and firm characteristics on adoption of new technologies.

The conceptual framework in figure 1.1 is at the core of the empirical work in this thesis. In the framework, the relevant relationship between external developments, perceptions, firm performance and firm development are specified (Figure 1.1). The conceptual framework is based on the strategic management literature (Grant, 1998; Lynch, 2000; David, 2001). The numbers in the concepts in figure 1.1 indicate in research questions the concepts are involved. Loops in the decision making process, which continuously occur in reality have been omitted in the research framework.

Firm structure reflects characteristics like firm size and degree of mechanization. Personal characteristics include variables like age of the entrepreneur and presence of a successor. Firm structure and personal characteristics determine the family-firm life cycle stage of the firm. Firm structure and personal characteristics have a direct impact on firm performance. The entrepreneur determines his objectives according to firm performance and firm structure. Within the reality of firm structure and performance, the entrepreneur perceives strengths and weaknesses, but also external developments. The entrepreneur bases his firm strategy on objectives and perceptions within the context of the firm structure. Firm structure, personal characteristics, firm performance, perceptions and firm strategy determine firm developments like

innovations and strategic change (Figure 1.1). Firm developments determine both firm structure and firm performance, indicating that decision making is a continuous process.

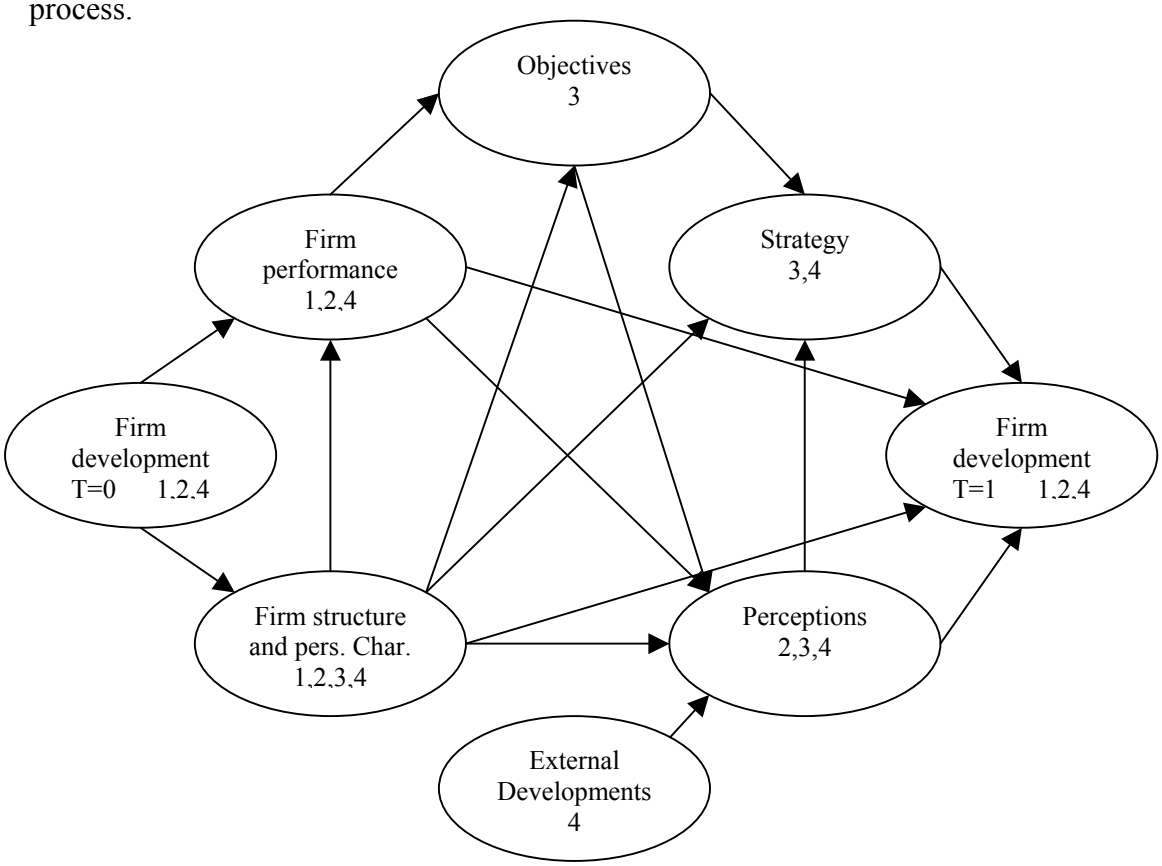

Figure 1.1 Conceptual framework for analysis.

1.3 Outline of the thesis

The thesis is structured according the research questions as described in section 1.2. In chapter 2, the effects of farmer characteristics, firm structure and firm performance on firm growth and innovation are analyzed using Probit models. Also, a comparison is made between horticulture protected cultivation and arable farms. Data have been derived from the Farm Accountancy Data Network (FADN) and a survey at firms which have ended their participation in the FADN. Chapter 3 uses the same data as chapter 2 to study the consequences of perceptions, innovation and firm growth for performance using a two-stage approach. In the first stage, the performance measured as efficiency and productivity growth is determined using DEA (data envelopment analysis). In the second stage, TOBIT is used to explain the level of technical and scale efficiency; OLS is used to explain the annual productivity changes. Chapter 4

uses Cluster Analysis to provide empirical evidence for the existence of the family-firm life cycle. The impact of the family-firm life cycle stage on key elements of the strategic decision-making process objectives, perceptions and strategy are investigated with non parametric Kruskal Wallis and Mann-Whitney tests. Data have been used from a selection of FADN participants, from which additional information is gathered through an extensive survey. In chapter 5, the role of perceptions and entrepreneurial strategies in the explanation of the adoption of energy-saving technologies are analyzed using Probity models. Both present technologies and future plans to save energy are investigated based on the same dataset used in chapter 4. In the final chapter, the general discussion reflects on the approach, methods and data used in this research, compares the results with findings in other branches consisting of small firms and ends with main conclusions.

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2 Analysis of Farm Development in Dutch Arable Farming and Horticulture[1]

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Abstract

This paper analyses the effects of farmer characteristics, firm structure and firm performance on firm renewal and firm growth. The data set used in this research consists of panel data from the Dutch Farm Accountancy Data Network of firms specialized in arable farming and horticulture protected cultivation combined with data from a survey among those firms. Results show that firm structure and performance have a larger impact on both firm renewal and firm growth than personal characteristics. Firm size has a significant, positive impact on firm growth in arable farming and a significant, negative impact on firm growth in horticulture protected cultivation. Profitability has a positive impact on both firm renewal and firm growth in horticulture protected cultivation and no impact in arable farming.

Key words: decision making, diversification, farm growth, farm structure, innovation, panel data

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2.1 Introduction

Due to external developments and internal forces, agriculture and horticulture change continuously. Goddard et al. (1993) distinguishes eight major causal factors: technology, prices, human capital, economic growth, demographics, off-farm employment, related market structure and public programs. Structural change in agriculture and horticulture is characterized by heterogeneous responses of firms. Gow and Stayner (1995) reviewed the variety of responses at the farm level and distinguish two categories, i.e. farm-related and household-related responses. Farm related responses include postponement of investments, restructuring, firm growth, diversification, exit and other factors.

Policy makers, trying to affect firm developments need insight in the determinants of structural change. Empirical studies about farm-related adjustments mostly focus on explaining one type of farm adjustment, i.e. firm growth, diversification or innovation.

Firm growth refers to increases in business size (Barry et al., 2000). Clark et al. (1992) found that Gibrat's Law was not rejected for several regions in Canada. Correspondingly, diseconomies of size found little support in their study. In essence Gibrat's Law implies that farm growth is determined by random factors and that it is independent of initial farm size (Weiss, 1999), i.e. proportionate changes in size are independent of current size and past history. In Austria, Weiss (1999) found two separate "centers of attraction" of farm size. Part-time farms tend to grow to a smaller farm size than full-time farms. He suggests to account for additional economic determinants like farm income, debt, profitability, productivity and farmer's attitude towards risk in order to explain firm survival and growth. On the base of longitudinal analysis of farm size over the farmer's life cycle, Gale (1994) concluded that firms operated by young farmers grow faster than farms operated by more experienced farmers. Aged farmers rather tend to decrease farm size.

Gertler (1996) links firm growth directly to specialization by stating that the government's efforts in the Canadian Plains have been directed towards increasing production and labour productivity by their positive effect on firm size, capitalization and specialization of surviving farms. Specialization, enables a farmer to concentrate management and capital on production of fewer commodities at a larger scale, and thus to spread fixed costs over more acres of crop, or head of livestock.

Diversification includes production of other products (horizontal) and introduction of complementary business such as food processing (vertical). Initiatives to diversification can be located within firms and in joint-ventures. In a sociological study, Anosike and Coughenour (1990) tried to explain the rate of diversification of Kentucky farmers and found a positive relationship between the rate of diversification, firm size and the level of education. Also regional differences in land and soil types were found to have an impact on diversification.

The diffusion and adoption of innovations have been widely studied in agriculture. Innovation is defined as an idea, practice of object that is perceived as new by an individual of other unit of adoption. Diffusion is the process by which an innovation is communicated through certain channels over time among members of a social system. Adoption is the individual decision to make use of an innovation (Rogers, 1995). These approaches assume that farmers and growers are (hardly or) not involved in the development of innovations. This corresponds to the taxonomy of innovations by Pavitt (1984), who classifies the innovation process in agriculture as a process that is dominated by suppliers. As a consequence, in most empirical studies the innovation process has been studied in relation to a certain innovation mature for application.

Diffusion studies provide some useful information on this issue. On the base of the innovation adoption speed, Rogers (1995) divided firms into several categories. On the base of this division, characteristics of the 'ideal' types of these adopter categories have been studied. Considering the socio-economic status, Rogers states that a positive relationship exists between wealth and the degree of innovativeness, although not all wealthy farmers are found to be innovative. The question about the causal relation remains to be answered. Some new ideas are costly to adopt but provide, if successful, first-mover advantages. A positive relationship also exists between education and the degree of innovativeness. Early adopters generally have larger firms than late adopters. Rogers (1995) did not find relationships between innovativeness and age.

Yaron et al. (1992) found that innovativeness is not affected by education, positively affected by risk tolerance and extension contacts, and negatively by farm size. An explanation of the latter outcome is that farmers strive to increase their income by adoption of input-intensive innovations, due to lack of firm growth possibilities. This finding supports the induced innovation hypothesis of Hayami and

Ruttan (1985), who hypothesize that the direction of innovation is affected by (changes in) relative prices of production factors. Labour scarcity results in high labour costs, which supports the development of labour saving techniques. Land scarcity results in high land prices which supports the development of products and techniques which increase production per ha.

The studies of Anosike and Coughenour (1990), Clark and Brown (1992), Yaron et al. (1992), Gale (1994), Gertler (1996) and Weiss (1999) have in common that they try to explain changes on the base of firm structure or personal characteristics of the farmer. The objective of this paper is to analyse the effects of characteristics of the farmer, farm structure and performance on firm growth and firm renewal. Firm growth refers to quantitative developments and firm renewal refers to qualitative developments, covering all changes at the firm requiring the application of new knowledge, including diversification and innovation. The data set, consisting of two samples combines panel data from the Dutch Farm Accountancy Data Network of arable farms and horticulture protected cultivation and data from a survey among those firms. Binary choice models were used to determine the likelihood of the changes.

The remainder of this paper is structured as follows: Section 2.2 presents a description of the branch characteristics. This is followed in section 2.3 by a discussion of the empirical model, data and estimation methods. Section 2.4 presents the results and the paper concludes with comment in section 2.5.

2.2 Branch characteristics

This study is applied to a range of firms specialized in arable farming and horticulture protected cultivation, including greenhouse horticulture and mushroom production. These branches have been chosen because they differ in two ways. First, arable farms are rather small firms where labour input is largely provided by the family. Horticulture protected cultivation consist of larger firms dependent from foreign labour. Second, arable farms have a rather continuous investment cycle, whereas the investment patterns of firms in horticulture protected cultivation have a peak when buildings like greenhouses are replaced. A summary of the characteristics of these branches is presented in table 2.1. The total production value indicates the economic

importance of the branches in Dutch agriculture. The number of specialized firms and the average firm size are an indication how production is structured. The annual average change of the number of firms reflects the speed of restructuring and the average profitability indicates the economic performance of the branches.

Table 2.1 Characteristics of Dutch plant production

Branch	Total prod value (* 10^9 Euro, 2000)	Number of specialized firms, with average annual change (%) (1990-2000)	Av. Dutch size Units per firm based upon gross standard margin (2000) 1 unit = 1.390 Euro	Av. Profitability. 1996 – 2000 (revenues/costs *100%)	Average of Total Agr. Work units per firm (2000)
Arable farming	2.2	13.749 (-1.7%)	57	86	1.37
Mushroom	0.3	516 (-4.1%)	234	93	5.97
Vegetable under glass prod	1.2	2.644 (-4.6%)	212	102	5.38
Cut flower prod	3.5	5.264 (-1.3%)	197	98	5.24
Pot plants prod				99	

LEI, CBS (2000)

Arable farms mainly grow potatoes, sugar beets and cereals. The Dutch arable farming sector is internationally of minor importance. The average farm cultivates 50 hectares of land. Arable farms are faced by decreasing profitability, mainly caused by reduction of the European Union subsidies. Increase of firm size is desirable to benefit from economies of scale, but is difficult to achieve because of the large demand for land for nature development, infrastructure, industries, growth of cities and other agricultural sectors. Alternative strategies are to grow products with higher net added value per ha, like vegetables and flower bulbs. The number farms is decreasing by 1.7% per year (Anonymous, 2001). Solvency of arable farming is high compared to other branches. An explanation for this is that a large share of the total capital consists of the value of farmland.

Internationally, Dutch horticulture plays an important role. The majority of the products are exported, mainly to European countries. In the early nineties, the production of vegetables under glass suffered a major crisis due to a bad environmental image in Germany. The large decrease of the number of firms, market and product innovations have led to a higher profitability in the late nineties. The

share of non-food products in total production is increasing. Producers of ornamental products like flowers are less vulnerable to the market conditions.

2.3 Empirical model and data

2.3.1 Conceptual model

The conceptual framework as represented in Figure 2.1 is based on the literature review, although the diversity in explanations does not provide a blueprint for a general theory. The independent variables are summarized in three concepts: personal characteristics, firm structure and (financial) performance. The arrows in Figure 1 indicate the assumed causality of the relationships with the firm renewal and firm growth.

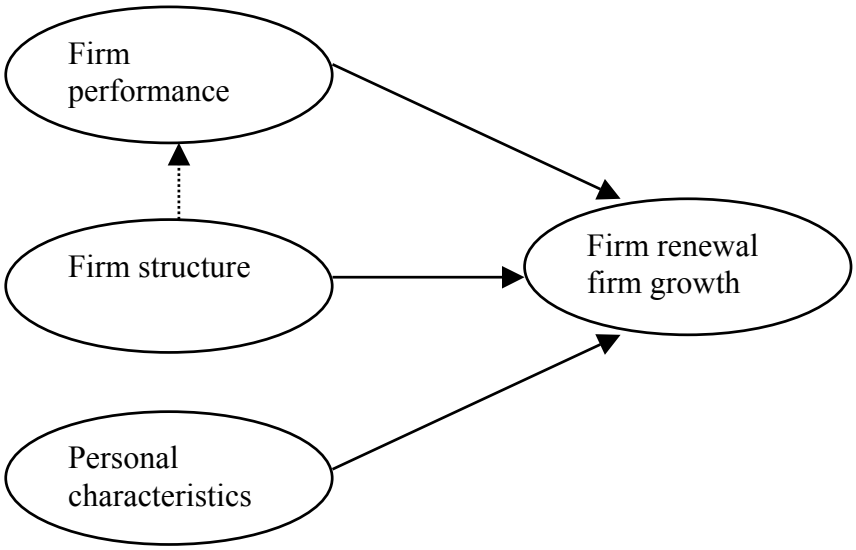

Figure 2.1. Conceptual model.

Personal characteristics like risk attitude and personal objectives are not included in the research due to lack of data. Age of the entrepreneur is included as an indicator of experience and linked to the family firm life cycle concept (Gale, 1994). It is assumed that most firm developments occur during the growth stage when the entrepreneur is rather young, so a negative relationship between age and firm growth is assumed. A short time horizon of the entrepreneur means that he will end his firm in the short term. Investments in firm developments are not likely because the entrepreneur wants

to save money, so a positive relationship between time horizon and firm developments is likely. Education is assumed to have a positive impact on both firm renewal and firm growth. Education helps the entrepreneur in gathering information and making decisions. Off-farm income is included as an indicator of focus on the firm. Off-farm income includes revenues from labour and capital outside the firm, social benefits etc. minus private costs (the off-farm income can be negative). The higher the off-farm income, the less important the firm is for providing income to the firm operator.

Geographic location is assumed to influence both firm renewal and firm developments. Differences in firm culture between regions can influence the likelihood of both innovation and firm growth. Furthermore, environmental and political possibilities for firm growth may differ between regions. It is hypothesized that firm size has a positive impact on firm renewal and no impact on firm growth. Family labour input is an indicator for the commitment of the family to the firm, which is assumed to influence both firm renewal and firm development positively. Solvency is an indicator for the ambition of the entrepreneur. A low solvency suggests the entrepreneur does not avoid making debts in order to invest in new firm capital. On the contrary, a low solvency can be the consequence of a low performance. Thus, no impact on firm developments is expected. The degree of mechanization indicates to what degree durable goods and firm size are balanced. A high degree of mechanization implies a willingness to renew the firm, but may also indicate that firm growth is advisable to get more returns to scale.

Profitability has a mutual relationship with firm development. Successful innovations and firm expansions increase profitability. A higher profitability encourages and enables the entrepreneur to invest in firm developments.

2.3.2 Data

Unbalanced panel data of firms in horticulture protected cultivation and arable farming have been obtained from a rotating panel of farms that participate in the Dutch Farm Accountancy Data Network (FADN). The FADN data contains an abundance of high quality data on firm structure, investments, performance etc. and have been collected by the Agricultural Economics Research Institute (LEI). A selection of firms has been made using a number of criteria. First, the samples have been restricted to firms that have participated for at least four years. Second, the last

year of participation should be 1996 or later. The selected firms have been asked to participate in an additional survey in order to collect more detailed data about their strategic and innovative behaviour. This resulted in the participation of 105 firms: 55 arable farms and 50 horticultural firms. The response rate in the survey for arable farms was 75% and for horticulture 67%. The selected firms participated, on average 7 years in FADN. Comparison of the descriptives (Table 2.2) with the averages in the FADN indicates that the participating firms form a representative sample of arable farms and horticulture protected cultivation. The only exception may be that the age of the entrepreneur is rather high.

Two explained variables are distinguished, i.e. firm renewal (diversification and innovation) and firm growth. Firm renewal has been based on both available FADN data and on the survey. FADN provided data about diversification. Diversification implies that a farmer or grower has to expand his activities by growing a new genus. An arable farmer producing barley next to wheat is not diversifying. However, the same farmer starting to grow flower bulbs is diversifying. FADN data provided no information about innovation and diversification within the chain (integration). An example of integration is a grower who starts breeding new varieties. This information is gathered by the additional survey, asking the farmers to mention the most important strategic changes and innovations at the firm in the former ten years and in which year these changes occurred. The answers of the participants have been checked and compared with the investment level reported in the FADN data. Firm growth is based on FADN data and measured as a dummy variable which takes the value 1 if the area and production size measured by standardized firm units both increased by at least 5% in two succeeding years. This combined measurement has been performed to prevent for accidental changes.

Explanatory variables are derived from the FADN. Time horizon has been included as a dummy variable that takes the value of 1 if the time horizon is long, i.e. if entrepreneurs have a successor or have an age lower than 50. Labour input is measured as the number of hours per year the family of the entrepreneur is working on the firm. Education is reflected by a dummy variable, that takes the value 1 for farmers that have finished at least secondary school and 0 otherwise. No data about education were available from firms in horticulture. Location is measured for horticulture protected cultivation by a regional dummy, which takes the value 1 for firms in the Westland, i.e. the glasshouse district in the western part of the country,

and 0 for firms in other regions. No regional dummies are included for arable farming, because these farms are spread all over the country. Firm size is measured by standardized firm units based upon the net value added per ha. This criterion allows for comparison of size of activities between different branches like arable farming and greenhouse cultivation. Solvency is given by the percentage equity capital of total capital. The degree of mechanization has been determined by the sum of replacement value of all durable goods per ha. To compare different sectors, the individual score has been divided by the average of the sector[2]. This average has been derived from all firms participating in the FADN.

Profitability is the only variable in the category performance and is measured as the ratio of revenues and costs. In order to correct for structural differences in average profitability between sectors, the individual profitability has been divided by the mean of the branch, which was obtained from the FADN.

Table 2.2. Descriptive statistics of the arable farm sample

Variable	Mean	St. dev.	Description
Explained variables			
EXP	0.09	0.28	1 if both area and firm size are increased by at least 5%
REN	0.08	0.28	1 if renewal of firm has taken place
Personal characteristics			
AGE	46	12	Age of the entrepreneur
SUC	0.88	0.32	1 if entrepreneur has a long time horizon
OFI	-1.14	12.5	Off farm income * f 10000
EDU	0.32	0.47	1 if educational level is at least secondary school
Firm structure			
SIZE	335	168	Firm size (sbe)
FLI	2.15	0.55	Family labour input (total hours * 1000)
SOLV	0.72	0.28	Solvency (equity capital / total capital)
MECH	0.95	0.35	Degree of mechanization (replacement value per ha/ average replacement value per ha of branch)
Performance			
PROF	0.90	0.20	Profitability (total revenues / total costs)
Total number of firms			55
Total number of observations			348

A description of the data sets that are used in this paper is given in Table 2.2 and Table 2.3. Only a part of the explanatory variables (like costs, profitability) are continuous variables. The dependent variables are binary variables. Probit models are

[2] The invested amount of durable goods per ha is very high in cultivation under glass and very low in arable farm because of the intensity of land use.

able to handle these dependent variables[3]. Probit models allow for an assessment of the impact of different explanatory variables on the probability of an event (formulated as a binary choice) and assume that the error terms of the functions follow a normal distribution (Greene, 1997).

Table 2.3. Descriptive statistics of the horticulture protected cultivation sample

Variable	Mean	St. dev.	Description
Explained variables			
EXP	0.02	0.15	1 if both area and firm size are increased by at least 5%
REN	0.15	0.35	1 if renewal of firm has taken place
Personal characteristics			
AGE	45	9	Age of the entrepreneur
SUC	0.80	0.40	1 if entrepreneur has a long time horizon
OFI	3.09	3.17	Off farm income * f 10.000
Firm structure			
LOC	0.39	0.49	1 if firm is located in the Dutch Glasshouse District
SIZE	749	511	Firm size (sbe)
FLI	902	831	Family labour input (total hours)
SOLV	0.44	0.35	Solvency (equity capital / total capital)
MECH	0.85	0.33	Degree of mechanization (replacement value per ha/ average replacement value per ha of branch)
Performance			
PROF	0.94	0.15	Profitability (total revenues / total costs)
Total number of firms			50
Total number of observations			310

The following functions in which firm renewal (REN) and firm growth (EXP) are endogenous variables have been estimated:

$$\text{Prob (REN=1)} = \phi (\alpha_0 + \alpha_1 AGE + \alpha_2 SUC + \alpha_3 EDU + \alpha_4 OFI + \alpha_5 SIZE + \alpha_6 LOC + \alpha_7 FLI + \alpha_8 SOLV + \alpha_9 MECH + \alpha_{10} PROF + e) \quad (1)$$

$$\text{Prob (EXP=1)} = \phi (\beta_0 + \beta_1 AGE + \beta_2 SUC + \beta_3 EDU + \beta_4 OFI + \beta_5 SIZE + \beta_6 LOC + B_7 FLI + \beta_8 SOLV + \beta_9 MECH + \beta_{10} PROF + e) \quad (2)$$

Where ϕ is the normal cumulative density function.

[3] Random effects probit models and multivariate probit models turned out to have no significant additional results compared to single probit models.

2.4 Results and discussion

Probit models consistent with (1) and (2) have been estimated using the statistical package LIMDEP (Greene, 1997). Marginal effects have been calculated using parameter estimates of the probit models. Results are presented in Table 4 (arable farming) and Table 5 (horticulture protected cultivation). Two measures of goodness of fit have been used: pseudo R^2 (ZM) has been computed (Table 4 and 5) and the frequencies of actual and predicted outcomes are presented in appendix 2.A (Table 2.A.1 and 2.A.2).

Table 2.4 Parameter estimates of probit model based on observations in arable farming

Variable	Firm growth (n=297)		Firm renewal (n=348)	
	Marginal effect	Significance	Marginal effect	Significance
Const	-0.27	0.08*	-0.26	0.05**
Age	0.04	0.80	-0.06	0.66
Suc	-0.02	0.68	0.06	0.36
Ofi	0.03	0.10	0.00	0.32
Edu	0.01	0.71	-0.03	0.36
Size	0.22	0.06*	0.26	0.01***
FLI	0.05	0.19	0.13	0.61
Solv	-0.04	0.53	-0.01	0.88
Mech	0.81	0.13	0.97	0.03**
Prof	-0.04	0.68	-0.12	0.13
		Goodness of fit		Goodness of fit
ZM R^2		0.29		0.33

* significant at 10% level
**significant at 5% level
*** significant at 1% level

2.4.1 Arable farming

Table 2.4 makes clear that the age of the farmer (Age), time horizon (Suc), education (Edu) nor off-farm income (Ofi) have any significant impact on either firm growth and firm renewal. It is possible to consider firm growth in arable farming as a temporary strategy because of the reversible character. Firm size (Size) has a positive impact on both firm growth and firm renewal, rejecting Gibrat's Law. Family labour input (Fli) and solvency (Solv) have no influence on firm developments. The degree of mechanization (Mech) has no impact on firm growth and a positive impact on firm renewal. Profitability ($Prof_{t-1}$)has no impact on firm developments. The results suggest that firms, which have invested in firm growth and durable goods are

encouraged to continue to invest in firm developments whereas firms, which have not invested tend to avoid risks.

The goodness of fit of the models to predict firm growth (ZM R^2 = 0.29) and firm renewal (ZM R^2 = 0.33) in arable farming are rather low. The results in Tables 2.A1 (Appendix 2.A) show that zero observations are predicted correctly in a large number of cases, whereas the occurrence of renewal and growth is predicted incorrectly.

Table 2.5 Parameter estimates of probit model based on observations in horticulture protected cultivation.

Variable	Firm growth (n=260)		Firm renewal (n=310)	
	Marginal effect	Significance	Marginal effect	Significance
Const	-0.001	0.60	-0.42	0.09*
Age	+0.002	0.07*	-0.15	0.59
Suc			+0.00	0.99
Ofi	+0.000	0.35	+0.00	0.74
Loc	+0.000	0.52	-0.05	0.30
Size	-0.001	0.09*	+0.04	0.42
Fli	-0.000	0.12	+0.02	0.51
Solv	-0.000	0.52	-0.11	0.11
Mech	-0.001	0.78	+0.61	0.44
PROF t-1	-0.002	0.03**	-0.12	0.51
PROF t-2	+0.002	0.07*	+0.34	0.08*
		Goodness of fit		Goodness of fit
ZM R^2		0.78		0.33

* significant at 10% level
**significant at 5% level
*** significant at 1% level

2.4.2 Horticulture protected cultivation

Results are summarized in Table 2.5 for horticulture protected cultivation[4]. Firm growth is positively correlated with the age of the entrepreneur. This can be explained by the fact that firm growth requires huge investments, which can be paid after a period of good earnings. The negative relationship between profitability in the year before and firm growth is caused by the fact that a time lag between investment and full capacity utilization exists. The negative effect of profitability has to be considered as a consequence instead of a cause of firm growth. The positive impact of the profitability two years before on firm growth confirms the positive impact of profitability on firm growth. Differences in location do not affect firm development in

[4] Time horizon is not included in the analysis because of perfect prediction, which is the case when a certain combination between the independent and dependent variable lacks observations.

horticulture protected cultivation i.e. firms in the glasshouse district (Westland) do not differ from other firms in terms of firm renewal and firm growth. The only determinant with a significant (positive) impact on firm renewal is the profitability two years before. This may indicate that in the firm renewal process also a time lag exists caused by the decision making process or implementation of the renewal.

Remarkably, the goodness of fit of the model predicting firm growth in horticulture (0.78) is rather high. The goodness of fit of the model predicting firm renewal in horticulture (0.33) is equal to arable farming. The frequencies of actual and predicted outcomes, for both groups are presented in appendix 2.1. The results show the same pattern as before, i.e. that zero observations are predicted correctly in a large number of cases, whereas the occurrence of renewal and growth is overall predicted incorrectly.

2.4.3 Comparison of branches

The results show that firm growth is much more likely at firms specialized in field production than at firms specialized in horticulture protected cultivation. This can be explained by the fact that firm growth in protected production requires huge investments in buildings, which are largely sunk costs. In field production, expansion of the firm can be realized by renting additional land, which can be easily given up if profits drop. Therefore firm growth in horticulture protected cultivation is more risky and thus less likely than in field production.

It is obvious from the results that firm structure has a larger impact on firm development than personal characteristics. Only age has an influence on firm growth in horticulture protected cultivation. Firm structure reflects both possibility and necessity to develop the firm. Personal characteristics are indicators of the capacity and ambitions of the entrepreneur. An explanation is that dummies represent the personal characteristics like education and time horizon too roughly. An alternative explanation is that the personal indicators represent the capacity and ambitions of the entrepreneur too weakly. Therefore, it is advisable to measure personal capacities, perceptions and ambitions directly in order to understand the decision making process about firm development in depth.

The most obvious difference is that firm size has a negative impact on firm growth for horticulture protected cultivation and a positive impact on arable farming. This result indicates an increasing diversity in firm size in arable farming and a

decreasing diversity in firm size in horticulture protected cultivation. This can be explained by the fact that the continuous trend of increase of scale and the decrease in number results in an increasing average of firm and the low incidence of firm growth in relation to the investment cycle. An other obvious difference is the impact of profitability on firm developments, which is absent in arable farming.

Generally, the results show that a large proportion of zero observations is predicted correctly, whereas the other observations are overall predicted incorrectly (Appendix 2.1). The poor prediction of the occurrence of renewal and firm growth in this case is a common feature of probit models that are estimated on data containing a small share of one choice alternative. Most firms provide only five or six observations and firm growth and renewal take place in a limited number of years. A second reason may be that the incentive to change cannot be limited to one year.

2.5 Concluding remarks

The purpose of this research was to analyse the impact of firm structure, firm performance and personal characteristics of the farmers on firm renewal and firm growth. Farm accountancy data from arable farms and horticultural firms have been combined with data from an additional survey. The effects of different variables on firm growth and firm renewal have been estimated using probit models.

The results show that firm structure, represented by variables like firm size, solvency and degree of mechanization has a larger impact on firm renewal and firm growth than personal characteristics and performance. This indicates a tendency towards increasing diversity within agriculture: successful firms will grow whereas less successful entrepreneurs are doomed to exit farming. Separate estimation of probit models for arable farming and horticulture protected cultivation shows that firm size has a negative impact on firm growth in horticulture and a positive impact in arable farming.

The importance of these results for policy makers is that they are able to distinguish between firms regarding the likelihood of firm developments. Especially in horticulture protected cultivations, firm growth has a low incidence. However, the frequencies of correct predictions show that the present models do not provide a satisfactory explanation for firm growth and firm renewal. The explanation of the

process of firm growth and firm renewal may improve if factors with a direct impact on the decision making process are incorporated in the model. This implies that the model should be expanded with long term objectives and risk attitudes of the entrepreneur, his information gathering and processing behaviour and his perception of the firm and its environment.

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Appendix 2.1 Frequencies of actual and predicted outcomes.

Table A.2.1 Frequencies of actual and predicted outcomes for firm growth and firm renewal in arable farming

	predicted		
Actual	0	1	total
Firm growth			
0	271	0	271
1	26	0	26
Total	297	0	297
Firm renewal			
0	319	0	319
1	29	0	29
Total	348	0	348

Table A.2.2 Frequencies of actual and predicted outcomes for firm growth and firm renewal in horticulture protected cultivation

	predicted		
Actual	0	1	total
Firm growth			
0	254	0	254
1	5	1	6
Total	259	1	260
Firm renewal			
0	264	0	264
1	46	0	46
Total	310	0	310

3 The Impact of Innovation, Firm Growth and Perceptions on Technical and Scale Efficiency[5]

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Abstract

This paper uses a two-stage approach to explain efficiency and productivity of Dutch glasshouse firms over the period 1991-1998. DEA is used in the first stage to determine production frontiers and individual technical and scale efficiency. In the second stage TOBIT is used to explain the level of technical and scale efficiency; OLS is used to explain the annual productivity changes. The main explanatory variables are structural changes (innovation and firm growth), socio-economic variables and perceptions classified according to the SWOT-analysis. The conclusion is that variables that are stable over time, i.e. socio-economic variables of the firm and perceptions of the entrepreneur explain the level of technical and scale efficiency whereas incidental changes like innovation and firm growth significantly contribute to the explanation of changes in technical and scale efficiency.

Key words: firm growth, innovation, panel data, productivity growth scale efficiency, socio-economic structure, technical efficiency

3.1 Introduction

The explanation of firm performance has been the subject of numerous studies, and studies focusing on efficiency form a main category among these studies. Technical

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efficiency reflects the ability of a firm to obtain maximum output from a given set of inputs or minimum input to produce a given set of outputs (Coelli *et al*., 1999)[6]. The production frontier represents the maximum possible output level related to the given input level, connecting the efficient firms. Firms produce either on that frontier if they are technically efficient or beneath the frontier, if they are technically inefficient.

In the efficiency literature, a large number of studies explain efficiency using a two-stage approach. The first stage determines the individual level of efficiency whereas the second stage explains efficiency from a set of socio-economic variables. Ideally, all variables representing input and output have to be included in the first stage. If all inputs are correctly used to determine production frontiers and individual efficiencies, differences in technical efficiencies between firms who produce under equal circumstances can besides stochastic effects be attributed to differences in the level of knowledge and motivation of the entrepreneur. Thus, inefficiency reflects the lack of knowledge about the production process and or the motivation of the entrepreneur to produce efficiently. So, variables representing the level of knowledge and motivation have to be included in the second stage of the analysis, to explain the efficiency level.

The previous literature has used a variety of socio-economic variables to explain the level of efficiency. Bravo-Ureta and Rieger (1991) find a significant positive influence from firm size and extension on technical efficiency and find no impact of the farmer's experience and education. Hallam and Machado (1996) report a positive relationship between firm size and efficiency. Andreakos *et al*. (1997) find a significant positive relationship between efficiency and the farmer's age and his formal education and the access of the farm to credit. The presence of a successor has a significant negative influence, as well as the region in which the firm is located; no significant effect is found from firm size and specialization. Wilson *et al*. (1998) report a negative effect of the farmer's experience and a positive effect of firm size on technical efficiency; geographical location has no significant impact. Alvarez and

[6] The economic performance is optimal if the firm is not only technically efficient, but also allocatively efficient. In the last case the firm uses the inputs also in the optimal proportions, given their respective prices and the production technology. It is assumed that innovation and firm growth have a larger impact on technical efficiency than on allocative efficiency. Therefore, allocative efficiency has been left out of considerations in this study.

Gonzalez (1999) find, after adjusting the data for quality effects, a negative relationship between firm size and efficiency in dairy farming. Their hypothesis is that, given a constant management capacity, farms in the largest size category are experiencing limits to a manager's span of control over the farm operation. Amara *et al*. (1999) also find a negative relationship between firm size and efficiency in Canadian arable farming and a positive effect of the number of years with farming experience. No relationship is found between the farmer's perception of environmental degradation and efficiency; adoption of conservation practices, measured as the number of such practices the farmer is using was positively correlated to efficiency. Table 3.1 summarizes the results of the above mentioned studies.

Table 3.1. Overview of studies explaining efficiency.

	Bravo-Ureta and Rieger (1991)	Hallam and Machado (1996)	Adreakos et al. (1997)	Wilson et al. (1998)	Amara et al. (1999)	Alvarez and Gonzalez (1999)
Used technique						
First stage	SFA	SFA	SFA	SFA	SFA	SFA
Second stage	ANOVA/ Kruskal Wallis	OLS	OLS	Jointly estimation	OLS	OLS
Socio-economic variables						
Age/experience	0	ni	+	-	+	+
Successor present	Ni	ni	-	ni	ni	ni
Education	0	ni	+	ni	0	ni
Credit access	Ni	ni	+	ni	ni	ni
Firm size	+	+	0	+	-	-
Specialization	Ni	-	0	ni	ni	ni
Location[a]	Ni	+	+	0	0	0
Degree of mechanization	Ni	0	Ni	ni	ni	ni

\+ Significant positive relationship[a]
\- Significant negative relationship
0 No significant relationship
ni Not included
[a] for location, the sign has no significance

The socio-economic variables discussed above are weak indicators for the farmer's knowledge level. It is expected that the explanation of the efficiency can be improved if better data about the entrepreneur's knowledge are included in the analysis. Moreover, the socio-economic variables as described above are rather stable over time. These variables are more suitable for explaining differences between firms at

the same time, and do not explain advances of individual firms in productivity over time. The explanation of the changes in productivity can be improved if direct information about factors with an impact on the individual productivity change can be included in the analysis. Productivity change can be decomposed in technical change and efficiency change.

This paper contributes to literature by extending the explanation of efficiency and productivity change by socio-economic variables with the firm operator's perceptions of firm and environment reflecting his knowledge and motivation. Also, variables reflecting strategic changes such as innovation and firm growth are accounted for. The empirical focus is on Dutch horticulture under glass. Panel data from the Dutch Farm Accountancy Data Network has been extended with survey data with information about strategic changes, innovations and a SWOT-analysis.

The remainder of this paper is structured as follows. The conceptual model is discussed in section 3.2. Section 3.3 describes branch characteristics of Dutch horticulture under glass. This is followed by data (section 3.4). Section 3.5 presents the results, and section 3.6 concludes this paper with discussion and future outlook.

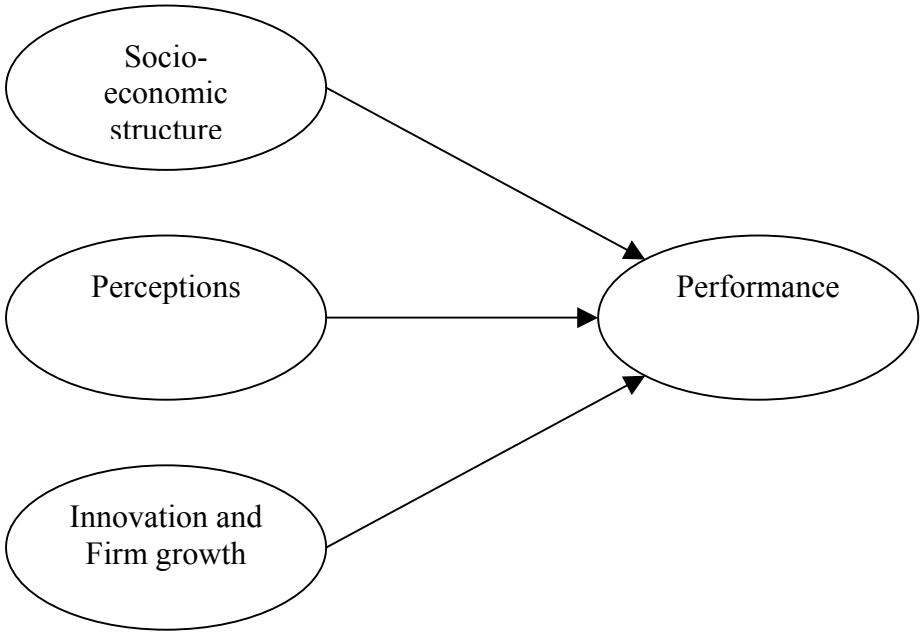

Figure 3.1 Graphical outline of the conceptual model.

3.2 Conceptual model

The studies as summarized in Table 3.1 explain the level of technical efficiency from socio-economic variables. On the base of the before described theory, the conceptual model, which relates 'performance' and 'socio-economic structure', is extended with explanatory concepts derived from the strategic management literature, i.e. 'perceptions', reflecting the outcomes of a SWOT-analysis, and 'innovation and firm growth'. A graphical outline of the model is presented in figure 3.1. The concepts are subsequently explained.

3.2.1 Performance

Technical and scale efficiency and productivity growth are chosen to represent performance. Technical efficiency reflects the ability of a firm to obtain maximum output from a given set of inputs or minimum input to produce a given set of outputs (Coelli *et al*., 1999)[7]. The production frontier reflects the minimum input levels to obtain a certain output level. The minimum combinations are based on empirical observations reflecting the best agricultural practice under the assumption of variable returns to scale (VRS). Firms producing on the production frontier are technically efficient. However, because of the VRS assumption, they possibly produce not at an optimal scale. Firms are scale efficient if they produce technical efficient under the assumption of constant returns to scale.

Productivity reflects the ratio of the produced output to the used input (Coelli, *et al.,* 1999). Productivity growth is the relative increase of the productivity over time and is composed of technical change and efficiency change.

3.2.2 Socio-economic variables

To elaborate existing models, variables representing the socio-economic variables are at the basis of the conceptual model. The socio-economic variables refer to all those

[7] The economic performance is optimal if the firm is not only technically efficient, but also allocatively efficient. In the last case the firm uses the inputs also in the optimal proportions, given their respective prices and the production technology. It is assumed that innovation and firm growth have a larger impact on technical efficiency than on allocative efficiency. Therefore, allocative efficiency has been left out of considerations in this study.

characteristics of the entrepreneur and the firm, which are assumed to influence firm performance. Examples are age of the entrepreneur, location, solvency etc.

3.2.3 Perceptions

As concluded in the introduction, in the ideal situation inefficiency can be explained by lack of knowledge or his motivation. Therefore, the conceptual model is extended with perceptions, as a concept which reflects knowledge. Perceptions refer to (perceived) knowledge about external developments and firm characteristics under and beyond control of the entrepreneur inside and outside the firm, which are perceived by the entrepreneur to have a negative or a positive influence on the realization of the objectives. A SWOT-analysis can be used to measure external and internal, positive and negative perceptions. Perceptions of the firm operator are at the basis of strategic decisions.

3.2.4 Innovation and firm growth

To understand changes in efficiency and productivity over time, strategic changes have been included in the conceptual model. Two types of strategic changes have been distinguished: innovation and firm growth. Innovation has been broadly defined as any idea, practice or object that is perceived as new by the entrepreneur (Rogers, 1995). Because of the emphasis on adoption versus development of innovations, firm developments like diversification and integration are included in this definition. Firm growth refers to a substantial expansion of the production capacity, thereby increasing the managerial border.

If (almost) efficient entrepreneurs adopt innovations and use them in the most efficient way, the frontier will shift upwards. Thus, the shifting frontier reflects technical change. Firm growth enables the entrepreneur to optimise the proportions of his inputs, and in that way to improve his scale efficiency. So it is likely that the individual efficiency, and especially the residual component, which reflects the variations in efficiency and productivity within the firm over time, is affected by changes like innovation and firm growth. However, adoption of innovation and expansion requires more of the management capacity. Innovations demand for additional knowledge, whereas expansion requires that the available management capacity has to be spread over a larger firm. So it is possible that innovation and expansion of the firm do not immediately increase productivity and efficiency or do

not increase productivity and efficiency at all. The consequence is that for a correct understanding of the dynamic aspects of efficiency and productivity developments, the empirical research has to be extended with data about innovation, strategic management and knowledge.

3.3 Characteristics of Dutch horticulture under glass

This section describes characteristics and developments of Dutch horticulture under glass, the focus of this study. In most strategic management handbooks, the relationships between strategic changes and performance have been based upon case studies. Empirical studies, which statistically investigate these relationships, are rare. The field of agriculture is no exception to this rule. However, the atomistic structure of agriculture implying a simple management structure at the individual firm and the availability of a large number of homogeneous firms makes this branch attractive for empirical research. Within agriculture, horticulture under glass has been chosen as the focus of this study. Contrary to other Dutch agricultural branches, horticulture under glass is not subject to production, market or price regulations. These characteristics, market decisions and human resource management make this sector comparable to other small and medium sized enterprises outside agriculture.

Three main categories of products in Dutch horticulture are distinguished: (1) vegetables with main products like tomatoes, cucumbers and peppers, (2) cut flowers like roses, chrysanthemum, tulips and lilies and (3) pot plants. Geographical advantages of horticulture in the Netherlands are relatively low temperatures in summer, mild winters, a high light intensity along the coast and the neighbourhood of large markets for vegetables and flowers. These factors contribute to the national and international success of this branch. The position has been strengthened by a trading system with auctions and a balanced system of research, extension and education (Vijverberg, 1996).

However, several developments violate the leading position of Dutch horticulture under glass. Lack of area in the traditional specialized glasshouse regions results in high land prices, high labour costs and stringent environmental legislation. Rising production costs are the consequence. Furthermore, vegetable production faces increasing competition of Mediterranean countries having higher temperatures and

more sunshine in spring, winter and autumn, a larger availability of land and lower labour costs. However, competition with producers in these regions triggers the development of innovations. During the early nineties, vegetable producers suffered from a bad environmental image in Germany, the main market for Dutch horticultural products. Prices of vegetables are more sensitive to changes in supply and demand than prices of ornamental products like flowers and pot plants, making the production of vegetables more risky. The very low prices forced many growers to terminate the firm or to shift to other products. The importance of horticulture for the Dutch economy and some branch characteristics are presented in Table 3.2.

Table 3.2. Characteristics of Dutch horticulture under glass

	Vegetables	Cut flowers	Pot plants
Sector data			
Total production value*10^6 Euro, 2001	1,155	2,078	1,214
Number of specialized firms in 2001	2,457	4,884 [a]	
Annual change in number of firms, 1990 – 2001	-4.8%	-1.9%[a]	
Firm data			
Firm size (standard firm units)[b] in 2001	248	211	243
Greenhouse area per firm (ha), 2001	1.65	1.13[a]	
Annual change in greenhouse area per firm in 1990 – 2001	4.8%	3.1%[a]	
Profitability, 1990 – 2000 (revenues/costs *100%)	97	95	99
Total man year per firm in 2001	6.87	5.44[a]	

Source: Anonymous, 2002; Anonymous 1990-2000
[a] The data source does not provide figures for cut flowers and pot plants separately
[b] one standard firm unit represents € 248 standardized net added value

Innovations in production and marketing and a decreased supply of vegetables resulted in high profits during the late nineties. These developments explain both the high annual decrease in the number of firms and the high annual increase in firm size (Table 3.2). Cut flower production is faced with increasing competition from countries like Israel, Kenya and Ecuador, although this competition is less severe than in vegetables. The supply of these products in wintertime is complementary to Dutch production. A large share of these products is also traded by the Dutch auctions thereby reinforcing the Dutch market system. The innovativeness of this branch, the decreasing number of firms, the increasing scale of production as well as the dynamic developments in the environment makes Dutch horticulture under glass attractive for this research.

3.4 Methods and Data

A two-stage approach is used to test the conceptual model presented in section 3.2. The first stage determines individual technical and scale efficiencies, which constitute the concept performance (Figure 3.1). Data envelopment analysis (DEA) has been used to determine the individual (scale) efficiencies of firms. DEA is more flexible than Stochastic Frontier Analysis (SFA) as it does not require a functional specification for the production frontier, and it avoids distributional assumptions for inefficiencies effects (Coelli *et al*., 1999). A disadvantage of DEA is the vulnerability for measurement errors in the variables. Especially outliers of firms producing on the frontier, which have a benchmark function, will lead to lower efficiencies for other firms. The quality of FADN data has been tested by a sensitivity analysis based on super-efficiency DEA models. In this approach, firms under evaluation are excluded from the reference set. A huge distance between an efficient firm and the production frontier after exclusion may indicate measurement errors (Zhu, 2003).
Additionally, productivity changes have been calculated using the Malmquist TFP (total factor productivity) index (input-oriented). Furthermore, the decomposition of this index in efficiency change and technical change has been calculated (Coelli, *et al.,* 1999).

The second stage employs the TOBIT-regression to explain technical and scale efficiencies, and OLS-regressions to explain the changes in productivity.

3.4.1 First stage: determination of efficiencies and productivities with DEA

Panel data of firms in horticulture under glass covering the period 1991-1998 are obtained from a rotating panel of farms that participate in the Dutch Farm Accountancy Data Network (FADN). The FADN is a stratified sample of Dutch agriculture and horticulture and contains an abundance of high quality data on firm structure, investments, and performance and so on, which have been collected by the Agricultural Economics Research Institute. The firms typically remain in the panel for a maximum of about eight years, so the panel is incomplete. Firms rotate in and out the sample to avoid a selection bias, which arises when firms improve their performance by their presence in the accounting system. The data set used for determination of the production frontier and individual technical efficiency contains 1,821 observations from 481 firms.

One output and six inputs (energy, materials, services, structures, machinery and installations and labour) are distinguished. Output consists of vegetables, fruits, pot plants and flowers. Energy consists of gas, oil and electricity, as well as heat deliveries by electricity plants. Materials consist of seeds and planting materials, pesticides, fertilisers and other materials. Services are activities provided by contract workers and from storage and delivery of outputs. Fixed inputs are structures (buildings, glasshouses, land and paving), machinery and installations and labour. Labour is measured in quality-corrected man-years, and includes family as well as hired labour. Labour is assumed to be a fixed input because a large share of total labour consists of family labour. Flexibility of hired labour is further restricted by the presence of permanent contracts and by the fact that hiring additional labour involves search costs for the firm operator. The quality correction of labour is performed by the LEI and is necessary to aggregate labour from able-bodied adults with labour supplied by young people (e.g., young family members) or partly disabled workers. Capital in structures, machinery and installations is measured at constant 1990 prices and is valued in replacement costs[8].

Tornqvist price indexes are calculated for output and the three composite variable inputs with prices obtained from the LEI/CBS. The price indexes vary over the years but not over the firms, implying differences in the composition of inputs and output or quality differences are reflected in the quantity (Cox and Wohlgenant, 1986). Implicit quantity indexes are generated as the ratio of value to the price index. A more detailed description of the data is found in Table 3.3. Differences between firm types are relatively small. Vegetable producers have the lowest costs and output per firm, pot plant production has the highest costs and output per firm.

[8] The deflators for capital in structures and machinery and installations are calculated from the data supplied by the LEI accounting system. Comparison of the balance value in year t and the balance value in year t-1 gives the yearly price correction used by the LEI. This price correction is used to construct a price index for capital and a price index for machinery and installations. These price indices are used as deflators.

Table 3.3: Variables and Descriptive Statistics of FADN Data

Firm type	Variable	Dimension	Mean	Standard dev.
Vegetables	Output	1000 Guilders	1075.66	837.21
	Energy	1000 Guilders	154.95	131.52
	Materials	1000 Guilders	135.15	106.07
	Services	1000 Guilders	92.08	64.05
	Structures	1000 Guilders	842.54	687.88
	Machinery	1000 Guilders	316.07	302.43
	Labour	Man year	6.60	4.33
Cut Flowers	Output	1000 Guilders	1177.07	929.40
	Energy	1000 Guilders	155.31	125.97
	Materials	1000 Guilders	203.66	264.05
	Services	1000 Guilders	131.09	99.84
	Structures	1000 Guilders	814.01	703.30
	Machinery	1000 Guilders	438.63	519.35
	Labour	Man year	7.07	4.85
Pot plants	Output	1000 Guilders	1454.85	1167.53
	Energy	1000 Guilders	142.59	127.63
	Materials	1000 Guilders	392.36	344.05
	Services	1000 Guilders	187.72	156.35
	Structures	1000 Guilders	935.16	926.95
	Machinery	1000 Guilders	461.40	536.50
	Labour	Man year	7.51	5.77

3.4.2 Second stage: TOBIT and OLS-regression

Subsequently, both technical and scale efficiency have been regressed on the variables listed in Table 3.4. The dependent variables take values larger than zero and at most one. Because of this censoring, Tobit is used for the estimations (Greene, 1997). OLS is used to regress the change in technical and scale efficiency on the same set of regressors.

Innovation, diversification and firm growth are observed from the available FADN data. However, in order to obtain data about other innovations like the adoption of new technologies, chain integration and perceptions an additional survey is necessary. A selection of firms from the FADN was made using a number of criteria. The sample was restricted to firms that have participated for at least four years, with the last year of participation 1996 or later. [9] Next, in the year 2000 the selected firms have been requested to participate in an additional survey in order to collect more detailed data about their strategic and innovative behaviour. This resulted in the participation of 39 firms covering 232 observations in the FADN-data. In the

[9] It was not allowed to make use of firms who still participated in the FADN, because of their participation in other research. An additional request implied a risk that they would terminate for that reason their participation in FADN.

survey, farmers and growers were asked to mention the most important strategic changes and innovations in the period 1991-1998. The answers of the participants have been checked and compared with the investment level reported in the FADN data. Firm growth is measured as a dummy variable, which takes the value 1 if the area and firm size measured in standardized firm units both increased by at least 5%. The variables representing perceptions (i.e. the SWOT-analysis) have also been obtained from the survey[10]. Respondents have been asked to mention strengths, weaknesses, opportunities and threats in open-ended questions, with at most three items per category. The answers have been categorized as shown in table 3.4.

Table 3.4. Descriptive statistics of the sample (n=242)

Variable	Mean	St. dev.	Description
Innovation and firm growth			
INACT	0.149	0.357	1 if firm renewal occurs in the same year
INACT_1	0.135	0.343	1 if firm renewal occurs in the year before
EXP	0.023	0.148	1 if firm growth occurs in the same year
EXP_1	0.027	0.163	1 if firm growth occurs in the year before
Socio-economic variables			
AGE	46.6	9.8	Age of the entrepreneur
SUC	0.22	0.416	1 if entrepreneur has a long time horizon
OND	1.62	0.797	Number of entrepreneurs
SIZE	807	535	Firm size (sbe)
SOLV	0.453	0.352	Solvency (equity capital / total capital)
MOD	1.34	0.486	Relative degree of modernity of durable goods (book value / replacement value)
LOC	0.45	0.499	1 if firm is located in Westland, the Dutch greenhouse District
Perceptions			
SSTRUC	0.23	0.422	1 if entrepreneur mentions firm structure, including firm size as a strength
SPROD	0.5	0.501	1 if entrepreneur mentions production means as a strength
SMANA	0.671	0.471	1 if entrepreneur mentions management as a strength
SKNOW	0.077	0.267	1 if entrepreneur mentions knowledge as a strength
SMARK	0.104	0.305	1 if entrepreneur mentions market management as a strength
SFINA	0.126	0.333	1 if entrepreneur mentions financial situation as a strength
OPOLI	0.18	0.385	1 if entrepreneur mentions political developments as an opportunity
OPROD	0.086	0.28	1 if entrepreneur mentions developments in production means as an opportunity
OMARK	0.315	0.466	1 if entrepreneur mentions market developments as an opportunity
OTECH	0.257	0.438	1 if entrepreneur mentions technical developments as an opportunity
OCOMM	0.185	0.389	1 if entrepreneur mentions developments in communication and image formation in sector and society as an opportunity
OSPAT	0.054	0.227	1 if entrepreneur mentions spatial developments as an opportunity

[10] Panel data about perceptions were not available and could not be reconstructed. Cross-sectional data after the participation in FADN was the best alternative.

The classification for both external categories and for both internal categories has been kept equal[11]. After classification, the variables have been transformed for analysis. A dummy variable was created for each category taking the value one if the entrepreneur mentioned at least one item in the category and zero otherwise.

Socio-economic variables have also been derived from the FADN. Variables are selected on the base of the literature and the availability in the FADN. Time horizon has been included as a dummy variable that takes the value of 1 if the time horizon is long, i.e. firm entrepreneurs with a successor or aged below 50; data about education were not available from the FADN. Firm structure is reflected by: location, firm size, solvency and the modernity of durable goods. A regional dummy is included taking the value one for firms located in the glasshouse district (in the western part of the country), and zero for firms in other regions.

Standardized firm units reflect firm size, a measure based upon the net added value per ha (Welten, 1997). This criterion allows for comparing sizes of activities between different branches like the production of roses and tomatoes. Solvency is measured as the percentage equity capital in total capital. The modernity of durable goods has been determined by dividing the sum of the book value of all durable goods by the sum of the replacement value[12]. A description of the second stage regressors is found in Table 3.4.

3.5 Results

3.5.1 First stage: determination of efficiencies by DEA

The program ONFRONT (Fare and Grosskopf, 2000) has been used to measure productivity growth and overall technical efficiency and scale efficiency under the assumption of variable returns to scale (VRS) and strong disposability of all inputs. Table 3.5 present averages of technical and scale efficiency for the data set of all firms in the FADN. Results of the subset of firms that participated in the survey are presented in Table 3.6. This table has been extended with the descriptive statistics of

[11] A two level classification has been applied, which can be requested at the first author.

[12] Because of the degressive method of depreciation of durable goods, the expected average value for modernity is 0.33

productivity change, and its decomposition into efficiency change and technical change. Productivity change and efficiencies have been determined for specialized vegetables, cut flowers and pot plants firms separately for each year in the period 1991 – 1998. It is important to note that the mean technical efficiency is influenced by the size of these samples. In small samples, relatively more firms are producing on the production frontier.

Table 3.5. Descriptive statistics of technical efficiencies and scale efficiencies 1991 – 1998, whole dataset.

	Mean	St. dev.	Minimum	Maximum	sample size
Technical efficiency					
Vegetables	0.89	0.12	0.49	1.00	691
Cut flowers	0.92	0.10	0.56	1.00	706
Pot plants	0.93	0.10	0.54	1.00	412
Scale efficiency					
Vegetables	0.96	0.06	0.46	1.00	691
Cut flowers	0.96	0.06	0.54	1.00	706
Pot plants	0.95	0.07	0.47	1.00	412

Table 3.6. Descriptive statistics of technical efficiencies and scale efficiencies 1991 – 1998 of sample used for further analysis.

	Mean	St. dev.	Minimum	Maximum	Sample size
Technical efficiency					
Vegetables	0.84	0.13	0.58	1.00	84
Cut flowers	0.89	0.11	0.62	1.00	88
Pot plants	0.91	0.09	0.71	1.00	70
Total sample	0.88	0.12	0.58	1.00	242
Scale efficiency					
Vegetables	0.96	0.05	0.80	1.00	84
Cut flowers	0.97	0.04	0.85	1.00	88
Pot plants	0.96	0.06	0.75	1.00	71
Total sample	0.96	0.05	0.75	1.00	242
Productivity change					
Vegetables	1,06	0,31	0,61	2,96	63
Cut flowers	1,03	0,19	0,64	1,92	68
Pot plants	1,03	0,14	0,81	1,46	58
Total sample	1,04	0,23	0,61	2,96	189
Efficiency change					
Vegetables	1,00	0,21	0,65	2,04	63
Cut flowers	1,01	0,13	0,74	1,47	68
Pot plants	0,99	0,10	0,78	1,23	58
Total sample	1,00	0,15	0,65	2,04	189
Technical change					
Vegetables	1,06	0,12	0,71	1,46	63
Cut flowers	1,01	0,10	0,82	1,45	68
Pot plants	1,04	0,08	0,82	1,25	58
Total sample	1,04	0,10	0,71	1,46	189

Tables 3.5 and 3.6 show that technical efficiency of vegetable production is smaller than technical efficiency of specialized cut flowers and pot plants firms. The standard deviation of technical efficiency is higher in vegetable production than in the production of cut flowers and pot plants, implying a larger variation in technical efficiency within the group of vegetable producers. Furthermore, Table 6 shows that the standard deviation of the productivity change is also higher in vegetable production than in cut flower and pot plant production. These findings are in line with the conclusion in section 3.3 that vegetable production is more risky than cut flower and pot plant production. Moreover, the larger differences in efficiency between vegetable producers contribute to the explanation of the high decrease in the number of firms and consequently the increase in firm growth (Table 3.5). Comparison of Table 3.5 and 3.6 indicates that participants of the subset are slightly less technical efficient than the firms who did not participate in the survey. The average scale efficiency is almost the same.

In order to assess the impact of measurement errors on performance measures, a sensitivity analysis has been performed. This analysis is based on the super-efficiency approach (Zhu, 2003) and shows large differences between years within each firm type (appendix 3.1). For vegetables the maximum score of the efficient firms during the years 1995 – 1998 was much higher than during 1991 – 1994. Cut flowers and pot plants show comparable differences. The maximum score in 1994 of firm type ‘cut flower’ (25.90) is much higher than the maximum score in 1991 (4.32). This indicates that the sample possibly contains outliers. Comparison of the raw data of the firms with the maximum sensitivity scores with the other firms in the samples showed that in each of the firm types one firm produced in fully depreciated greenhouses. The potential distortion of these firms on the production frontier has been investigated by determining the correlation coefficient between the maximum sensitivity scores and the average efficiency for each firm type and each year. Distortion would exist if the average efficiency in years with a high maximum sensitivity score would be significantly lower than in years with a low maximum sensitivity score. The correlation coefficient was not significant (at 5%) indicating the absence of distortions.

3.5.2 Second stage: explaining technical and scale efficiency

The results of the Tobit-regression are presented in Table 3.7. A correlation matrix has been calculated for the independent variables to test if multicollinearity exists. None of the variables has been skipped. The likelihood ratio test has been used to test the goodness of fit of the model (appendix 3.2). The results show that both the blocks of socio-economic variables and the perceptions significantly contribute to the explanation of technical and scale efficiency. The block 'innovation and firm growth' does not contribute significantly.

Table 3.7. Results of Technical Efficiency and Scale Efficiency regression, for explanation of the variables, see Table 3.4.

Variable	Technical Efficiency		Scale efficiency	
	Marginal effect	p-value	Marginal effect	p-value
Constant	0.99	0.00	0.97	0.00
Innovation and firm growth				
INACT	-0.01	0.68	-0.01	0.32
INACT_1	-0.03	0.27	-0.02	0.23
EXPANS	0.15	0.06	-0.02	0.52
EXPANS_1	-0.01	0.88	-0.02	0.47
Socio-economic variables				
AGE	-0.32	0.02	0.02	0.80
SUC	0.01	0.83	0.02	0.08
OND	0.03	0.18	-0.01	0.32
SIZE	0.03	0.26	0.01	0.60
SOLV	0.15	0.00	-0.03	0.09
MOD	-0.04	0.08	0.01	0.32
LOC	-0.07	0.00	0.03	0.00
Perceptions				
SSTRUC	-0.00	0.99	0.04	0.00
SPROD	0.07	0.00	-0.04	0.00
SMANA	-0.01	0.70	-0.01	0.38
SKNOW	0.04	0.35	-0.06	0.02
SMARK	-0.07	0.04	0.01	0.37
SFINA	-0.10	0.01	0.04	0.04
OPOLI	-0.13	0.00	0.05	0.01
OPROD	0.04	0.37	0.01	0.60
OMARK	-0.06	0.01	0.01	0.38
OTECH	0.06	0.04	-0.03	0.02
OCOMM	0.17	0.00	0.01	0.47
OSPAT	0.01	0.91	-0.03	0.27
Goodness of Fit				
Sigma	0.12		0.60	

The results show that firm growth (EXPANS) has a significant (at 10%) positive impact on technical efficiency in the same year. The insignificant impact of EXPANS_1 suggests that the improvement of the efficiency has eroded away after one year. This effect may be expected if the investment in expansion has been preceded by an extensive evaluation of the firm, providing the entrepreneur a host of

information about firm performance and the underlying causes. Innovation in the same year (INACT) and the year before (INACT_1) and firm growth in the year before have a negative though not significant impact on the level of overall technical efficiency.

Socio-economic variables have more significant correlations than structural changes. Contrary to results of Andreakos *et al*. (1997), Alvarez and Gonzalez (1999) and Amara *et al*. (1999), but in accordance with Wilson *et al*. (1998) age has a negative influence on technical efficiency. This is explained by the fact that structural developments in horticulture under glass require a flexible and sharp mind rather than experience. The developments concern different areas of entrepreneurship like marketing, assortment choices, production technology etc. Entrepreneurs cannot permit themselves to concentrate on one or two topics. A priori it is expected that these conditions provide a competitive advantage to young entrepreneurs. Although no data are available, the higher level of education of younger entrepreneurs may also play a role here.

The positive impact on technical efficiency of solvency (SOLV) and the negative impact of modernity (MOD) suggest that firms that have been investing much (causing lower solvency) tend towards over investment. Firm size doesn't have a significant impact contrary to the results of Hallam and Machado (1996), Bravo-Ureta and Rieger (1991) and Wilson *et al*. (1998) but in line with the results of Amara *et al*. (1999) and Alvarez and Gonzalez (1999). Location in the glasshouse district (LOC) has a negative impact, implying that the presence of many colleagues in the vicinity increasing the scope for participation in study groups does not improve technical performance. This result may be caused by high land prices in the glasshouse district, causing high costs for structures.

Scale efficiency is positively correlated with the presence of a successor (SUC), location in the glasshouse district (LOC), and negatively correlated with solvency (SOLV). These results can be explained by the fact that entrepreneurs with a long-term perspective invest to reach the right scale, although these investments do not immediately lead to higher technical efficiency.

Several perception categories are significantly correlated with technical efficiency and scale efficiency.[13] Mentioning production means (SPROD) as a strength and perceiving developments in technology (OTECH) and communications and image formation in branch and society (OCOMM) as opportunities are positively related with technical efficiency. A firm with good production facilities has a balanced set of high quality input like labour, assortment, which directly affects technical efficiency. Developments in technology give the entrepreneur possibilities to improve production facilities, whereas developments in communication and image formation provide information and motivation to improve efficiency.

Mentioning marketing (SMARK) as a strength and market developments (OMARK) as an opportunity have negative impacts on technical efficiency indicating that a focus on other firm aspects than production results in lower technical efficiency. Observing the own financial situation (SFINA), covering solvency, liquidity and profitability as a strength has also a negative impact on technical efficiency. Entrepreneurs with a strong financial position lack a trigger to perform optimal, and have no direct need to invest. The entrepreneur lacks a trigger to improve the performance, which leads to under-investments. The perception of political developments (OPOLI) as an opportunity is negatively correlated with technical efficiency. Trust in the government is a sign that the entrepreneur expects more advantages from external parties rather than from his own qualities. A general conclusion is that positive perceptions of developments and qualities, which are directly linked with production, have a positive influence. Positive perceptions of developments and qualities that are not directly linked with production, have a negative influence.

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[13] Threats and weaknesses have been excluded from the analysis. Adding 12 binary variables will cause multicollinearity. The consequence is that the interpretation of the relationships between efficiency and positive perceptions (strengths and opportunities) may falsely result in conclusions that mentioning development in opposite categories would show opposite relationships. This is not automatically the case, because the referred developments are not necessarily the same. E.g., a negative relationship between political developments as an opportunity and efficiency does not imply that the relationship between political developments as a threat and efficiency is positive. Environmental legislation can be a threat and expansion of the European Union can be an opportunity. Therefore, the TOBIT estimations have been repeated after replacement of strengths by weaknesses and opportunities by threats. The analysis of these results corresponds to the above-described results.

The perception of a strong firm structure (SSTRUC), as well as the perception of a strong financial situation (SFINA) has a positive influence on scale efficiency. Firm size is an important feature of firm structure and directly linked with the scale of production, which explains this relationship. The perception of a strong financial situation indicates that the entrepreneur has reached the optimal scale measured in terms of scale efficiency. There is no need for further expansion of the firm. Mentioning production means (SPROD) and knowledge (SKNOW) as strengths is negatively correlated with scale efficiency. The meaning of these results is that firms, which mention these aspects, have a narrow focus on production and do not pay attention to the scale of the production. The same explanation holds for perceiving technology (OTECH) as an opportunity that has a negative influence on scale efficiency. Technological developments affect technical efficiency directly and scale efficiency indirectly. The relationship with scale efficiency exists if technological changes affect the optimal scale of production. The perception that political developments (OPOLI) provide opportunities has a positive impact on scale efficiency. A possible explanation is that entrepreneurs producing at an optimal scale perceive the liberalization of the energy market with its positive scale effects as an opportunity. A conclusion summarizing these findings is that, in line with the conclusion about technical efficiency, mentioning strengths and opportunities that have a direct relationship with the firm's scale efficiency have a positive impact on scale efficiency.

3.5.3 Second stage: Explaining productivity change

OLS has been used to analyse the impact of a limited set regressors on productivity change, and its two components: efficiency change and technical change. Perceptions have been skipped from the analysis because tentative results showed no significant effects and low marginal values of the perceptions. The R^2 decreased slightly by skipping them.

The results (Table 3.8) show that only structural changes influence the annual change in efficiency positively. Firm growth (EXPANS) has the largest marginal impact on productivity change. Innovation (INACT) has also a significant effect on productivity change. Socio-economic variables don't have any significant impact on productivity change. A second important result is that innovation and firm growth

have an immediate effect on efficiency, i.e. the effect has eroded away after one year. Regressors, which do not vary from year to year, do not have a significant impact on the productivity change. Subdivision of productivity change into efficiency change and technical change make clear that both innovation and firm growth affect efficiency change. They have no significant impact on technical change: This can be explained by the fact that most firms use techniques after innovation and growth, which are already in use by efficiently producing firms.

Table 8. Parameter estimates and goodness of fit of OLS-model for productivity change

Variable	Mi		EC		TC	
	Marg.effect	p-value	Marg.effect	p-value	Marg.effect	p-value
Constant	1.13	0.00	1.03	0.00	1.08	0.00
Structural changes						
INACT	0.11	0.01	0.06	0.05	0.03	0.12
INACT_1	0.01	0.79	0.01	0.87	0.00	0.94
EXPANS	0.50	0.00	0.33	0.00	0.07	0.13
EXPANS_1	0.07	0.48	0.03	0.71	0.05	0.26
Socio-economic variables						
AGE	-0.18	0.38	-0.02	0.90	-0.16	0.13
SUC	-0.02	0.61	-0.02	0.50	0.00	0.96
OND	0.02	0.40	0.01	0.73	0.01	0.32
SIZE	0.00	1.00	0.01	0.59	-0.01	0.57
SOLV	0.00	0.92	-0.03	0.36	0.03	0.23
MOD	-0.05	0.13	-0.04	0.13	0.00	0.97
LOC	0.00	1.00	0.01	0.81	-0.01	0.66
Goodness of Fit						
R^2	0.18		0.15		0.05	
Residual statistics	Mean	St. dev.	Mean	St. dev.	Mean	St. dev.
Predicted Value	1.04	0.10	1.00	0.06	1.04	0.02
Residual	0.00	0.20	0.00	0.14	0.00	0.10

Comparison of Tables 3.7 and 3.8 supports the conclusion that regressors that are stable over time explain the level of firm efficiency and regressors that vary across years better explain the change in efficiency. The results of the OLS regression on technical and scale efficiency change are supplementary to the results of the TOBIT-analysis on the efficiency levels and lend support to entrepreneurs who want to improve their performance through innovation and firm growth. Innovation and firm growth affect the firm structure, which is covered by the socio-economic variables affecting technical and scale efficiency.

3.6 Conclusion and future outlook

The necessity to innovate and continuously change the firm strategy on the one hand and the risk associated with wrong decisions about innovation or strategic change on the other hand create the need for more empirical insight in the relationships between performance, perceptions, innovation and firm growth. This paper uses DEA to determine technical and scale efficiency as indicators for firm performance. Next, TOBIT is used to explain the level of technical and scale efficiency and OLS to explain the annual productivity growth. The main explanatory categories are socio-economic variables, structural changes (innovation and firm growth), and perceptions classified according to the SWOT-analysis. Until now, most studies have been limited to socio-economic variables, which mostly reflect the outcome of managerial decisions. This study incorporates both the decisions (structural changes) and possible causes for change (perceptions), making the explanation more general. The empirical focus is on data on Dutch glasshouse firms over the period 1991-1998.

The results show that innovation has no impact on the level of technical efficiency and scale efficiency. Firm growth has a significant positive impact on technical efficiency and has no influence on scale efficiency. Both innovation and firm growth have an immediate significant positive influence on the change in technical efficiency and firm growth has a significant positive influence on the change in scale efficiency. The socio-economic structure has much more impact on both technical and scale efficiency. Young entrepreneurs are technically more efficient than old producers. A long-term perspective and investments, indicated by the low solvency improve scale efficiency. Perceptions have a significant impact on both technical and scale efficiency. Positive perceptions about firm characteristics and developments, which have a direct link with production technology, contribute significantly to a higher technical efficiency. Positive perceptions about firm characteristics and developments therein (having a direct link with the firm's scale) contribute significantly to higher scale efficiency. Both results support the idea that significant positive perceptions reflect the areas of interest of the entrepreneur.

Both innovation and firm growth have a significant positive impact on the productivity growth, and on technical efficiency change; it has no impact on technical change.

The general conclusion is that variables which are rather stable over time like the socio-economic structure of the firm and the perceptions of the entrepreneur contribute to the explanation of the level of technical and scale efficiency whereas incidental changes like innovation and firm growth significantly contribute to the explanation of the change in technical and scale efficiency.

This paper is the first to explain technical and scale efficiency from socio-economic variables, strategic changes and perceptions. Perceptions trigger or prohibit managerial decisions, strategic changes reflect managerial decisions, and socio-economic variables like solvency and firm size are indicators of the outcomes of decisions. Panel data about socio-economic variables and strategic changes are used. From perceptions only cross-sectional data are available. The understanding of efficiency will get more in-depth if panel data of perceptions are available as it allows the analysis of (changes in) perceptions and strategic changes on technical and scale efficiency.

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Appendix 3.1 Sensitivity analysis of efficiency scores

Firm type	Year	Average efficiency	Maximum sensitivity score
Vegetables	1991	0.93	4.48
	1992	0.90	5.37
	1993	0.90	4.16
	1994	0.86	4.29
	1995	0.90	11.03
	1996	0.84	14.09
	1997	0.90	13.05
	1998	0.88	12.64
Cut flowers	1991	0.94	4.32
	1992	0.91	2.93
	1993	0.91	4.12
	1994	0.87	25.90
	1995	0.91	26.38
	1996	0.92	24.22
	1997	0.92	26.51
	1998	0.91	6.78
Pot plants	1991	0.96	26.23
	1992	0.91	24.66
	1993	0.93	19.28
	1994	0.95	33.54
	1995	0.95	2.29
	1996	0.92	4.50
	1997	0.92	2.31
	1998	0.92	4.49

Appendix 3.2 Outcomes of LR-test for TOBIT regressions

		Degrees of freedom	Log likelihood ratio
Technical efficiency	Innovation and firm growth	4	5.0
	Socio-economic structure	7	28.7*
	Perceptions	11	55.2*
Scale efficiency	Innovation and firm growth	4	2.9
	Socio-economic structure	7	15.6*
	Perceptions	11	32.2*

*significant at 5% level

4 Farm life cycle analysis and strategic management: exploring patterns by cluster analysis[14]

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Abstract

This paper shows empirically the existence of the family-firm life cycle. To explore the impact of the family-firm life cycle on key elements in the strategic decision-making process cluster analysis is used to distinguish four stages (entry, growth, consolidation and exit) of the family firm life cycle within a sample of 93 horticultural firms. The results show that entrants are quite optimistic and have the ambition to behave in an environmental responsible way. In the growth stage, firms improve the firm structure and invest in client contacts in order to ensure long-term continuity. In the consolidation stage, firms keep attention for structure and management in balance, try to produce efficiently and are increasingly sensitive for societal wishes. Firms in the exit stage lack optimism and their main interest is to ensure a retirement reserve. The insights derived from this study can be used to help farmers and growers making strategic decisions and to help policy makers selecting appropriate policy measures on taking into account the family-firm life cycle stage(s) of the target group(s).

Key words: strategic decision-making, cluster analysis, family firm life cycle, horticulture, objectives, perceptions, strategy.

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4.1. Introduction

The family-firm life cycle concept has been used in the agricultural economics literature to describe long-term firm developments. Boehlje and Eidman (1984), and Boehlje (1992) hypothesize that the life cycle of the farm operator parallels the life cycle of the family firm and distinguish three stages. The first stage is the entry or establishment stage in which the (young) farmer evaluates the opportunities in farming compared to alternative occupations. The second stage is the stage of growth and survival (or expansion and consolidation). Kay and Edwards (1994) divide this stage into a growth stage, with emphasis on investments and increasing debts, and a consolidation stage with emphasis on efficiency improvement and decreasing debts. The third stage is the exit or disinvestment stage, in which the entrepreneur reduces his management efforts and to terminate his entrepreneurship and the existence of the firm.

Although a family-firm life cycle concept is referred to in many studies in agricultural economics (Lianos and Parliarou, 1986; LaDue *et al*., 1991; Gale, 1994), it was never justified by empirical data. Kay and Edwards (1994) describe the consequences of the family-firm life cycle for intervention strategies by stating that 'total capital invested, size of debt, income taxes, owner's goals and other factors are likely to be different in each stage.' Lianos and Parliarou (1986) found that farmers tend to subdivide their land at the end of their career and pass it over to their children, who as a consequence of marriage and/or purchase acquire additional land. LaDue *et al*. (1991) conclude on the basis of a survey among upstate New York farm businesses that gross income and farmer's age are important indicators of investment and firm expansion decisions. Gale (1994) found that, consistent with the family-firm life cycle, young US farmers increase their firm size rapidly, reaching a peak in their late 40's to early 50's and tend to decrease the firm size at the end of their careers. Potter and Lobley (1996) concluded that the succession status is a good predictor of the likelihood of land cover change.

The concept of family-firm life cycle has been used to explain farm size distributions within the agricultural sector, or within regions, or to explain changes in the size of family firms over time (LaDue *et al.*, 1991; Gale, 1994). Other studies use the family-firm life cycle concept to explain the occurrence of other firm developments and risk taking behavior (Lianos and Parliarou, 1986; Potter and

Lobley, 1996). Although there are strong indications that the family-firm life cycle stage influences the likelihood of important changes, neither the family-firm life cycle concept nor its implied relationships have an empirical basis. Most studies include elements of the family-firm life cycle concept in their empirical models. Insight in the impact of the family-firm life cycle on farmers decisions contributes to a sound understanding of agricultural development. In order to understand relationships between the family-firm life cycle stage and entrepreneurial decisions it is important to detect relationships between the family-firm life cycle stage and key elements of strategic decision-making. The objective of this study is to explore the impact of the family-firm life cycle on strategic decision making process. Based on literature, the elements include the objectives of the entrepreneur, his perceptions and his strategies.

The remainder of this paper is structured as follows. In section 4.2, the conceptual model underlying this study is explained. This is followed by a description of the data and methods in section 4.3. The results are presented in section 4.4. The paper concludes with a discussion and concluding comments.

4.2 Conceptual model

This section describes the theoretical framework of this study, it explains concepts and motivates expected relationships. The core of the conceptual model (Figure 4.1) is that the family-firm life cycle is assumed to affect core elements of the strategic management model. The family-firm life cycle contains four stages (Kay and Edwards, 1994): entry, growth, consolidation and exit. The entry-stage covers both the start of new firms and the succession of the entrepreneur by his or her son or daughter. In the exit stage, there is no successor and the firm ceases to exist.

The conceptual model depicted in Figure 4.1 reflects key elements of the strategic management model (e.g. (Grant, 1998; Lynch, 2000; David, 2001)). The key elements include mission statement, objectives, external and internal audits, strategies that determine managerial decision-making.

The mission statement identifies the scope of a firm's operations in terms of its products and markets and distinguishes the organization from all others (David, 2001). Therefore, it has a firm-specific character. Consequently, mission statements are not included in the conceptual model. Mission statements are the basis of the

strategic management model. Mission statements shape the framework in which objectives are established and determine the relevant environment of the firm.

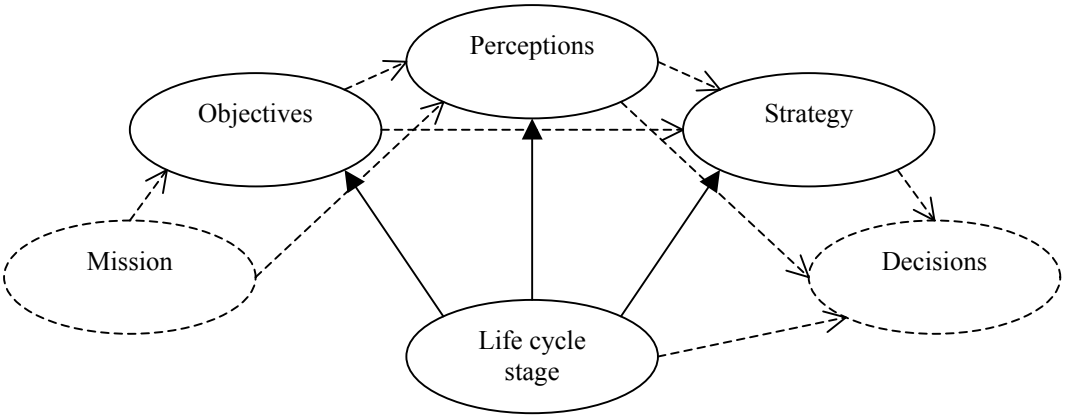

Figure 4.1. Graphical outline of the conceptual model. Solid lines represent the impact of the life cycle stage (a latent factor) on the strategic decision making process. Dotted lines represent not included relationships.

Objectives are the goals the farmer wants to realize in the long term. Examples are: minimum market share, income maximization and increasing the size of the farm business. In contrast with mission statements, long-term objectives are influenced by the family-firm life cycle stage. Objectives may deal with the development of the firm during the family-firm life cycle. The objective 'increasing the size of the farm business' is more likely to occur before the growth stage rather than afterwards, and the importance of 'saving costs' increases during the family-firm life cycle. So the total set of entrepreneurial objectives is assumed to adapt itself to the family-firm cycle.

The external and internal audits, typically assessed in a SWOT analysis (e.g. (Lynch, 2000)), result in perceptions about the firm characteristics and developments in the external environment. Perceptions reflect the entrepreneurs assessment of about processes and characteristics of the firm that are under his control and (external) developments that are beyond his control. These factors may harm or reinforce the farm organization and threaten or support the realization of the objectives (David, 2001). Firm characteristics as well as opportunities to respond to developments in the firm's environment change throughout the family-firm life cycle. In the entry stage, durable goods typically are outdated, but a relatively high solvency (just before the growth stage) enables the farmer to anticipate on changes in the environment through investments. A farmer has limited means to execute these investments at the end of

the growth stage because solvency is low by then. Throughout the consolidation stage, the solvency increases by utilization of the investments, creating new means for investments. There is no need to keep the firm in a good condition in the exit stage. The contents of perceptions change.

A strategy implies a preconceived outlined plan to realize the objectives. A strategy is a unifying theme and gives coherence and direction to actions and managerial decisions (Grant, 1998; Porter, 1980). In practice, strategies form the framework for individual managerial decisions. Strategic management is a continuous process, with many moments of feedback. Objectives and perceptions determine the selection of the farmer's strategy or strategies. Consistent with the theory described before, the family-firm life cycle concept is expected to affect managerial decisions about investments.

4.3 Data en methods

The impact of the family-firm life cycle on strategic management is studied using firm level data from Dutch greenhouse horticulture. This capital-intensive branch was chosen because societal concerns about the environment and high technological progress (and consequently high economies of scale) require horticultural growers to make strategic investments continuously.

A selection was made of 117 horticultural firms from the Dutch Farm Accountancy Data Network that is a stratified sample of Dutch agriculture (FADN, 1999). Firms specialized in potted plants, greenhouse vegetable production or greenhouse cut flower production were selected from the sample. 93 Firms, a response rate of 79% agreed to participate in an oral survey: 29 cut flower producers, 32 vegetable growers and 32 pot plant growers. Afterwards survey data of the firms were combined with cross-sectional FADN data from 2001 of the same firms. The FADN includes data about firm structure and performance. Descriptive statistics of data of the sample which are linked to the family firm life cycle are presented in Table 1. The sample contains both firms that are owned and operated by entrepreneurs from one generation and firms that are owned and operated by entrepreneurs from two different generations. Comparison with the averages of the FADN data indicates that

the average characteristics of the sample are close to the characteristics of the total population of Dutch horticulture under glass.

Table 4.1. Characteristics of the sample in 1999 - 2001 (averages of al FADN firms in parentheses)

	Vegetables (n=32)	Cut flowers (n= 29)	Pot plants (n=32)	Total sample (n=93)
Greenhouse area per firm (ha)	1.6 (1.4)	1.5 (1.1)	1.3 (1.1)	1.5 (1.2)
Profitability (revenues/costs *100%)	95 (99)	97 (96)	97 (97)	96 (97)
Solvency (%)	62 (61)	59 (55)	56 (49)	59 (56)
Modernity durable goods (%)	31 (32)	30 (28)	29 (32)	30 (30)
Total man year per firm	7.5 (6.9)	8.5 (6.1)	7.9 (7.4)	7.9 (6.7)

The survey contained questions about missions, objectives, information sources, contacts and perceptions with limited answer categories like a five point likert scale or ranking items. Variables for analysis of the family firm life cycle are selected using the conceptual model as presented in section 4.2.

A two-step approach has been used to explore the impact of the family-firm life cycle on key elements in the strategic decision making process. Cluster analysis using Ward's method (Hair jr. et al., 1998) is used to classify the firms in the stages of the family-firm life cycle. The variables used in this analysis are (Boehlje and Eidman, 1984; Boehlje, 1992; Kay and Edwards, 1994):

1. Age of the youngest entrepreneur. The age of the youngest entrepreneur has been chosen instead of the age of the oldest entrepreneur because during succession in the entry stage, both are registered as entrepreneur. If the oldest entrepreneur is chosen, no distinction can be made between entry and exit stage.[16]
2. Solvency, measured as the percentage equity capital of total capital, is rather high when the youngest entrepreneur enters the firm. Throughout the growth stage, solvency will decrease quickly because of investments, and increase during the consolidation stage. Disinvestments during the exit stage result in a high solvency again.

[16] The choice for the age of the youngest entrepreneur does not imply that the youngest entrepreneur provided the answers in the oral survey. This information is unknown. Assumed is that the most dominant entrepreneur provided the answers. The consequence is that differences in objectives, perceptions etc. between family-firm life cycle stages cannot be attributed to differences in age of the entrepreneurs.

3. Modernity of durable goods, measured as the percentage book value of replacement value.[17] Modernity of durable goods is rather low before the growth stage, rises strongly during the growth stage, and decreases slowly during the consolidation stage and rather quickly in the exit stage.
4. Average investments during the past three years, measured as the average yearly investments in durable goods divided by the total replacement value of durable goods. Investments are high in the growth stage and low in the other stages.

The final number of clusters used for further analysis is determined by combining the analysis of the agglomeration coefficient and theoretical considerations based upon the conceptual model predicting the presence of four clusters. After determining the number of clusters, results are analyzed and differences between the clusters regarding objectives, perceptions and strategies are tested. Since most of the variables in the survey were measured using a five point likert scale, non parametric Kruskal Wallis and Mann-Whitney tests are appropriate for testing differences in objectives, perceptions and strategies between the clusters.

4.4 Results

4.4.1 Cluster analysis: the four family firm life cycle stages

In Table 4.2, the results of the analysis of agglomeration coefficients are presented. The outcomes don't show a sharp kink, which means that no indication for a number of clusters can be derived from this analysis.[18] Therefore, based on the family-firm life cycle theory, the four-cluster solution has been selected for further analysis.

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[17] Due to a degressive depreciation method, the average modernity of durable goods is 33% if the entrepreneur replaces durable goods immediately when fully depreciated.

[18] The robustness of the cluster solution has been tested in several ways:

- Skipping variables
- replacement of variables
- using other clustering methods (e.g. average-linkage)
- using the same method in an other data set

With the exception of the skipping of age of youngest entrepreneur and the investment level, the cluster solution was comparable to the solution used in this paper.

Table 4.2. Analysis of agglomeration coefficients

Number of clusters	Agglomeration coefficient	Percentage change in coefficient to next level
10	4.12	8
9	4.46	8
8	4.96	11
7	5.54	12
6	6.37	15
5	7.22	13
4	8.33	15
3	9.78	17
2	11.80	21
1	15.77	34

Table 4.3. Outcomes of cluster analysis in greenhouse horticulture

Cluster	Cluster size	Average			
Life cycle stage		Age youngest entrepreneur[a]	Solvency (eq. Capital / total capital * 100%)	Modernity durable goods (book value / replacement value * 100%)[b]	Investment level 1997 – 1999
'Entry'	14	32.1 (5.8) a	89 (8) a	27 (10) a	5 (5) a
'Growth'	13	34.3 (6.9) a	54 (16) b	43 (21) b	26 (12) b
'Consolidation'	52	40.2 (7.0) b	43 (17) c	31 (14) a	7 (7) a
'Exit'	14	50.3 (6.56) c	90 (8) a	16 (8) c	2 (2) c
Total	93	39.7 (8.6)	59 (25)	30 (16)	9 (10)

[a] Different characters indicate significant differences between clusters, measured at 5% significance level

[b] Due to the degressive depreciation method, the normative modernity of durable goods is 33%

The cluster analysis resulted in four clusters matching the four life cycle stages (Table 4.3) as outlined by Kay and Edwards (1994). Entrants are on average 32 years old and have a high solvency because their predecessors still participate in the firm. Their modernity of durable goods and investment level are slightly below average. The growers are slightly older than the entrants. Their highly intensive investment activities result in a below average solvency and increasing modernity of durable goods. The consolidators are on average 40 years. Remarkably, their solvency is lower than the solvency of the firms in the growth stage. An explanation is that the firms in the growth stage continue to do investments, thereby decreasing their solvency before entering the consolidation stage. Furthermore, consolidators have an average modernity of durable goods, and a below average investment level. Entrepreneurs in the exit stage are on average 50 years and have a very low investment level. Their modernity of durable goods is very low and they have almost no debt capital.

Table 4.4. Impact of life cycle stage on objectives.

Objectives	Kruskal Wallis test	Mann-Whitney[b] test based on Cluster averages[c]			
	Significance[a]	Entry	Growth	Cons.	Exit
Personal oriented					
Earning a high income	0.73	3.86a	3.69a	3.81a	3.71a
Having much leisure	0.88	3.00a	3.00a	2.85a	3.00a
Firm oriented					
Making little debts	0.06*	3.71a	3.38ab	3.13b	3.79a
Preparing a good firm for successor	0.01***	3.36a	3.62a	3.50a	2.07b
Having little turnover of employees	0.09*	4.07a	4.08ab	4.25a	3.50b
External oriented					
Being an example with respect to energy use	0.05**	3.50a	2.69b	3.04b	2.71b
Being an example with respect to crop protection	0.15	3.64a	2.77b	3.19ab	3.21ab
Being appreciated by society	0.39	3.79ab	3.46a	3.92b	3.71ab
Being appreciated by colleagues	0.49	3.86a	3.69a	3.60a	3.64a

[a] * = significant at 10%
** = significant at 5%
*** = significant at 1%

[b] Different characters indicate significant differences between clusters, measured at 10% significance level

c Cluster averages measured on a 5-point likert scale, 1 = very unimportant, 5 = very important

4.4.2 Impact on objectives

The relation between the family firm life cycle and objectives is derived from Table 4.4. A distinction is made between objectives, which serve the entrepreneur and the firm directly, and objectives directed to others. Earning a high income and having much leisure are independent of the life cycle stage. However, the subjective interpretation of a high income may be dependent of the age of an entrepreneur. Making little debts is significantly more important for entrants and terminators than for entrepreneurs in the consolidation stage. This pattern is similar to the solvency (Table 4.3), indicating that entrants and terminators are more reluctant to make debts than firms in other stages. A result that confirms the cluster outcomes is that preparing a good firm for a successor is moderately important for firms in the entry, growth and consolidation stage, but not important for firms in the exit stage. Having little turnover of employees, which is important for the long term continuity is also only important for firms in entry, growth and consolidation stages. A high turnover of employees implies loss of experience and knowledge.

Being an example with respect to energy use is apparently more important for entrants than for entrepreneurs in the growth, consolidation and exit stage. The importance of being an example with respect to crop protection shows a comparable

pattern. This objective is significantly more important for entrants than for firms in the growth stage. Both results indicate that entrants are more sensitive to environmental concerns in society. Appreciation by society is less important in the growth stage than in the consolidation stage, which is in line with the importance of being an example with respect to energy use. Appreciation by colleagues does not differ significantly between stages.

The results show that objectives, which serve the entrepreneur himself, are not significantly different across life cycle stages. Objectives that serve the firm in the long term show significant differences. Results from the externally oriented objectives indicate that societal issues differ across the family-firm life cycle.

4.4.3 Impact on perceptions

The relation between the family-firm life cycle stage and perceptions is presented in Table 5[19]. Generally, entrepreneurs in greenhouse horticulture are more positive about their internal characteristics than about external developments. Firms operating in the entry and growth stage are rather optimistic; entrepreneurs in the exit stage are more pessimistic, which is explained by the fact that their future perspective makes them downcast. Growers in the consolidation stage are more optimistic about product price developments than growers in the entry and exit stage. Furthermore, the further firms have proceeded in the family firm life cycle, the more pessimistic they are about development of costs. An explanation is that entrepreneurs are generally concerned about developments in the price component of the costs. During the family firm life cycle, they are more optimistic about product prices. Product quality rises because of their increasing experience. No differences exist between stages in the perception of developments in space, labor market and energy policy.

The internal characteristics are divided in three groups: firm structure, management capacities and performance. Entrepreneurs are more optimistic about their management capacities than about firm structure. The differences between the perceptions of firm structure and management capacities are higher in the entry and exit stage than in the growth and consolidation stage due to investments in firm

[19] During the survey some questions regarding perceptions appeared to be unclear and had to be adjusted. The consequence is that only the external observations presented in Table 5 were available for interpretation.

structure. This result is consistent with the family firm life cycle: the quality of the firm structure is directly influenced by the firm life cycle, whereas management capacities have no direct relationship.

Table 4.5. Differences in perceptions between clusters

Perceptions	Kruskal Wallis test	Mann-Whitney[b] test based on Cluster averages[c]			
	Significance[a]	Entry	Growth	Cons.	Exit
External developments					
Spatial developments	0.97	2.79a	2.85a	2.69a	2.64a
Developments labor market	0.65	2.71a	2.62a	2.52a	2.29a
Development product prices	0.04**	2.79a	3.15ab	3.37b	2.57a
Development costs	0.13	2.71ab	2.69a	2.29ab	2.07b
Development energy policy	0.49	2.36a	2.08a	2.40a	2.00a
Internal characteristics					
Firm structure					
Firm size	0.11	3.29ab	3.46a	3.23a	2.57b
Modernity assortment	0.32	4.00a	3.69ab	3.87ab	3.50b
Modernity production means	0.00***	3.07ab	3.77c	3.48bc	2.57a
Degree of mechanization	0.14	3.00ab	3.62a	3.42a	2.86b
Management					
Labor productivity	0.33	4.00ab	3.85ab	3.88a	3.43b
Pest and disease management	0.37	4.14a	3.77ab	3.71b	3.71ab
Knowledge production methods	0.47	4.14a	4.00a	4.02a	3.79a
Product quality	0.23	4.36ab	4.62a	4.23ab	4.07b
Performance					
Solvency	0.00***	3.79a	3.54ab	3.23b	4.36c
Profitability	0.24	3.43a	3.46a	3.21ab	2.86b

[a] * = significant at 10%
** = significant at 5%
*** = significant at 1%

b Different characters indicate significant differences between clusters, measured at 10% significance level

c Cluster averages measured on a 5-point likert scale, 1 = large threat/weakness, 5 = large opportunity/strength

The results for perceptions of internal characteristics in Table 4.5 show significant differences between family firm life cycle stages, particularly those about modernity of production means and solvency. Their significance is also explained by the fact that the actual values of modernity and solvency have been used in the cluster analysis. Pair wise comparison of stages show that firms in the growth and consolidation stage are more satisfied about their firm size than firms in the exit stage. Firms in the entry stage are more satisfied about the modernity of their assortment, whereas firms in the growth stage are more satisfied about the modernity of production means and degree of mechanization. Firms in the consolidation stage are more positive about their labor productivity than firms in the exit stage. However, they are significantly less satisfied

about pest and disease management than firms in the entry stage. All entrepreneurs are equally satisfied about their knowledge of production methods. Their high modernity of durable goods and high degree of mechanization explains why firms in the growth stage are more positive about their product quality than firms in the exit stage. Entrepreneurs in the entry and growth stage have a more positive perception of their firm's profitability than firms in the exit stage.

Table 4.6. Impact of life cycle stage on strategies

Strategies	Kruskal Wallis test	Mann-Whitney[b] test based on Cluster averages[c]			
	Significance[a]	Entry	Growth	Cons.	Exit
Firm structure oriented					
Firm expansion	0.06*	3.00a	3.23a	2.98a	2.07b
Favorable location	0.08*	3.36a	2.92ab	2.98a	2.07b
Investment in labor conditions	0.98	3.56a	3.60a	3.58a	3.56a
Keeping the firm simple	0.01**	3.92a	4.15a	4.17a	3.29b
A detailed technical and economic registration	0.37	3.64a	3.46a	3.58a	3.14a
Input oriented					
Low cost strategy	0.10*	3.43a	3.69a	3.63a	4.29b
Low labor input	0.27	3.14ab	3.31ab	3.42a	3.86b
Low energy input	0.05**	3.57a	3.77a	3.87a	4.36b
Low fertilizer input	0.05**	3.36ab	2.85a	3.56b	3.64b
Low pesticides input	0.55	4.14a	3.92a	3.92a	4.21a
Output oriented					
A high production level	0.09*	4.36a	3.62b	3.83b	4.07ab
Specialization in product or way of production	0.87	3.79a	3.31a	3.46a	3.29a
Environment oriented					
Direct contact with clients	0.00***	3.64a	4.31b	3.81a	2.93c
Cooperation with suppliers	0.32	3.57a	3.31a	3.60a	3.14a
Cooperation with colleagues	0.71	3.36a	3.08a	3.31a	3.07a
Showing way of production to society	0.14	3.00ab	2.77a	3.40b	3.21ab

[a] * = significant at 10%
** = significant at 5%
*** = significant at 1%

b Different characters indicate significant differences between clusters, measured at 10% significance level

c Cluster averages measured on a 5-point likert scale, 1 = very unimportant, 5 = very important

4.4.4 Impact on strategies

Table 4.6 shows that the family firm life cycle stage has an impact on most firm strategies included in the research. A distinction has been made between firm structure, input, output and environment oriented strategies. In general, entrepreneurs give priority to input-oriented strategies; entrants are more output-oriented. Table 4.6 also shows that firms in the exit stage are not structure-oriented, rather, they are more input oriented than firms in other stages.

Firm expansion and production on a favorable location are fairly important strategies for firms in the stages with long-term perspectives, but not in the exit stage. Keeping the firm simple looses significantly importance when the firm enters the exit stage. The importance of investments in labor conditions and a detailed technical and economic administration is independent of the family firm life cycle. The significance of low labor and energy input shows a comparable pattern with low cost strategy, indicating that saving money is an important aspect for firms in the exit stage. Achieving a high production level is less important in the growth stage than in the entry and exit stage. Specialization in product or way of production is equally important during the whole family firm life cycle. Having direct contact with clients shows significant differences, i.e. it is very important for entrepreneurs in the growth stage, fairly important in the entry and consolidation stage and moderately important for firms in the exit stage. This makes clear that entrepreneurs investing in firm structure also invest in client contacts to ensure long-term sale. Cooperation with suppliers and colleagues is moderately important during the whole family firm life cycle. Showing way of production to society is significantly more important during the consolidation stage than during the growth. The investments require that they cannot pay much attention to issues, which do not generate money.

4.4.5 Sensitivity analysis of the cluster solutions

A sensitivity analysis is done in order to analyze the sensitivity of the results with respect to the number of clusters. The five-cluster solution separates the consolidation stage in two groups and leaves the entry, growth and exit stages unaffected. Characteristics of the two consolidation groups as well as differences in objectives, perceptions and strategies are presented in appendix 4.1.

One group, consisting of 19 firms (‘little ambition’), with an average age of 34 of the youngest entrepreneur has a rather low solvency (48%), a low modernity (23%) and a low investment level (0.04). The other group (33 firms) consists of older entrepreneurs (an average age of 44 for the youngest entrepreneur), a low solvency (41%), a high modernity and an average investment level (0.09). Apparently, the high modernity of the group with 33 firms (‘much ambition’) indicates that they recently passed through the growth stage, whereas the modernity of the group with the low modernity and low investment level indicates that they did not recently pass through

the growth stage. They also lack financial means to do large-scale investments. If they are not able to invest, the firm ceases to exist.

The two groups within the consolidation cluster differ in terms of their entrepreneurial ambition levels, i.e. the group with the high modernity consider the objectives 'earning a high income' and 'having much leisure' more important than the group with low modernity. They perceive developments in the labor market as a threat, are significantly more negative about their firm size and solvency, and more positive about their knowledge of production methods. The significantly more important objectives 'a detailed technical and economic administration', 'low labor input', 'a high production level', 'specialization in product of way of production' and 'showing way of production to society' indicate that the group with the high modernity has more ambitions to produce in a modern way. Comparison of the five-cluster solution with the four-cluster solution indicates that the hypothesis of Boehlje and Eidman (1984), i.e. that the family-firm life cycle and the life cycle of the entrepreneur run in a parallel way, does not always hold. The length of the consolidation stage may vary largely as a consequence of economic performance and ambition of the entrepreneur. An entrepreneur with a low profitability lacks the financial capital to replace the greenhouse when it is fully depreciated. On the contrary, an ambitious entrepreneur with a highly profitable firm wants to produce in the most modern greenhouse, replacing it before it is fully depreciated.

The three-cluster solution merges the entry and exit stages. The differences in future perspectives between both groups, which is obvious from their strategies makes it unattractive for policy makers to ignore this distinction.

4.5 Conclusion and future outlook

This paper presents the results of an empirical study of the impact of the family-firm life cycle on objectives, perceptions and strategies. Cluster analysis is used to distinguish four stages (entry, growth, consolidation and exit). The age of the youngest entrepreneur, the modernity of durable goods, the investment level during the past three years and the solvency are used as indicators for the family firm life cycle. Differences in objectives, perceptions and strategies between the four groups have been analyzed using non parametric Kruskal Wallis and Mann-Whitney tests.

The results of this study show that it makes sense to distinguish different stages of the family firm life cycle concepts. The cluster analysis results in four distinct stages, that are in line with family firm life cycle concepts as outlined by Boehlje and Eidman (1984), Boehlje (1992) and Kay and Edwards (1994).

Furthermore, the stage on the life cycle has an impact on key elements of the strategic decision making processes. Especially the importance of strategies differs by family-firm life cycle stage. Furthermore, the results show that entrants are rather optimistic about external developments and internal characteristics. They have the ambition to behave in an environmentally sound way. When they enter the growth stage, environmental sound behavior becomes less important. Improvement of the firm structure and investments in client contacts get emphasis in order to ensure long-term continuity. In the consolidation stage, firms try to produce efficiently and are increasingly sensitive to societal concerns. Firms in the exit stage shorten their time horizon; they lack optimism and are more interested in withdrawing money from the firm. Their pessimism may be the consequence of the low profitability, the absence of future perspectives or the absence of a successor.

The results also indicate that firms in the growth stage are less sensitive to social concerns than firms in the entry and consolidation stages. The consequence is that influencing socially desirable changes at the firm, which require investments, have to take place in the entry stage. However, an additional longitudinal study is necessary to detect if these influences persist in the long term. Only then it can be judged if the willingness to incorporate social desirable needs in the firm strategy continues to play a role in investment decision-making. These insights enable entrepreneurs to take correct decisions and may help policy makers to differentiate on the base of the family-firm life cycle.

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Appendix 4.1

Table A. Outcomes of cluster analysis in greenhouse horticulture: two consolidation groups

Cluster	Cluster size	Average[a]			
Consolidation groups		Age youngest entrepreneur	Solvency (eq. Capital / total capital * 100%)	Modernity durable goods	Investment level 1997 – 1999
'little ambition'	19	33.9 (3.7) a	47 (13) a	23 (11) a	4 (4) a
'much ambition'	33	43.8 (5.8) b	41 (19) a	35 (13) b	9 (8) b

[a] Different characters indicate significant differences between clusters, measured at 5% significance level

Table B. Impact of life cycle stage on objectives.

Objectives	Mann-Whitney[a] test based on Cluster averages[b]	
	'little ambition'	'much ambition'
Personal oriented		
Earning a high income	3.53a	3.97b
Having much spare time	2.42a	3.09b
Firm oriented		
Making little debts	3.42a	2.97a
Preparing a good firm for successor	3.21a	3.67a
Having little changes in employees	4.16a	4.30a
External oriented		
Being appreciated by society	3.95a	3.91a
Being appreciated by colleagues	3.58a	3.61a
Being an example with respect to energy use	3.05a	3.03a
Being an example with respect to crop protection	3.11a	3.24a

[a] Different characters indicate significant differences between clusters, measured at 5% significance level

[b] Measured on a 5-point likert scale, 1 = very unimportant, 5 = very important

Table C. Differences in perceptions between clusters

Perceptions	Mann-Whitney[a] test based on Cluster averages[b]	
	'little ambition'	'much ambition'
External developments		
Spatial developments	2.47a	2.82a
Developments labor market	3.05a	2.21b
Development product prices	3.63a	3.21a
Development costs	2.47a	2.18a
Development energy policy	2.58a	2.30a
Internal characteristics		
Firm structure		
Firm size	3.53a	3.06b
Modernity assortment	3.79a	3.91a
Modernity production means	3.32a	3.58a
Degree of mechanization	3.21a	3.55a
Management		
Labor productivity	3.95a	3.85a
Pest and disease management	3.53a	3.82a
Knowledge production methods	3.68a	4.21b
Product quality	4.26a	4.21a
Performance		
Solvency	3.63a	3.00b
Profitability	3.32a	3.15a

[a] Different characters indicate significant differences between clusters, measured at 5% significance level

[b] Cluster averages measured on a 5-point likert scale, 1 = large threat/weakness, 5 = large opportunity/strength

Table D. Impact of life cycle stage on strategies

Strategies	Mann-Whitney[a] test based on Cluster averages[b]	
	'little ambition'	'much ambition'
Firm structure		
Firm expansion	2.68	3.15a
Favorable location	2.89	3.03a
Investment in labor circumstances	3.57	3.59a
Keeping the firm simple	4.11	4.27a
A detailed technical and economic registration	3.16	3.82b
Input oriented		
Low cost strategy	3.53	3.70a
Low labor input	3.11	3.61b
Low energy input	3.95	3.82a
Low fertilizer input	3.68	3.48a
Low pesticides input	4.17	3.79a
Output oriented		
A high production level	3.00	4.30b
Specialization in product or way of production	3.00	3.73b
Environment oriented		
Direct contact with clients	3.95	3.73a
Cooperation with suppliers	3.47	3.67a
Cooperation with colleagues	3.11	3.42a
Showing way of production to society	3.00	3.64b

[a] Measured on a 5-point likert scale, 1 = very unimportant, 5 = very important

[b] Different characters indicate significant differences between clusters, measured at 5% significance level

5 The Impact of Firm Structure and Strategic Management on the Adoption of Energy-saving Principles in Dutch Greenhouse Horticulture[20]

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Abstract

This paper analyzes the role of perceptions and entrepreneurial strategies in the explanation of the adoption of energy-saving technologies. Both present technologies and future plans to save energy are investigated. Data from an oral survey have been combined with FADN data and analyzed with probit models. The results show that the presence of these energy-saving technologies is most likely at firms in the consolidation stage, with primarily a high production strategies, and consequently a low input strategy and thus an energy-saving strategy. Future plans are rather independent of the presence of energy-saving technologies. Strategies contribute more to the explanation of present energy-saving technologies whereas perceptions contribute to the explanation of future plans. This indicates that the general perceptions have to be considered thoroughly in order to decide which future plans have to be implemented according to the firm strategy.

Key words: strategic decision making, perceptions, strategies, energy-saving technologies

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5.1 Introduction

The reduction of greenhouse gas emissions is one of the major international challenges in environmental policy to prevent the world from global warming. In 1997, the international community has set future targets for the reduction of greenhouse gas emissions in the Kyoto protocol. As a result of the compliance of the Dutch government with the targets set in the Kyoto protocol, the emission of the greenhouse gases have to be reduced. The Dutch greenhouse industry accounts for 7% of the total energy use in the Netherlands. Furthermore, approximately 4% of greenhouse gas emissions in the Netherlands is produced by greenhouse horticulture.

One of the most unclear problems in environmental economics is that the adoption of energy-saving technologies which seem to be profitable for firms fall short of expectations by policy makers. Dutch greenhouse horticulture is no exception to this rule (Diederen et al., 2003). Saving fossil fuels reduces not only greenhouse gas emissions, but also inputs and thus costs. Assumptions underlying the expectations of policy makers are that the decision maker has full information, lacks any uncertainty, has no constraints in financial and other resources, has a long time horizon, gives priority to energy-saving investments, which are fully reversible and bases his decision on appropriate economic decision rules like the net present value of the investment (Soest and Bulte, 2001). Numerous studies have addressed this problem, violating one or more of the above mentioned assumptions. Verhoef and Nijkamp (2003) argue that energy taxes may reduce the attractiveness of energy-saving technologies. This is caused by the fact that energy taxes not only increase the price of energy, but also reduce the profit of the organization. The entrepreneur can also respond to energy taxes by decreasing his output. This can result in a situation that the profit through the adoption don't outweighs the costs of the adoption. Mulder et al. (2003) argue that adoption of energy-efficient technologies is a lengthy and costly process. It is more profitable for entrepreneurs to invest continuously making progress in small steps, because of the complementarity effect of investments. In this situation new technologies complement existing technologies, rather than substitute them. Besides, investment in new technologies means a loss of expertise and reduction of gains of learning-by-using. This finding links to the theory of adjustment cost (Lucas, 1967; Gould, 1968; Nickell, 1978) associated with the purchase,

productive implementation and sale of durable goods, which are assumed to increase with the size of the investments.

A relative large number of studies violate the assumptions that investments are reversible and that entrepreneurs have full information to compute the net present value of investments. DeCanio (1993) discusses several causes of the gap between the actual and theoretical behaviour regarding the use of energy. Bounded rationality, asymmetric information, divergent incentives and other focus of attention contribute to the explanation of this gap.

DeCanio and Watkins (1998) found that characteristics of firms do effect the decision to invest in energy-saving technologies. Besides, organizational and institutional factors are important determinants of firms' investment behaviour and outcomes (DeCanio, 1998). Soest and Bulte (2001) explain on the base of the real options theory that postponement of apparently profitable investment in energy-saving technologies may be profitable when additional information becomes available. Furthermore, higher rates of technological progress will increase both the opportunity costs and the rate of return of current investments.

Some studies partly or entirely concentrate on Dutch greenhouse horticulture. Diederen et al. (2003) tested real options theory on data on investments (gas combustion condensers and heat storage tanks) in energy-saving technologies in Dutch greenhouse horticulture. They found that real options theory was of minor importance in the explanation of the gap between the expected and observed adoption of energy-saving technologies. Groot et al. (2001) found that firm size, energy intensity and competitive position are important factors in explaining differences in behaviour and attitude towards policy. Among others, Dutch greenhouse firms participated in this survey.

The greenhouse industry made a covenant with the Dutch government to improve the energy efficiency (reduction of the energy input in relation to the physical output) with 65% in 2010 compared to the level of 1980. In 2002 the covenant has been upgraded by a new regulation requiring firm specific targets for reduction of energy use (Anonymus, 2002). So, Dutch greenhouse growers are forced by the government to huge efforts to save energy. The resolution forces greenhouse growers to innovate and invest in energy-saving technologies. However, it is expected that a considerable number of greenhouse firms are not capable to comply with the standards for 2010 set by the Dutch government, if they don't take additional

measures. The question to be answered is how the decision making process of these entrepreneurs can be facilitated in such a way that they can comply with the standards.

There is evidence from the above mentioned studies that the gap between the expected and observed adoption of energy-saving adoptions cannot be explained by the decision making procedure only. DeCanio and Watkins (1998) and Groot et al. (2001) show that incorporation of firm characteristics and subjective elements add to the explanation of the decision making process. The objective of this study is to make an in-depth investigation of the role of perceptions of external developments and firm characteristics, and entrepreneurial strategies in the explanation of the adoption of energy-saving technologies. The explanation of present technologies and future plans to save energy are compared to detect if barriers inhibit the entrepreneur to adopt energy-saving measures.

The paper is structured as follows. In section 5.2 the conceptual model is presented. In section 5.3 a description of Dutch horticulture under glass is given in order to understand the environment and developments of Dutch greenhouse horticulture. Data and methods are described in section 5.4 followed by the results in section 5.5. The paper ends with a conclusion and future outlook in section 5.6.

5.2 Conceptual model

This section describes the theoretical framework of this study, it explains concepts and motivates expected relationships. The conceptual model depicted in Figure 5.1 reflects key elements of the strategic management model (e.g. (Grant 1998; Lynch 2000; David 2001)). The elements, which are included in this research are perceptions based on external and internal audits and strategies that determine managerial decision-making. However, the decisions take place within the firm. So firm structure, family firm life cycle stage, which determine the context of the firm are assumed to influence the decision making process. Relationships between explanatory concepts are excluded from the research. Relationships between family-firm life cycle, strategies and perceptions have been subject of former research (Bremmer et al., 2004)

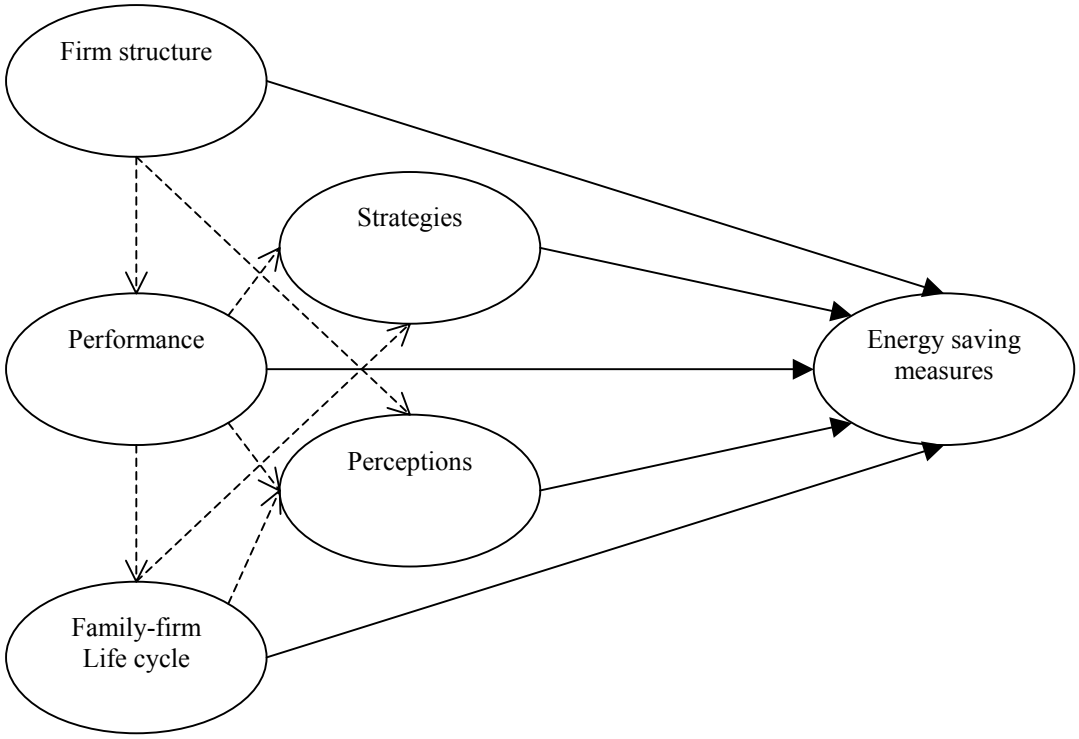

Figure 5.1. Graphical outline from the conceptual model. Dotted lines are not included in the analysis.

5.2.1 Energy-saving measures

Until now, most studies in the literature focus on the adoption of energy-saving technologies. The definition of energy-saving measures implies the adoption of energy-saving technologies, but also management adjustments. E.g., changing the greenhouse climate requires no additional investments if a climate computer is present, but has consequences for the energy use.

5.2.2 Firm structure

Firm structure refers to characteristics of the firm like firm size and degree of mechanization. If the profitability of investments is scale dependent, a relation between firm size and adoption is likely. The degree of mechanization indicates to what degree durable goods and firm size are balanced. A high degree of mechanization implies a willingness to renew the firm and thus assumed to be positively related to the adoption of energy-saving technologies. Conversely, the presence of energy-saving technologies, which increases the degree of mechanization

may have a negative impact on the adoption of energy-saving technologies and thus a positive impact on management adjustments (Pietola and Oude Lansink, 2002).

5.2.3 Family-firm life cycle stage

The family-firm life cycle concept has been used in the agricultural economics literature to describe long-term firm developments (Boehlje and Eidman, 1984; Kay and Edwards, 1994). Four stages are distinguished. The first stage is the entry or establishment stage in which the (young) farmer evaluates the opportunities in farming compared to alternative occupations. The second stage is the stage of growth, with emphasis on investments and increasing debts. The third stage is the consolidation stage with emphasis on efficiency improvement and decreasing debts. The fourth stage is the exit or disinvestment stage, in which the entrepreneur reduces his management efforts and to terminate his entrepreneurship and the existence of the firm. Because of the narrow relationship between the family-firm life cycle stage and the willingness to invest, relationship between the family-firm life cycle stage and the adoption of energy-saving technologies are assumed.

5.2.4 Performance

Different types of performance can be distinguished which are supposed to influence the likelihood of adoption of energy-saving technologies. The (overall) financial performance has a direct relationship with the financial means available for investments, but also an indirect relationship with regard to the necessity to save inputs. Technical performance has a direct relationship with the necessity to save inputs. A third relevant category with regard to energy-saving technologies is environmental performance.

5.2.5 Perceptions

Perceptions refer to (perceived) knowledge about external developments and firm characteristics under and beyond control of the entrepreneur, which are perceived by the entrepreneur to have a negative or a positive influence on the realization of the objectives. A SWOT-analysis can be used to measure external and internal, positive and negative perceptions. Perceptions of the firm operator are at basis of strategic decisions. E.g., the perception that energy consumption is high, causing high costs, encourages the farmer to invest in energy-saving consumptions (internal audit). On

the contrary, energy prices will not stimulate the entrepreneur to invest if they are perceived to be low (external audit).

5.2.6 Strategies

A strategy implies a preconceived outlined plan to realize the objectives. A strategy is a unifying theme and gives coherence and direction to actions and managerial decisions (Porter, 1980; Grant, 1998). In practice, strategies form the framework for individual managerial decisions. Strategies reflect the importance of energy-saving for the entrepreneur.

5.3 Characteristics of Dutch horticulture under glass

This section describes characteristics and developments of Dutch horticulture under glass, the focus of this study. The greenhouse is a dominant durable good at the firm which has a life span of fifteen years on average. Other durable goods are to a considerable extent related to the greenhouse. Examples are the heating system, growing system and internal transportation. Investments in new greenhouses are usually accompanied with investments in these durable goods. The consequence is that periods with a high investment level are alternated with periods with a low investment level. This results in rather abrupt transitions between family-firm life cycle stages. This is an attractive feature for empirical research to the family-firm life cycle.

Three main categories of products in Dutch horticulture are distinguished: (1) vegetables with main products like tomatoes, cucumbers and peppers, (2) cut flowers like roses, chrysanthemum, tulips and lilies and (3) pot plants. Geographical advantages of horticulture in the Netherlands are relatively low temperatures in summer, mild winters, a high light intensity along the coast and the neighbourhood of large markets for vegetables and flowers. These factors contribute to the national and international success of this branch. The position has been strengthened by a trading system with auctions and a balanced system of research, extension and education (Vijverberg, 1996). The relative importance of horticulture and some branch characteristics are presented in Table 5.1.

Table 5.1 Characteristics of Dutch horticulture under glass

	Vegetables	Cut flowers	Pot plants
Sector data			
Total production value*10^6 Euro, 2001	1,155	2,078	1,214
Number of specialized firms in 2001	2,457	4,884 [a]	
Annual change in number of firms, 1990 – 2001	-4.8%	-1.9%[a]	
Firm data			
Firm size (standard firm units)[b] in 2001	248	211	243
Greenhouse area per firm (ha), 2001	1.65	1.13[a]	
Annual change in greenhouse area per firm in 1990 – 2001	4.8%	3.1%[a]	
Profitability, 1990 – 2000 (revenues/costs *100%)	97	95	99
Total man year per firm in 2001	6.87	5.44[a]	

Source: Anonymous, 2002; Anonymous 1990-2000
[a] The data source does not provide figures for cut flowers and pot plants separately
[b] one standard firm unit represents € 248 standardized net added value

However, several developments violate the leading position of Dutch horticulture under glass. Lack of area in the traditional specialized glasshouse regions results in high land prices, high labour costs and stringent environmental legislation. Rising cost prices are the consequence. Furthermore, vegetable production suffers from international competition of Mediterranean countries, where higher temperatures and more sunshine in spring, winter and autumn result in an increasing supply and thus lower prices. The availability of land and lower labour costs result in lower cost prices. However, the competition with producers in these regions triggers the development of innovations. During the early nineties, vegetable producers suffered from a bad environmental image in Germany, the main market for Dutch horticultural products. Prices of vegetables are more sensitive to changes in supply and demand than prices of ornamental products like flowers and pot plants, making the production of vegetables more risky. The very low prices forced many growers to terminate the firm or to shift to other products.

Innovations in production and marketing and a decreased supply of vegetables resulted in high profitabilities during the late nineties. These developments explain both the high annual decrease in the number of firms and the high annual increase in firm size (Table 5.1). Cut flower production is faced with increasing competition from countries like Israel, Kenya and Ecuador, although this competition is less severe than in vegetables. The supply of these products in wintertime is complementary to Dutch production. A large share of these products is also traded by the Dutch auctions thereby reinforcing the Dutch market system.

The alternate investment pattern, the decreasing number of firms, the increasing scale of production as well as the dynamic developments in the environment make Dutch horticulture under glass attractive for this research.

5.4 Data and methods

5.4.1 Data

A selection of 117 horticultural firms specialized in potted plants, greenhouse vegetable production or greenhouse cut flower production was made from the Dutch Farm Accountancy Data Network that is a stratified random sample of Dutch agriculture (FADN, 1999). 93 Firms, a response rate of 79% agreed to participate in an oral survey. Because of missing data, 90 observations are usable: 28 cut flower producers, 32 vegetable growers and 30 pot plant growers. Data about firm structure, performance and the family firm life cycle stage (Figure 1) are derived from the FADN. Among other topics, the survey contained questions about strategies and perceptions with limited answer categories like a five point likert scale or ranking items and open ended questions dealing with future energy-saving options. Afterwards, survey data of the firms were combined with their FADN data, which include data about firm structure and performance. Comparison with the averages of the FADN data indicates that the average characteristics of the sample are close to the characteristics of the total population of Dutch horticulture under glass.

Variables for analysis are selected using the conceptual model as presented in section 2 (Figure 5.1). Because of the cross-sectional data structure and missing data about present energy-saving management adjustments, two categories of explained variables are distinguished: the rate of existing energy-saving technologies at the firm and future plans for saving energy. This makes it possible to analyze to what degree the explanation of the present technology and future plans are comparable. The adopted energy-saving technologies derived from the FADN, which are representative for the rate of energy-saving technology of the firm, are the following technologies: gas combustion condenser, heat storage tank, and total energy principle[21]. The

[21] The gas combustion condenser cools down exhaust fumes from the heating process. The recaptured heat can additionally be used for the heating process. Heat storage tanks capture the heat which is

present energy-saving techniques are measured as dummy variables, which take the value 1 if they are present at the firm.

The potential adoption of energy-saving measures is measured as follows. In the survey the respondents were asked to mention at most four future possibilities for saving energy by open-ended questions. The answers are clustered into four categories: new energy-saving technologies, expansion of present energy-saving technologies, management adaptation to save energy, like the application of temperature integration (compensation of lower temperatures during the night by higher temperatures during daytime) and avoidance of energy-saving pressure. An example of avoidance is that the entrepreneur grows other crops. Each of the four categories future plans are measured as a dummy variables, which takes the value 1 if the entrepreneur has mentioned an future plan, which belongs to that category.

Firm structure is represented as two variables: firm size and degree of mechanization. Firm size is measured by the total greenhouse area in ha. and the degree of mechanization is measured as the replacement value of durable goods per m^2. Other variables representing firm structure are summarized in the family-firm life cycle stage.

The family-firm life cycle stage is based on four underlying variables: age of the youngest entrepreneur, investment level during the last three years, modernity of durable goods and solvency. For a detailed description, we refer to Bremmer et al. (2004). The family-firm life cycle stage is measured as a dummy variable, which takes the value 1 if the firms is in that specific stage.

Firm performance is represented by a general indicator profitability measured as total revenues divided by total costs. The energy intensity measured as the total energy use in m^3 natural gas equivalents per m^2 represents both input and environmental performance.

Perceptions are measured on a five point likert scale ranging from a big threat to a big opportunity for external developments and ranging from a large weakness to a big strength for internal characteristics. Both general (social, technical economic and political) topics and energy related topics have been asked for in the survey. Strategies

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produced during daytime for the production of carbon dioxide and can be used for heating the greenhouse during the night. Total energy principle is a micro power station burning gas for the production of electricity and heat. The electricity is mainly used for assimilation lighting.

asked in the survey are based on (Boehlje and Eidman, 1984) and have been made more specific to Dutch greenhouse horticulture. They are also measured on a five point likert scale ranging from completely unimportant to very important. In order to reduce the number of variables in the further analysis, factor analysis has been employed[22]. The perceptions have been transformed to dummy variables by defining the scores 1, 2 and 3 as a threat or weakness and 4 and 5 as an opportunity or a strength. The strategies have been transformed to dummy variables by defining the scores 1, 2 and 3 as unimportant and 4 and 5 as important.

Table 5.2. Characteristics of the sample in 1999 (averages of all FADN firms in parentheses)

	Vegetables (n=32)	Cut flowers (n= 28)	Pot plants (n=30)	Total sample (n=90)
Greenhouse area per firm (ha)	1.6 (1.4)	1.5 (1.1)	1.3 (1.1)	1.5 (1.2)
Profitability (revenues/costs *100%)	95 (99)	97 (96)	97 (97)	96 (97)
Solvency (%)	62 (61)	59 (55)	56 (49)	59 (56)
Modernity durable goods (%)	31 (32)	30 (28)	29 (32)	30 (30)
Energy use (m^3 natural gas equivalents per m^2)	48 (13)	62 (23)	40 (17)	50 (20)
Total man year per firm	7.5 (6.9)	8.5 (6.1)	7.9 (7.4)	7.9 (6.7)

5.4.2 Methods

Characteristics of the data set that is used in this paper is given in Table 2 and the comparison with the whole FADN greenhouse horticulture population. It also gives an impression of the firm size (greenhouse area and total man year), structure (solvency and modernity durable goods) and performance (Profitability and energy intensity). Descriptive statistics of the sample are presented and Table 5.3 and partly overlaps Table 5.2. In Table 5.3, only one measure for firm size has been used (greenhouse area). Solvency and modernity of durable goods are variables which are covered by the family-firm life cycle stages. The variables in Table 5.3 are grouped according the concepts in Figure 5.1. Only a part of the explanatory variables (like profitability) are continuous variables. Since the dependent variables are binary variables, probit

[22] Factor analysis requires that the variables are measured at least at an interval scale. Five point likert scales are ordinal scales. For that reason factor analysis is used as a rough method to determine which the lowest number of perceptions useful for further analysis, without loosing to much information.

models are used in the estimations[23]. Probit models allow for an assessment of the impact of different explanatory variables on the probability of an event (formulated as a binary choice) and assume that the error terms of the functions follow a normal distribution (Greene, 2003).

Table 5.3. Descriptive statistics of the sample

Variable	Mean	St. dev.	Description
Present energy-saving techniques			
CON	0,81	0,39	1 if gas combustion condenser is present
BUF	0,37	0,48	1 if heat storage tank is present
WKK	0,37	0,48	1 if total energy principle is present
Future energy-saving plans			
TECHV	0,58	0,50	1 if a technical innovation is mentioned
TECHA	0,53	0,50	1 if a technical adjustment is mentioned
MAN	0,66	0,48	1 if a management adjustment is mentioned
ONTW	0,11	0,32	1 if an avoidance is mentioned
Firm structure			
OPPBEDR	1,48	0,92	Total area greenhouse (ha)
MECH99	224	81	Degree of mechanisation (replacement value of durable goods per m^2)
Life cycle stage			
START	0,14	0,35	1 if firm is in the entry stage
GROWTH	0,14	0,35	1 if firm is in the growth stage
CONSOL	0,56	0,50	1 if firm is in the consolidation stage
Performance			
RENT99	96	14	Profitability (total revenues / total costs)
ENERINT	50	20	Energy use (m^3 natural gas equivalents per m^2)
Strategies			
STR_OPET	0,40	0,49	1 if firm growth is important (firm oriented)
STR_ZUIN	0,78	0,42	1 if little energy use is important (input oriented)
STR_KWAL	0,63	0,48	1 if entrepreneur invests in client contacts (environment oriented)
STR_PROD	0,74	0,44	1 if high production is important (output oriented)
Perceptions			
OT_ARB	0,22	0,42	1 if developments on labour market is an opportunity
OT_ENERB	0,22	0,42	1 if energy policy is an opportunity
OT_ENERT	0,67	0,47	1 if developments in energy-saving technologies is an opportunity
OT_AMVB	0,13	0,34	1 if greenhouse resolution on energy-saving is an opportunity
SW_STRUC	0,49	0,50	1 if firm structure is a strength
SW_TECHK	0,80	0,40	1 if technical knowledge is a strength
SW_KWAL	0,89	0,32	1 if product quality is a strength
SW_PROF	0,37	0,48	1 if profitability is a strength
Total number of observations			90

[23] The number of variables was too limited to apply random effects probit models and multivariate probit models turned out to have no results.

5.5 Results

Probit models have been estimated using the statistical package LIMDEP (Greene, 2003). Marginal effects have been calculated using parameter estimates of the probit models. Results are presented in Table 5.4 (presence of energy-saving techniques) and Table 5.5 (future plans on saving energy). Perceptions have been excluded from analysis for two reasons. First, perceptions are measured after the investments have been done, thereby complicating the causality of the relationship. Second, tentative results showed that perceptions contributed litte to the explanation of the presence of energy-saving technologies. Two measures of goodness of fit have been used: pseudo R^2 (ZM) has been computed (Table 5.4 and 5.5) and the frequencies of actual and predicted outcomes are presented in appendix 5.A (Table 5.A.1 and 5.A.2).

Table 5.4 Parameter estimates of Probit models for presence of energy-saving technologies.

Variable	CON		BUF		WKK	
	Marg.effect	p-value	Marg.effect	p-value	Marg.effect	p-value
Constant	-0.60	0.01	-1.75	0.00	-1.88	0.00
Firm structure						
OPPBEDR	-0.00	0.85	0.13	0.07	0.07	0.32
MECH99	0.06	0.12	-0.13	0.16	0.30	0.00
Life cycle stage						
START	-0.04	0.59	0.42	0.04	0.68	0.03
GROWTH	0.14	0.14	0.49	0.06	0.38	0.25
CONSOL	0.15	0.04	0.44	0.02	0.58	0.05
Performance						
RENT99	0.33	0.03	0.28	0.55	-0.09	0.85
ENERINT	0.33	0.02	1.33	0.00	0.68	0.08
Strategies						
STR_OPET	-0.07	0.11	-0.13	0.27	0.03	0.82
STR_ZUIN	0.10	0.09	0.25	0.05	0.13	0.36
STR_KWAL	-0.11	0.04	-0.33	0.01	0.03	0.83
STR_PROD	0.09	0.09	0.51	0.01	0.09	0.54
Goodness of fit						
ZM R^2	0.77		0.77		0.65	

5.5.1 Energy-saving technologies

In general, the results indicate that mainly life cycle stages, performance and strategies contribute to the explanation of the presence of energy-saving technologies at greenhouse firms (Table 5.4). Both variables representing firm structure are significant for one energy-saving technology. A larger firm size increases the likelihood that a heat storage tank is present, indicating scale dependancy. The degree

of mechanization has a positive impact on the presence of the total energy principle, supporting the hypothesis that a high degree of mechanization implies a willingness to renew the firm.

Ceteris paribus, of all stages, the presence of a gas combustion condenser is most likely in the consolidation stage. This can be explained by the fact that a condenser is complementary to the heater, suggesting an emphasis on fine tuning of the production process in the consolidation stage. The significant positive relationship between the presence of the heat storage tank and all three mentioned life cycle stages indicates the importance of long term future perspective for energy saving investments. The significant relationship between the presence of total energy principle and the entry stage is more difficult to explain.

Profitability has a positive impact (marginal value is 0.33) on the presence of a condenser. However, the energy intensity has much more impact on the likelihood of all energy-saving technologies, stressed by the high marginal values (0.33, 1.33 and 0.68 respectively for condenser, heat storage tank and total energy principle). This finding underlines the rational decision making by growers, i.e. they understand the importance of saving costs by input-saving investments. However, the technical innovations are not enough to limit the energy use to an average or below average level.

The results show that the impact of strategies on the presence of the gas combustion condenser and the heat storage tank is comparable in terms of significancies and sign of the marginal values. The strategies of low energy use (0.10 and 0.25) and a high production (0.09 and 0.51) have a positive impact. This seems to be contradictory, because a high production requires more input and thus a higher energy use. However, energy intensive production renders the energy-saving strategy also more profitable.

The general conclusion is that the explanation of the presence of a gas combustion condenser and a heat storage tank have a comparable pattern. The presence of these energy-saving technologies is most likely at firms in the consolidation stage, with an emphasis on a high production, and consequently a high energy use and thus an energy-saving strategy. The presence of the total energy principle (WKK) is more difficult to explain because the marginal values which have a significant impact on the likelihood don't raise a consistent pattern. A high degree of mechanization and a high energy intensity are conditions, which go together with

the presence of the total energy principle. These findings are in line with both measures of goodness of fit (Table 5.4 and appendix 5.A.1), which indicate that the present model explains the presence of gas combustion condensers and heat storage tanks good, but the total energy principle moderately.

Table 5.5 Parameter estimates of Probit models for future plans to save energy

Variable	TECHV		TECHA		MAN		ONTW[24]	
	Marg. effect	p-value	Marg. effect	p-value	Marg. Effect	p-value	Marg. effect	p-value
Constant	0.55	0.39	-0.12	0.87	1.14	0.09	-0.01	0.94
Present energy-saving techniques								
CON	-0.25	0.24	-0.25	0.22	0.01	0.93	0.02	0.72
BUF	-0.42	0.03	-0.10	0.95	-0.16	0.32	-0.03	0.35
WKK	0.15	0.36	-0.33	0.05	0.20	0.20	-0.05	0.16
Firm structure								
OPPBEDR	-0.09	0.35	0.03	0.74	-0.04	0.60	0.04	0.09
MECH99	-0.27	0.01	0.01	0.90	-0.20	0.03	-0.01	0.65
Life cycle stage								
START	-0.14	0.61	0.19	0.45	0.84	0.00	0.04	0.40
GROWTH	-0.35	0.24	0.46	0.11	0.55	0.04	-0.06	0.29
CONSOL	-0.26	0.31	0.43	0.07	0.50	0.03	-0.05	0.28
Performance								
RENT99	0.32	0.57	-0.06	0.91	-0.64	0.25	-0.01	0.94
ENERINT	1.28	0.01	0.94	0.03	0.19	0.61	-0.05	0.62
Strategies								
STR_OPET	0.10	0.49	0.21	0.14	-0.04	0.73		
STR_ZUIN	-0.08	0.66	-0.28	0.13	0.11	0.48		
STR_KWAL	0.08	0.65	0.08	0.58	-0.06	0.68		
STR_PROD	0.06	0.72	0.28	0.11	-0.11	0.46		
Perceptions								
OT_ARB	0.03	0.84	-0.32	0.06	-0.22	0.11	-0.05	0.30
OT_ENERB	0.27	0.11	-0.20	0.20	0.05	0.74	-0.05	0.24
OT_ENERT	-0.08	0.62	0.04	0.82	-0.09	0.50	-0.07	0.05
OT_AMVB	0.52	0.02	0.12	0.61	-0.25	0.18		
SW_STRUC	-0.24	0.13	-0.32	0.06	0.09	0.50	0.10	0.01
SW_TECHK	0.20	0.25	-0.37	0.04	-0.22	0.20	0.01	0.87
SW_KWAL	-0.35	0.19	0.05	0.82	-0.11	0.59		
SW_PROF	0.16	0.91	0.03	0.86	-0.03	0.81	-0.09	0.06
Goodness of fit								
ZM R^2	0.61		0.57		0.55		0.67	

5.5.2 Future plans for saving energy

Firm structure, family-firm life cycle stage, performance and perceptions mainly contribute to the explanation of future plans for saving energy (Table 5.5). The presence of important energy-saving technologies is less important; strategies don't

[24] Strategies have been excluded from estimations of avoidance. The limited number of observations and the misbalance between zero and one observations limit the number of explaining variables.

contribute at all, contrary to their contribution in the explanation of the presence of energy-saving principles (Table 5.4).

The presence of a heat storage tank has a significant negative impact (-0.42) on the likelihood of mentioning a technological energy-saving innovation. The presence of a total energy principle has a negative impact (-0.33) on future plans of extending present energy-saving technologies. These results are in line with the assumption that future plans about technical solutions is less likely if important energy-saving technologies are present.

Firm size has a significant positive impact on future plans to avoid energy-saving pressure. A large firm requires a large span of control, which doesn't endure energy-saving pressure. The degree of mechanization has a significant negative impact on future plans on technological energy-saving innovations and management adjustments. This may indicate that firms with a high degree of mechanization have already adopted important energy-saving technologies. However, the degree of mechanization (-0.20) also has a negative impact on management adjustments. This may indicate that highly mechanized firms already have an emphasis on efficiency and thus don't have many options left to save energy. Future plans with a technical and management focus don't exclude each other.

Being in the consolidation stage has a significant impact on the likelihood of future plans of extending present energy-saving technologies. In this stage, extension of present technologies can serve the emphasis on fine tuning of the production process. Being in the the entry, growth and consolidation stage makes mentioning management adjustments more likely, and less likely in the exit stage. This implies that although entrepreneurs have the opportunity to apply management adjustments which do not require high costs, they are no longer focussed at saving energy by management adjustments.

Energy intensity has a positive impact on both technological innovations (1.28) and technological adjustments (0.94) to save energy. This can be explained in two ways. First, a high energy intensity means that few energy-saving technologies are present. Second, a high energy intensity has a positive impact on the profitability of energy-saving technologies.

The perception that developments on the labour market is an opportunity has a negative impact (-0.32) on the likelihood that entrepreneurs mention technical adjustments to save energy. The perception that developments in energy-saving

technologies is an opportunity has a significant negative impact on mentioning avoidance as an energy-saving option. This can be explained by the fact that avoidance is not the first alternative solution for the entrepreneur. Only if the entrepreneur doesn't see other solutions, he will avoid energy-saving pressure of policy makers and society. The perception that the greenhouse regulation on saving energy is an opportunity has a significant positive impact on the likelihood that the entrepreneurs mentions technological innovations to save energy. This can be explained by the fact that entrepreneurs which have the opportunity to invest in energy-saving innovations have a broader range of energy-saving options than colleagues, which lack this opportunity. The greenhouse regulation is more likely perceived as a threat by these colleagues and thus an opportunity for the entrepreneurs with the broader range of energy-saving options.

The perceptions that firm structure is a strength (-0.32) and that technical knowledge is a strength (-0.37) have a negative impact on the likelihood of mentioning technical adjustments to save energy. An explanation is that these entrepreneurs are critical towards their own firm and entrepreneurial qualities and are not satisfied with only technical adjustments to save energy. The perception that firm structure is a strength has a significant positive impact on the likelihood of mentioning avoidance as an energy-saving option. These entrepreneurs are confident about their firm structure and don't prefer to avoid energy-saving pressure. The perception of profitability as a strength has a significant negative impact on the likelihood of mentioning avoidance. This indicates that these entrepreneurs don't perceive possibilities to comply with future standards of energy use.

In general, future plans are rather independent of the presence of energy-saving technologies. The negative relationships between the presence of the heat storage tank and the future plans on technological innovations to save energy and between the presence of the total energy principle and future plans on technological adjustments to save energy indicate that technological solutions are less likely if the rate of energy-saving technology is high. Mentioning technological innovations is more likely at firms with a low degree of mechanization and a high energy intensity, which perceive the greenhouse resolution on saving energy as an opportunity. These firms have a broader scope for saving energy. Mentioning technological adjustments is more likely at firms in the consolidation stage, which still have a high energy intensity, but which entrepreneurs are less positive about their firm and management

quality. Mentioning management solutions is more likely at all firms with positive future perspectives. The likelihood of mentioning management solutions is increased by a low degree of mechanization, which indicates that these entrepreneurs pay much attention to fine tuning of the production process. Avoidance is more likely at big firms which, if entrepreneurs are positive about their firm qualities and they are less positive about firm performance and future developments on energy-saving principles.

Both measures of goodness of fit indicate that the explanatory power of the models explaining the presence of energy-saving technologies (Table 5.4 and Appendix 5.A1) is higher than the models explaining future plans on saving energy (Table 5.5 and Appendix 5.A2). This can be explained by the fact that the existing technologies are hard data, representing real decision making, while future plans are based on what entrepreneurs say and still have to realize.

5.5.3 Comparison of presences of energy-saving technologies and future plans to save energy

Variables representing the presence of energy-saving technologies and variables representing future plans to save energy are not fully comparable. The energy-saving technologies, which are represented by the gas combustion condenser, the heat storage tank and the total energy principle are covered by the categories technical innovations and technical adjustments mentioned as future plans. Future plans also include management adjustments and avoidance.

A direct connection has been made with the energy-saving technologies in the explanation of future plans. The negative impact of the presence of a heat storage tank on mentioning technical innovations and the negative impact of the total energy principle and mentioning technical adjustments indicate both are important energy-saving solutions and thus that technical solutions are less likely solutions to save energy. However, the conclusion cannot be drawn that management adjustments are more likely at firms which have already adopted technical energy-saving solutions. Management adjustments are more likely to be mentioned if the firm has a long term future perspective. Therefore, technical and management solutions are not mutually exclusive.

Furthermore, comparison of Table 5.4 and Table 5.5 shows that firm structure, life cycle stage and performance contribute to the explanation of the presence of

energy-saving technologies and future plans. The estimation results indicate that firm strategies contribute to the explanation of the presence of energy-saving technologies are consistent with (Table 5.4), and perceptions contribute to the explanation of future plans to save energy (Table 5.5). The results of incorporation of present energy-saving technologies in the explanation of future plans show consistency between present technologies and future plans, so a indirect relationship between strategies and perceptions may exist. An explanation is that the present energy-saving technologies reflecting implemented decisions, are consistent with the strategies, which are rather stable over time. The perceptions reflect the general evaluation of external developments and internal characteristics. However, these perceptions are not considered within the context of the firm strategy. A more profound assessment of these perceptions in the framework of the firm strategy determines which future plans to save energy will be implemented.

5.6 Conclusion and future outlook

This study makes an in-depth investigation of the impact of perceptions of external developments and firm characteristics, and entrepreneurial strategies on adoption of energy-saving technologies. Both present technologies and future plans to save energy are analyzed to detect if barriers exist in the decision making process which inhibit the entrepreneur from adopting energy-saving measures. Data from an oral survey have been combined with FADN data and analyzed with probit models.

Ceteris paribus, the presence of these energy-saving technologies is more likely at firms in the consolidation stage. The presence of important energy-saving technologies makes mentioning technical energy-saving options less likely. A high energy intensity, a high production strategy and consequently a low input and energy-saving strategy contribute to the likelihood of the presence of energy-saving technologies. The different categories of energy-saving solutions reflect the (perceived) positions of the firms. E.g. mentioning technical options is likely if important technical energy-saving techniques are not adopted; mentioning avoidance is likely if entrepreneurs are positive about firm qualities, but less positive about firm performance and future developments on energy-saving principles. The contribution of strategies to the explanation of the presence of energy-saving technologies and the

contribution of the perceptions to the explanation of future plans indicate that the general perceptions have to be considered thoroughly in order to decide which future plans have to be implemented according to the firm strategy.

The understanding of these decision processes can be improved by empirical research in which the decision making process is studied extensively. This is enabled by collecting panel data (e.g. FADN) with more detailed questions about the gathering of external and internal information, the evaluation of this information and the relationship between the judgement of this evaluating process, the firm strategies and the entrepreneurial decisions.

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Apendix 5.A

Table 5.A.1 Frequencies of actual and predicted outcomes for presence of energy-saving technologies

	predicted		
Actual	0	1	total
Heat storage tank			
0	9	8	17
1	4	69	73
Total	13	77	90
Gas combustion condenser			
0	50	7	57
1	7	26	33
Total	57	33	90
Total energy principle			
0	51	6	57
1	15	18	33
Total	66	24	90

Table 5.A.2 Frequencies of actual and predicted outcomes for future plans on saving energy

	predicted		
Actual	0	1	total
Technical innovation			
0	25	13	38
1	14	38	52
Total	39	51	90
Technical Adjustment			
0	28	14	42
1	11	37	48
Total	39	51	90
Management adjustment			
0	154	16	31
1	8	51	59
Total	23	67	90
Avoidance			
0	79	1	80
1	8	2	10
Total	87	3	90

6 General discussion and conclusions

6.1 Introduction

The general objective of this study is to investigate the mutual relationships between perceived external developments, firm development, firm structure and firm performance. A research framework based on the strategic management literature has been developed to answer four research question derived from the objective. Two data sets have been used from firms participating in the FADN, supplemented with surveys focused at gathering variables regarding firm development and strategic management. This chapter provides a reflection on the data and methods used in this research (6.2) and addresses the question to what degree the data and methods are appropriate for answering the research questions. This is followed by a discussion about the research objective and results to determine to what degree the research questions have been answered and the general objective has been realized (par. 6.3). This is followed by the main conclusions in 6.4. This chapter ends with a future outlook in 6.5.

6.2 Data and research methods

6.2.1 Data

In the research, two data set have been used. The first data set contains unbalanced panel data from 105 firms that formerly participated in the FADN: 55 arable farms and 50 horticulture firms consisting of greenhouse growers and mushroom producers. The last year of participation in the FADN was 1996, 1997 or 1998. In 2000, these firms participated in an additional survey to provide data about strategic decision making. The combined data set has been used in chapter 2 resulting in 658 observations. In chapter 3, the 39 greenhouse firms have been selected for further analysis providing 242 observations.

The availability of firms participating in the FADN has the advantage that an abundance of data about firm structure, firm performance and personal characteristics are available. Representativeness of the sample is easily determined. Therefore, the survey in-depth focused on additional management information. Although the data set

is very rich, it had some limitations. First, the firms in the sample were rather heterogeneous. The difference in firm structure of arable farms on the one hand and of greenhouse firms and mushroom producers complicated the analysis of the results. The data set had to be split into two samples, arable farms and horticulture protected cultivation, each consisting of about 50 firms. Second, the focus of the survey was too broad. Questions regarding innovations and strategic changes resulted in a wide variety of answers, which had to be interpreted and classified. Arbitrary choices had to be made if mentioned innovations corresponded with the employed definition of innovation. The limited number of observations reporting either innovation, or strategic changes regarding the application of new principles like diversification required aggregation of these changes into a new variable: firm renewal. The criterion used was that the entrepreneur needed additional knowledge and information to apply the renewal. Limitation of the survey to a specific topic (e.g. energy-saving behaviour) would have simplified the identification of significant relationships. On the contrary, generalization of the results would have been complicated. Third, a disadvantage of the data set was the lack of panel data about strategic decision making. FADN panel data were combined with cross-sectional survey data, implicitly assuming management variables like perceptions are constant over time. Analysis of the influence of the family-firm life cycle on key elements of the strategic decision making process in chapter 3 violates this assumption. The results indicate that internal firm characteristics and external developments are differently perceived in the family-firm life cycle stages and are thus not constant over time. The fourth limitation concerns causality. The measured management variables are assumed to explain the strategic changes and innovations. However, the changes took place before the management variables were measured. Ideally, measurement of management variables has to take place during the decision making process. If management variables are constant, the moment of measurement is less important.

The second data set used in this thesis contains cross-sectional data of 93 greenhouse firms still participating in the FADN and was used in chapters 4 and 5. Additional management information has been collected through an extensive oral survey. The management information is partly general, and partly focused at energy-saving behaviour. In chapter 5, because of missing data, 90 observations have been used for analysis. This data set largely overcomes the shortcomings of the first data set. First, the data set is more homogeneous, containing only greenhouse growers.

Second, the survey has been focused at energy-saving behaviour and innovations. Third, contrary to the first data set, cross-sectional FADN data are combined with management variables collected by the survey with only a limited time lag. Chapter 4 does not focus on causal relationships. Difficulties with causalities are avoided in chapter 5 because perceptions are not included in the explanation of presence of energy-saving technologies. Strategies are presumably more steady over time and are included in the analysis. Because of the measurement of management variables and future plans to save energy in one survey, no problems with causality exist.

Both surveys used in this thesis contained open ended questions and multiple choice questions. Analysis of open ended questions required interpretation and classification of the answers, requiring some arbitrary choices. Most questions with limited answer categories used likert scales to score the answers. Likert scales are ratio scales, implying that the data cannot be used directly in e.g. linear regression analysis. The answers had to be transformed to binary variables. E.g. perceptions measured on a five-point likert scale ranging from heavy threat to large opportunity had to be transformed to a binary variable with the options opportunity and threat. Because of the chosen methods, which were not able to handle likert scales, information got lost.

The limitations discussed have consequences for the realization of the general objective. The limitations of the data set used in chapter 2 and 3 (heterogeneity of the firms, lack of focus, and difficulties with causality) and the limited number of observations and lack of panel data about management variables in both data set inhibited the application of sophisticated research methods covering a more comprehensive part of the conceptual model. Instead, this thesis analyzed less comprehensive relationships in each of the chapters. The relatively small number of observations also limited the number of explaining variables incorporated in the statistical analysis.

6.2.2 Quantitative methods

In this thesis several quantitative methods have been used to address research questions. In this section, the usefulness of the methods are discussed and recommendations are made. Different criteria determine the choice of the research methods. The choice between a stochastic versus deterministic method is largely determined by the question whether relations have to be tested statistically. If

relationships have to be identified, the nature of the relationship (causality or not) plays a role. Finally, limitations like the number of observations, the availability of cross-sectional rather than panel data, and the measurement of variables play a role.

Limitations on data also put limitations on the research methods. In chapter 2, Probit analysis has been used to determine the impact of variables on firm developments. The small fraction of observations reporting innovations, diversification and firm growth caused imbalance between zero and one observations of the explained variables. The large share of observations that don't report renewal or firm growth cause that the estimated probit models tend to predict only negative occurrences of the phenomena under observation, thus demonstrating the limited predictive power of the model. Furthermore, the limited number of firms and large share of observations reporting no change inhibited the application of both multivariate probit models and probit models with random effects. Therefore, heterogeneity among the firms in the sample, interrelationships between different types of firm developments like firm growth and innovation could not be accounted for in the analysis. In chapter 5, probit analysis has been used to determine the impact of variables on existing energy-saving technologies and future plans to save energy. Multivariate probit models could not be used because of the limited number of observations. Therefore, the less advanced technique of univariate probit analysis was employed. Probit models are suitable for identifying univariate models which can be explored in future research when more sophisticated techniques are employed.

In chapter 3, DEA (Data Envelopment Analysis) is preferred over SFA (Stochastic Frontier Analysis). The advantage of DEA, a deterministic technique, is that it is a flexible tool that does not require a functional specification. Therefore, inaccurate assumptions about the functional specification are avoided. A disadvantage is that DEA is more vulnerable for measurement errors and outliers. However, the procedure about gathering and handling information in the FADN reduce the risk for measurement errors. Besides, the super efficiency approach did not detect any outliers. DEA is limited to technical measures of performance like technical efficiency, scale efficiency and productivity growth. The overall performance of firms is determined by both technical performance and market performance. Market performance represents the proved ability of an entrepreneur to realize a high turnover for his products, given the quality and size of the production. DEA would gain attractiveness for analysis if it is extended with measures of market performance.

In chapter 3, both Tobit (and OLS) are used for analysis of the second stage. Compared to OLS models, an additional feature is that TOBIT is able to handle censored data.

In chapter 4, cluster analysis is used to distinguish family-firm life cycle stages within the sample. The application of cluster analysis contains some subjective elements. Based on the theoretical model, the researcher motivates the variables that constitute the criteria to distinguish groups. In the second stage, differences between the groups are tested. The (subjective) choices in the first stage have an impact on the results in the second stage. Changes in the selected variables in the first stage would constitute differences in the composition of the groups and thus influence the differences between groups regarding the variables investigated in the second stage. However, in the case of an inferior theoretical model, cluster analysis would not have led to identifiable life cycle stages.

6.3 Objectives and conclusions

The objective of this study is to investigate the impact of firm performance, firm characteristics, perceptions and strategies on strategic changes and innovation and the consequences of strategic changes and innovation for firm performance. A conceptual model has been developed (Figure 1.1). To investigate the relationships as outlined in the conceptual model, four research questions have been defined. The questions have been addressed in the subsequent chapters. The central issue in this section is to discuss the contribution of the different chapters to the fulfillment of the general objective of the research. Section 6.3.1 mainly focuses on consistency of results between chapters and completeness and depth of the analysis, whereas in section 6.3.2 a comparison is made between the results of this study and results of empirical studies focused on small firms in other in branches .

6.3.1 Consistency, completeness and depth

Firm structure, personal characteristics. In chapter 2 and 3, firm structure and personal characteristics are represented by separate variables in the analysis. The results of chapter 2 show that firm size has a negative impact, and age a positive impact on firm growth in horticulture protected cultivation, among which greenhouse

firms dominate the sample. The results of chapter 3 indicate that variables representing personal characteristics and firm structure have a large impact on firm performance measured by technical efficiency and scale efficiency. Age has a negative impact on technical efficiency, solvency has a positive impact on technical efficiency and a negative impact on scale efficiency. The modernity of durable goods has a negative impact on technical efficiency.

Firm performance. The results of chapter 2 indicate that profitability has a positive impact on both firm growth and firm renewal. This is in line with the results in chapter 5, where profitability has a positive impact on the presence of energy-saving technologies.

Firm developments. Firm developments like firm growth and innovation have a small impact on the level of technical and scale efficiency, but a large impact on the change in technical efficiency and consequently also on productivity growth. The conclusion in chapter 3 is that variables which are stable over time like firm structure and personal characteristics contribute to the level of firm performance, whereas firm developments like innovation and firm growth positively contribute to change of performance. Combination of the result of chapter 2 with the conclusion of chapter 3 suggests the existence of a loop with a positive feedback: firm developments increase firm performance whereas a high performance induces new firm developments.

Family-firm life cycle. The results of chapter 2 and 3 also give rise to the existence of the family-firm life cycle in greenhouse horticulture meaning that periods with large investments are alternated with periods of few investments, dependent on the firm production means and the age of the entrepreneur. The theory of the family firm life cycle has been tested in chapter 4, showing consistency with the results. The consequences of the family-firm life cycle stages are investigated in chapter 5. The results of chapter 5 confirm previous findings showing that the family-firm life cycle has an impact on the likelihood of the presence of major energy-saving technologies and on the likelihood of future plans to save energy.

Perceptions. Strategic decision making precedes important changes like innovation and firm growth. To understand the decision making process more in-depth, key elements of the strategic decision-making process are involved in the research in chapters 3, 4 and 5. In chapter 3, the impact of perceptions on firm performance has been investigated. The positive significant relationships between perceptions and firm performance (technical and scale efficiency) indicate that entrepreneurs are positive

about their area's of interest. The results in chapter 4 show that some perceptions vary over the family-firm life cycle. Especially those area's which vary over the family-firm life cycle are evaluated differently like solvency and modernity of production means. The evaluation of external developments shows that entrepreneurs are more optimistic about product prices and less optimistic about production costs during the family-firm life cycle. An exception is the exit stage, when entrepreneurs on average evaluate both internal characteristics and external developments more negative. An hypothesis is that in early stages of the family life cycle, entrepreneurs have more possibilities to anticipate to rising costs than in latter stages. These results are consistent with the findings in chapter 5, measuring the impact of perceptions on the likelihood of mentioning different future plans for saving energy. Entrepreneurs that are positive about greenhouse legislation aimed at saving energy, more likely mention plans for saving energy through technical innovations.

Objectives and strategies. The relationship between the family-firm life cycle and objectives have been investigated in chapter 4. The results show that personal-oriented objectives like 'earning a high income' don't differ over the family-firm life cycle. Firm oriented objectives like 'making little debts' are consistent with the characteristics of the life cycle stages. The analysis of external oriented objectives indicates that the sensitivity of entrepreneurs for societal issues is higher in the entry and consolidation stage than in the growth and exit stage.

Strategies differ considerably over the family-firm life cycle. Saving costs is most important in the exit stage. Firm expansion strategy is most important in the growth stage, as well as strategies oriented at clients and suppliers. Strategies explain the presence of energy-saving technologies (chapter 5). A high production strategy and a low cost strategy have a positive impact whereas the strategy to invest in client contacts has a negative impact on the presence of important energy-saving technologies. Remarkably, strategies have no relationship with future plans to save energy.

The results suggest mutual relationships between firm performance and firm developments like innovation and firm growth. This creates a loop with a positive feedback: firm developments increase firm performance whereas a high performance induces firm developments. This loop has also a long term version: the family-firm life cycle. If future perspectives disappear, either by bad performances, or by lack of successors, firm developments like firm growth and innovation do not take place and

the entrepreneur withdraws money from the firm in the exit stage. Objectives and strategies are consistent with the life cycle stage and the firm performance. The general conclusion about the relation between perceptions and firm developments is that the perception to what degree firm characteristics or consequences of external developments are within the entrepreneur's control determines his or her optimism about firm characteristics and external developments. However, the indirect relationship between perceptions and strategies as hypothesised in chapter five indicates that perceptions at least partly represent the attitude of the entrepreneur rather than the evaluation of characteristics and external developments. This is in line with Zachariasse (1974) who states that the perception of the entrepreneur will be more sharp if the reference situation used for evaluation of the perception is more well-defined.

6.3.2 Comparison with other empirical studies

In the introduction of this thesis (section 1.1) it is argued that a comparison with empirical studies in the field of strategic decision making in other branches characterised by large firms is complicated by several aspects. First, strategic decision making at large firms is organizational decision making. Therefore, a large body of empirical studies focus at the impact of organizational structure and processes on aspects of strategic decision making. Second, the focus on *organizational* aspects complicate research with respect to the content of strategic decision making processes, which is the subject of this thesis. Third, it is almost impossible to obtain a sufficiently large number of observations of large firms for performing statistical analysis, because the analysis of the strategic decision making processes within a large firm is a time consuming process. However, a number of empirical studies deals with small firms in other than agricultural branches, which are useful for benchmarking. In this section results of this thesis are compared with results in a few recent empirical studies, in order to determine the extent to which the results of this thesis can be generalized.

Both Bhattacharya and Bloch (2004) and Rogers (2004) have investigated the determinants of innovation in small to medium sized firms in Australia. Their research method is quite similar to the method used in chapter 2 of this thesis. The only corresponding variable with the study of Rogers (2004) and this thesis is firm size. Firm size has a positive impact on innovation. However, repetition of the

analysis per firm size category shows that firm size has no impact per category (which is no surprise) and that determinants of innovation vary with firm size. Therefore, the direct impact of firm size cannot be derived from the results of Rogers (2004). Bhattacharya and Bloch (2004) also report a positive impact of firm size on innovation. Given the fact that the variability in firm size in the samples used by Rogers (2004) and Bhattacharya and Bloch (2004) is much higher than in the sample used in chapter 2, the results of both studies don't violate the results of chapter 2. Bhattacharya and Bloch (2004) also include profitability in their study as an explanatory variable and find no impact. This result contradicts to the results of chapter 2, in which a positive relationship is reported, and is in accordance with the hypothesis of Bhattacharya and Bloch (2004).

Becchetti and Trovato (2002) have investigated the determinants of firm growth in small and medium sized firms. Their results indicate that small surviving firms have higher than average growth potential, corresponding to the results reported in chapter 2 regarding firm growth in horticulture protected cultivation. Their finding that scarce availability of external finance (corresponding to the variable 'solvency') limits firm growth is not confirmed in chapter 2.

The positive relationship between innovation and firm performance (chapter 3) finds support by the study of Verhees and Meulenberg (2004), dealing with market orientation, innovativeness, product innovation and performance in small rose growing firms.

Van Gelderen et al. (2000) investigated the performance of small business start-ups, which links to the research on the family-firm life cycle (chapter 4). Important differences are that (1) they limit themselves to the entry stage of the life cycle, (2) they use strategies as explaining variables and (3) these strategies are process strategies, contrary to the content strategies used in chapter 4. Examples of process strategies are reactive strategy and complete planning strategy. Examples of content strategies are low cost strategy and differentiation strategy. However, the results of Van Gelderen et al. (2000) do not disagree with the results of chapter 4. Their findings are that poorly performing business owners employ a reactive strategy, which has a negative impact on firm performance, resulting in a higher likelihood to end the firm. This corresponds with the results of chapter 4 with regard to the firms in the exit stage. The result that high performing business owners employ a more top-down (complete planning) approach corresponds with the fact that firms after the

growth stage pay attention to fine tuning of the production process. Comparison of the approach applied in chapter 4 with the study of Kazanjian and Drazin (1990) shows that the way the firm life cycle is made operational depends on characteristics of the branch. Their study is aimed at start-ups of new firms, based on new technologies. The determination in which stage the firms are depends on the problems the firms are faced to. They focus their study to consequences of start-up, growth and stabilization for centralization and formalization of the decision making process. New business start-ups are rare in horticulture and do generally not depend on new technologies. The stage in which they are is largely based on the firm structure.

The study of Beal (2000) is most comparable with this thesis, although his emphasis is on the process of environmental scanning rather than on content. The *process* of environmental scanning deals with the use of information sources and the frequency of environmental scanning. The *content* of environmental scanning deals with the topics, which are scanned, and the resulting perceptions. Beal (2000) explicitly takes the importance of the firm life cycle stage into account. His multi-item index to detect the stage the firm is currently operating in, has been based on perceptions of managers or CEOs. His result that obtaining information on several aspects of specific environmental sectors facilitates alignment between some competitive strategies and environments is consistent with the result reported in chapter 5 that future plans are consistent with perceptions of the environment and that implemented plans are consistent with firm strategies. This finding gives rise to the relationship hypothesised in chapter 5 that perceptions have to be analysed in-depth, corresponding to the firm strategy in order to decide which plans have to be implemented.

The comparison of results in this thesis with the above mentioned studies does not provide a clear answer to the question about the degree to which the results of this thesis can be generalized. First, the results of chapter 2 are not fully consistent with the results reported in the studies discussed above. However, review of the literature about innovation and firm growth shows that different results in comparable studies is the rule rather than the exception. Second, few studies focus on the content of decision making (relationships between the content of strategies, actual perceptions and decisions), but focus on decision making process. The differences between both approaches complicate a comparison between these studies. Third, although strategic management in horticulture is not a priori different from firms in other branches,

specific features of horticulture, like market structure and firm size make provides this branch rather unique characteristics. However, the comparison made in this section indicates that the results of this thesis provide additional insigths.

6.4 General conclusion

The results of this thesis can be summarized into the following conclusions.

- Profitability has a positive impact on the likelihood of both firm renewal and firm growth in greenhouse horticulture. Innovation and firm growth have an immediate positive impact on productivity growth in greenhouse horticulture. This creates a loop with a positive feedback: firm developments increase firm performance whereas a high performance induces firm developments.
- Positive perceptions about firm characteristics and developments, which have a direct link with production technology, have a significant relationship with technical efficiency. Positive perceptions about firm characteristics and developments therein (having a direct link with the firm's scale) have a significant relationship with scale efficiency.
- Entrepreneurs are most concerned about long term firm continuity in the growth stage. The importance of contacts with clients, and the relative little importance of showing the way of production to society indicate that guarantees to make positive cash flows is important in the growth stage, when huge investments take place.
- Entrepreneurs in the exit stage are mainly interested in withdrawing capital from the firm. This is supported by the high importance of a low cost strategy (on average 4.29 on a five-point likert scale).
- Strategies contribute to the explanation of the presence of energy-saving technologies; perceptions contribute to the explanation of future plans. These conclusions indicate that the general perceptions have to be considered thoroughly in accordance with the firm strategy in order to decide which future plans have to be implemented.
- The analysis of strategic decision making will be more in-depth if panel data of management variables and panel data including personal characteristics, firm structure and firm performance are collected simultaneously.

6.5 Future outlook

The research has provided useful insights that can be elaborated in future research. To realize more depth in the research, the relationships as elaborated in figure 1.1 could be analyzed simultaneously. Structural equation modeling, LISREL is a convenient method for analyzing relationships simultaneously (Boomsma, 2000). However, the method requires a large number of observations. Furthermore, the investigation of mutual relationships between the strategic decision making process, firm structure, firm developments and firm performance requires the measurement of panel data of management variables. These variables could be collected at firms participating in the FADN in the future.

The results of this thesis suggest that the measured perceptions are not the result of a careful evaluation process, but correspond to the attitude of the entrepreneur. On the contrary, the results of chapter 4 indicate that perceptions vary over the family-firm life cycle. Therefore, this problem can be analyzed in future research if a distinction is made between (objective measurable) knowledge based on real information and evaluation of the knowledge when measuring perceptions.

The research can be extended in several ways. Including risk and uncertainty and the measurement of risk attitude will contribute to the understanding of the relationship between perceptions and decision making (Hardaker, Anderson et al. 1997). Firm developments can be extended with investments in different capital goods.

The research approach described in this section can provide a convenient toolkit for policy makers. First, they are able to observe the degree to policy objectives are realized. Second, they are able to analyze why policy objectives are realized or not. Potential topics are energy regulations, regulations on crop protection and nutrient management. In general, it is also possible to analyze the effects of deregulation. Simultaneous monitoring of the effects of liberalization of agricultural laws can provide understanding, if and why entrepreneurs still behave in a social responsible way.

Furthermore, empirical evidence on the impact of strategic decision making affects on firm performance can be helpful to entrepreneurs . Development of courses about strategic decision making may support the improvement. Finally, strategic management concepts can be adjusted on the base of empirical insights.

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Summary

Problem definition

Greenhouse producers face major political changes, among which regulations regarding energy are prominent. Liberalisation of the energy market separates costs of energy from costs of the technical infrastructure, which are based on the delivery capacity. The capacity has to be based on the moment when the demand for heat is maximal, that is during heavy frost. The unequal demand for heat results in rising costs for infrastructure. In the future, greenhouse growers are faced with regulations, which limit the use of energy to a large extent. The continuously decreasing number of firms coupled with the increasing firm size in greenhouse horticulture provide empirical evidence that greenhouse growers need to understand external processes in order to adjust the firm strategy. They have to evaluate firm and entrepreneurial qualities to know whether they are able to face the external changes. Besides, the government is increasingly aware that legislation which restricts entrepreneurial freedom harms the international competitive position. At present, one of the intentions of the Dutch government is to tune policy processes to entrepreneurial processes. This implies deregulation of topics which can be left to the responsibility of the entrepreneurs. It also implies the choice of a suitable set of policy instruments and facilitating measures which enable the entrepreneurs to comply with future policy objectives, which cannot be left to the responsibility of the entrepreneurs. To perform this change in the political strategy, policy makers need to know how greenhouse growers make decisions, and if and how they evaluate political processes, which concern greenhouse horticulture. Both entrepreneurs and policy makers benefit from knowledge of the relation between external developments and the decision making process.

Successful embedding of policy processes in entrepreneurial behaviour requires that policy makers understand how entrepreneurs behave and make decisions. Besides, empirical evidence about the impact of legislation on firm processes will help greenhouse growers to improve their decision making. The studies mentioned before ignore either the relation between external processes, decision making and firm development, or lack an empirical approach. The general objective of this study is to

investigate the impact of firm performance, firm characteristics, perceptions and strategies on firm development and the consequences of firm development for firm performance. Firm development include strategic changes and innovation.

The following research questions have been distinguished to realize the objective, which have been subsequently addressed in the chapters 2, 3, 4 and 5:
1. What are the effects of characteristics of the farmer, farm structure and performance on the firm developments?
2. What is the impact of the firm operator's perceptions, firm structure and firm developments on performance of the firm.
3. What is the impact of the family-firm life cycle, determined by firm structure and personal characteristics on the strategic decision making process.
4. What is the role of perceptions of external developments and firm characteristics, and entrepreneurial strategies on adoption of new technologies.

Conceptual framework

A conceptual framework has been developed to answer these research questions. In the framework, the relevant relationship between external developments, perceptions, firm performance and firm development are specified (Figure 1.1). The conceptual framework is based on the strategic management literature. The concepts in the figure indicate in which research questions they are involved. Loops in the decision making process, which continuously occur in reality have been omitted in the research framework.

Firm structure reflects characteristics like firm size and degree of mechanization. Personal characteristics include variables like age of the entrepreneur and presence of a successor. Firm structure and personal characteristics determine the family-firm life cycle stage of the firm. Firm structure and personal characteristics determine directly firm performance. The entrepreneur determines his objectives according to firm performance and firm structure. Within the reality of firm structure and performance, the entrepreneur perceives strengths and weaknesses, but also external developments. The entrepreneur bases his firm strategy on objectives and perceptions within the context of the firm structure. Firm structure, personal characteristics, firm performance, perceptions and firm strategy determine firm developments like

innovations and strategic change (Figure 1). Firm developments determine both firm structure and firm performance, indicating that decision making is a continuous process.

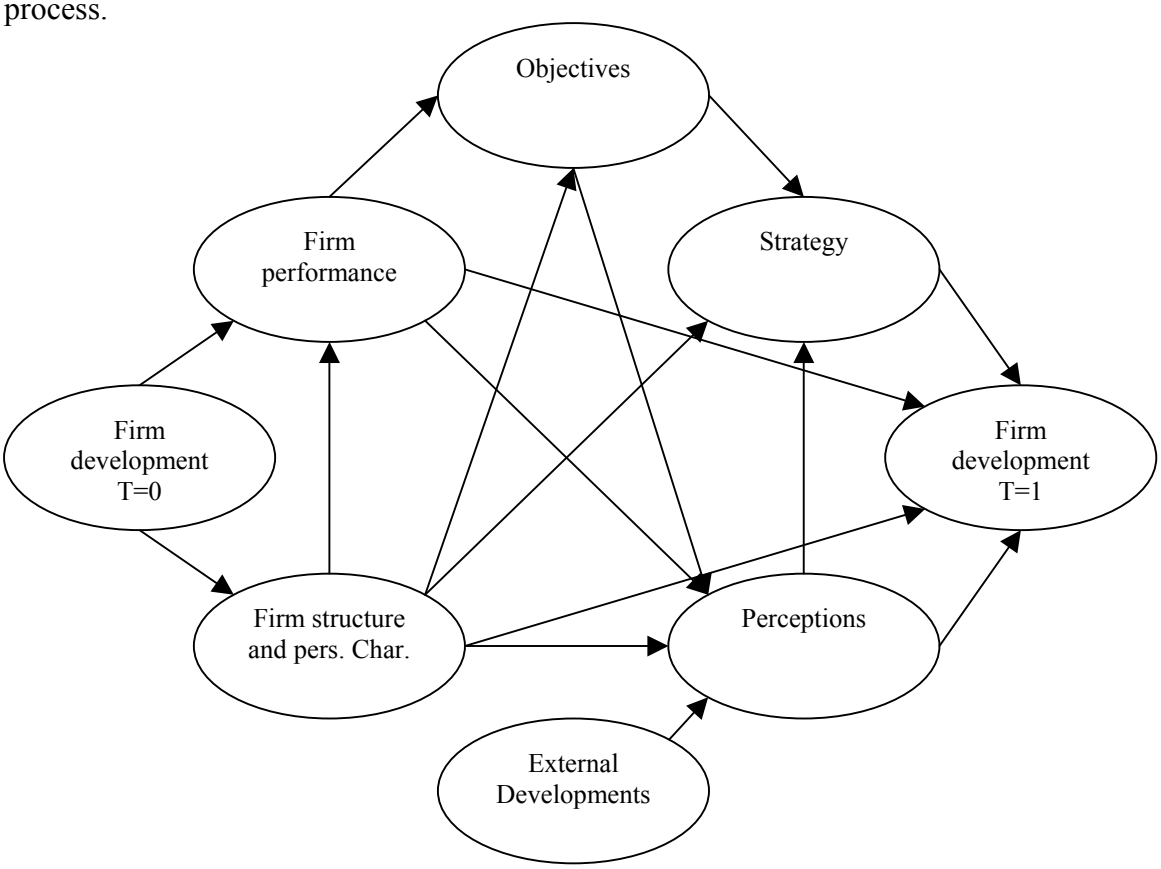


Figure 1. Conceptual framework for analysis.

Results

Firm developments

In chapter 2, The impact of firm structure, firm performance and personal characteristics of the farmers on firm renewal and firm growth has been analysed. Farm accountancy data derived from the FADN from arable farms and horticultural firms have been combined with data from an additional survey. The effects of different variables on firm growth and firm renewal have been estimated using probit models.

The results show that firm growth is much more likely at firms specialized in field production than at firms specialized in horticulture protected cultivation. This can be explained by the fact that firm growth in protected production requires huge investments in buildings, which are largely sunk costs. In field production, expansion of the firm can be realized by renting additional land, which can be easily given up if

profits drop. Therefore firm growth in horticulture protected cultivation is more risky and thus less likely than in field production.

It is obvious from the results that firm structure has a larger impact on firm development than personal characteristics. Only age has an influence on firm growth in horticulture protected cultivation. Firm structure reflects both possibility and necessity to develop the firm. Personal characteristics are indicators of the capacity and ambitions of the entrepreneur. An explanation is that dummies represent the personal characteristics like education and time horizon too roughly. An alternative explanation is that the personal indicators represent the capacity and ambitions of the entrepreneur too weakly. Therefore, it is advisable to measure personal capacities, perceptions and ambitions directly in order to understand the decision making process about firm development in depth.

The most obvious difference is that firm size has a negative impact on firm growth for horticulture protected cultivation and a positive impact on arable farming. This result indicates an increasing diversity in firm size in arable farming and a decreasing diversity in firm size in horticulture protected cultivation. An other obvious difference is the impact of profitability on firm developments, which is absent in arable farming.

Firm performance

The necessity to innovate and continuously change the firm strategy on the one hand and the risk associated with wrong decisions about innovation or strategic change on the other hand create the need for more empirical insight in the relationships between performance, perceptions, innovation and firm growth. In chapter 3, DEA is used to determine technical and scale efficiency as indicators for firm performance. Next, TOBIT is used to explain the level of technical and scale efficiency and OLS to explain the annual productivity growth. The main explanatory categories are socio-economic variables, structural changes (innovation and firm growth), and perceptions classified according to the SWOT-analysis. This study incorporates both the decisions (structural changes) and possible causes for change (perceptions), making the explanation more general. The empirical focus is on data on Dutch glasshouse firms over the period 1991-1998.

The results show that innovation has no impact on the level of technical efficiency and scale efficiency. Firm growth has a significant positive impact on

technical efficiency and has no influence on scale efficiency. Both innovation and firm growth have an immediate significant positive influence on the change in technical efficiency and firm growth has a significant positive influence on the change in scale efficiency. The socio-economic structure has much more impact on both technical and scale efficiency. Young entrepreneurs are technically more efficient than old producers. A long-term perspective and investments, indicated by the low solvency improve scale efficiency. Perceptions have a significant impact on both technical and scale efficiency. Positive perceptions about firm characteristics and developments, which have a direct link with production technology, contribute significantly to a higher technical efficiency. Positive perceptions about firm characteristics and developments therein (having a direct link with the firm's scale) contribute significantly to higher scale efficiency. Both results support the idea that significant positive perceptions reflect the areas of interest of the entrepreneur.

Both innovation and firm growth have a significant positive impact on the productivity growth, and on technical efficiency change; it has no impact on technical change.

The general conclusion of chapter 3 is that variables which are rather stable over time like the socio-economic structure of the firm and the perceptions of the entrepreneur contribute to the explanation of the level of technical and scale efficiency whereas incidental changes like innovation and firm growth significantly contribute to the explanation of the change in technical and scale efficiency.

Family-firm life cycle

Chapter 4 presents the results of an empirical study of the impact of the family-firm life cycle on objectives, perceptions and strategies. Cluster analysis is used to distinguish four stages (entry, growth, consolidation and exit). The age of the youngest entrepreneur, the modernity of durable goods, the investment level during the past three years and the solvency are used as indicators for the family firm life cycle. Differences in objectives, perceptions and strategies between the four groups have been analysed using non parametric Kruskal Wallis and Mann-Whitney tests.

The results of chapter 4 study show that it makes sense to distinguish different stages of the family firm life cycle concepts. The cluster analysis results in four distinct stages, that are in line with family firm life cycle concepts as outlined by Boehlje and Eidman (1984), Boehlje (1992) and Kay and Edwards (1994).

Furthermore, the stage on the life cycle has an impact on key elements of the strategic decision making processes. Especially the importance of strategies differs by family-firm life cycle stage. Furthermore, the results show that entrants are rather optimistic about external developments and internal characteristics. They have the ambition to behave in an environmentally sound way. When they enter the growth stage, environmental sound behaviour becomes less important. Improvement of the firm structure and investments in client contacts get emphasis in order to ensure long-term continuity. In the consolidation stage, firms try to produce efficiently and are increasingly sensitive to societal concerns. Firms in the exit stage shorten their time horizon; they lack optimism and are more interested in withdrawing money from the firm. Their pessimism may be the consequence of the low profitability, the absence of future perspectives or the absence of a successor.

The results also indicate that firms in the growth stage are less sensitive to social concerns than firms in the entry and consolidation stages. The consequence is that influencing socially desirable changes at the firm, which require investments, have to take place in the entry stage. However, an additional longitudinal study is necessary to detect if these influences persist in the long term. Only then it can be judged if the willingness to incorporate social desirable needs in the firm strategy continues to play a role in investment decision-making. These insights enable entrepreneurs to take correct decisions and may help policy makers to differentiate on the base of the family-firm life cycle.

Firm development focussed at saving energy

Chapter 5 describes an in-depth investigation of the impact of perceptions of external developments and firm characteristics, and entrepreneurial strategies on adoption of energy-saving technologies. Both present technologies and future plans to save energy are analyzed to detect if barriers exist in the decision making process which inhibit the entrepreneur from adopting energy-saving measures. Data from an oral survey have been combined with FADN data and analyzed with probit models.

Ceteris paribus, the presence of these energy-saving technologies is more likely at firms in the consolidation stage. The presence of important energy-saving technologies makes mentioning technical energy-saving options less likely. A high energy intensity, a high production strategy and consequently a low input and energy-saving strategy contribute to the likelihood of the presence of energy-saving

technologies. The different categories of energy-saving solutions reflect the (perceived) positions of the firms. E.g. mentioning technical options is likely if important technical energy-saving techniques are not adopted; mentioning avoidance is likely if entrepreneurs are positive about firm qualities, but less positive about firm performance and future developments on energy-saving principles. The contribution of strategies to the explanation of the presence of energy-saving technologies and the contribution of the perceptions to the explanation of future plans indicate that the general perceptions have to be considered thoroughly in order to decide which future plans have to be implemented according to the firm strategy.

Conclusions

The results of this thesis can be summarized into the following conclusions.

- Profitability has a positive impact on the likelihood of both firm renewal and firm growth in greenhouse horticulture. Innovation and firm growth have an immediate positive impact on productivity growth in greenhouse horticulture. This creates a loop with a positive feedback: firm developments increase firm performance whereas a high performance induces firm developments.
- Positive perceptions about firm characteristics and developments, which have a direct link with production technology, have a significant relationship with technical efficiency. Positive perceptions about firm characteristics and developments therein (having a direct link with the firm's scale) have a significant relationship with scale efficiency.
- Entrepreneurs are most concerned about long term firm continuity in the growth stage. The importance of contacts with clients, and the relative little importance of showing the way of production to society indicate that guarantees to make positive cash flows is important in the growth stage, when huge investments take place.
- Entrepreneurs in the exit stage are mainly interested in withdrawing capital from the firm. This is supported by the high importance of a low cost strategy (on average 4.29 on a five-point likert scale).
- Strategies contribute to the explanation of the presence of energy-saving technologies; perceptions contribute to the explanation of future plans. These

conclusions indicate that the general perceptions have to be considered thoroughly in accordance with the firm strategy in order to decide which future plans have to be implemented.

- The analysis of strategic decision making will be more in-depth if panel data of management variables and panel data including personal characteristics, firm structure and firm performance are collected simultaneously.

Samenvatting

Probleemstelling

De glastuinbouw heeft te maken met ingrijpende politieke veranderingen. Regelgeving met betrekking tot energie heeft daarin een prominente plaats. De liberalisering van de energiemarkt maakt een scheiding tussen de energiekosten en de kosten voor de technische infrastructuur, die gebaseerd is op de leveringscapaciteit. De capaciteit dient gebaseerd te zijn op het moment dat de warmtebehoefte het grootst is, namelijk tijdens strenge vorst. De ongelijke warmtebehoefte leidt tot toenemende kosten voor de technische infrastructuur. In de toekomst worden de glastuinders geconfronteerd met regelgeving die het gebruik van energie in hoge mate beperkt. Het voortdurend afnemende aantal bedrijven, gepaard gaande met de toenemende bedrijfsomvang van de overblijvende bedrijven maken duidelijk dat glastuinders de ontwikkelingen in de omgeving van het bedrijf moeten onderkennen om de bedrijfsstrategie daarop aan te kunnen passen. Zij dienen de kracht van het bedrijf en hun competenties te kennen om te weten of zij in staat zijn het hoofd te bieden aan de externe ontwikkelingen. De overheid is zich echter in toenemende mate bewust van het feit dat toenemende regulering die de ondernemersvrijheid inperkt de internationale concurrentiepositie schaadt. Een van de voornemens van de overheid is om de politieke ontwikkelingen af te stemmen op bedrijfsprocessen. Dat betekent deregulering van zaken die aan de verantwoordelijkheid van ondernemers kunnen worden overgelaten. Het houdt ook een keuze voor een passend beleidsinstrumentarium in en faciliterende maatregelen die de ondernemers in staat stelt om te voldoen aan toekomstige politieke doelstellingen, die niet aan de verantwoordelijkheid van ondernemers kunnen worden overgelaten. Om deze verandering in de politieke strategie te kunnen bewerkstelligen is het nodig dat beleidsmakers weten hoe glastuinders beslissingen nemen en hoe zij politieke processen waarnemen en analyseren die de glastuinbouw betreffen. Zowel ondernemers als beleidsmakers hebben baat bij inzicht in de relatie tussen ontwikkelingen buiten het bedrijf en besluitvormingsprocessen van ondernemers.

Succesvolle inpassing van beleidsprocessen in ondernemersgedrag vereist dat beleidsmakers begrijpen hoe ondernemers zich gedragen en besluiten nemen. Verder zullen inzichten afgeleid uit de praktijk glastuinders helpen hun besluitvorming te verbeteren. De meeste studies veronachtzamen het verband tussen externe processen, besluitvorming en bedrijfsontwikkeling, of hebben geen empirische benadering. De doelstelling van dit onderzoek is om na te gaan wat de invloed van bedrijfsprestaties, bedrijfskenmerken, percepties van de ondernemer en strategieën is op de bedrijfsontwikkelingen innovatie en strategische veranderingen is, en wat de gevolgen zijn van de veranderingen op de bedrijfsprestatie.

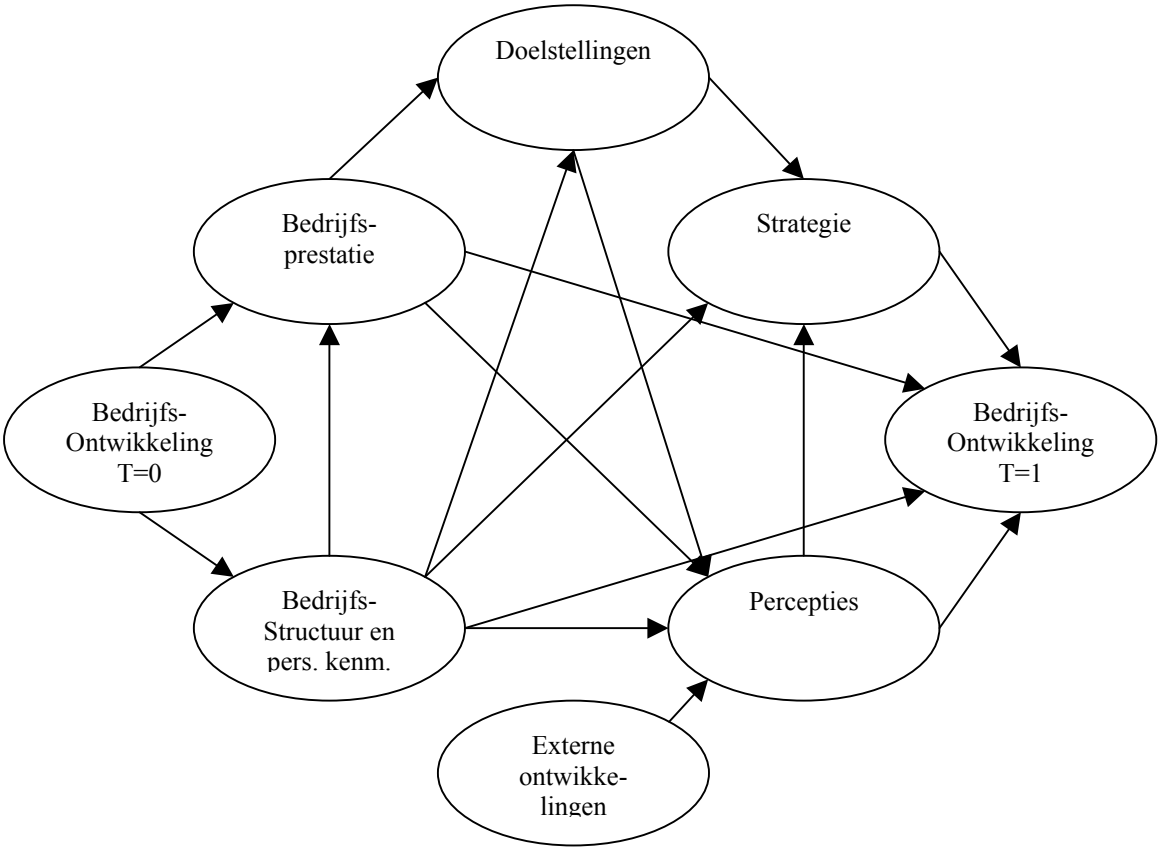
De volgende onderzoeksvragen zijn onderscheiden om de doelstelling te verwezenlijken, die achtereenvolgens in de hoofdstukken 2, 3, 4 en 5 behandeld zijn:
1. Wat zijn de gevolgen van ondernemerskenmerken, bedrijfsstructuur en bedrijfsprestatie voor bedrijfsontwikkelingen?
2. Wat is de invloed van de percepties van de ondernemer, de bedrijfsstructuur en bedrijfsontwikkelingen op de prestatie van de onderneming?
3. Wat is de invloed van de bedrijfslevenscyclus, bepaald door bedrijfsstructuur en persoonlijke eigenschappen op het strategische besluitvormingsproces?
4. Wat is de rol van percepties van externe ontwikkelingen en kenmerken van het bedrijf, en ondernemers strategieën op de adoptie van nieuwe technologieën?

Conceptueel raamwerk

Een conceptueel raamwerk is ontwikkeld om deze vier onderzoeksvragen te beantwoorden. In het raamwerk zijn de relevante relaties tussen externe ontwikkelingen, percepties, bedrijfsprestatie en bedrijfsontwikkelingen gespecificeerd (Figuur 1). Het conceptuele raamwerk is gebaseerd op de strategische management literatuur. De concepten in de figuur geven aan bij welke onderzoeksvragen ze betrokken zijn. Loops in het besluitvormingsproces die zich voortdurend voordoen zijn uit het onderzoeksraamwerk weggelaten.

De bedrijfsstructuur geeft kenmerken zoals omvang van het bedrijf en de mechanisatiegraad aan. Persoonlijke kenmerken impliceren variabelen zoals leeftijd van de ondernemer en de aanwezigheid van een opvolger. Bedrijfsstructuur en persoonlijke kenmerken bepalen de fase op de bedrijfslevenscyclus van het bedrijf.

Bedrijfsstructuur en persoonlijke kenmerken beïnvloeden rechtstreeks de bedrijfsprestatie. De ondernemer bepaalt zijn doelstellingen overeenkomstig de bedrijfsprestatie en bedrijfsstructuur. Binnen de realiteit van bedrijfsstructuur en bedrijfsprestatie neemt de ondernemer sterkten en zwakten, maar ook externe ontwikkelingen waar. De ondernemer baseert zijn bedrijfsstrategie op doelstellingen en percepties in samenhang met de bedrijfsstructuur. Bedrijfsstructuur, persoonlijke kenmerken, bedrijfsprestatie, percepties en bedrijfsstrategie bepalen bedrijfsontwikkelingen zoals innovatie en strategische verandering (Figuur 1). Bedrijfsontwikkelingen bepalen zowel bedrijfsstructuur als bedrijfsprestatie, waarmee wordt aangegeven dat besluitvorming een continu proces is.



Figuur 1. Conceptuele raamwerk voor analyse.

Resultaten

Bedrijfsontwikkelingen

In hoofdstuk 2 zijn de invloed van de bedrijfsstructuur, de bedrijfsprestatie en persoonlijke kenmerken van boeren en tuinders op bedrijfsvernieuwing en schaalvergroting geanalyseerd. Data afkomstig uit het Bedrijven InformatieNet van

akkerbouwbedrijven en tuinbouwbedrijven zijn gecombineerd met data verzameld in een aanvullende enquête. De gevolgen van verschillende variabelen op schaalvergroting en bedrijfsvernieuwing zijn geschat met behulp van probit modellen.

De resultaten laten zien dat schaalvergroting waarschijnlijker is op bedrijven die telen in de open grond dan op tuinbouwbedrijven gespecialiseerd in beschermde teelten. Dit kan verklaard worden door het feit dat schaalvergroting op tuinbouwbedrijven gespecialiseerd in beschermde teelten grote investeringen in gebouwen vergt, die grotendeels onomkeerbaar zijn. In opengrondsteelten kan uitbreiding van het bedrijf gerealiseerd worden door het huren van extra land, wat gemakkelijk afgestoten kan worden wanneer de winst daalt. Schaalvergroting op tuinbouwbedrijven gespecialiseerd in beschermde teelten is riskanter en daarom minder waarschijnlijk dan in open teelten.

De resultaten laten zien dat de bedrijfsstructuur een grotere invloed heeft op bedrijfsontwikkeling dan persoonlijke kenmerken. Alleen leeftijd beïnvloed schaalvergroting op tuinbouwbedrijven gespecialiseerd in beschermde teelten. De bedrijfsstructuur geeft zowel de mogelijkheid als de noodzaak van bedrijfsontwikkeling aan. Persoonlijke kenmerken zijn indicatoren van de capaciteit en de ambities van de ondernemer. Een verklaring is dat dummy's de persoonlijke kenmerken zoals opleiding of tijdshorizon te grof weergeven. Een alternatieve verklaring is dat de persoonlijke kenmerken de capaciteit en ambities te zwak weergeven. Het is daarom raadzaam om persoonlijke competenties, percepties en ambities rechtstreeks te meten om het besluitvormingsproces met betrekking tot bedrijfsontwikkeling diepgaander te verklaren.

Het meest opvallende verschil is dat de bedrijfsomvang een negatieve invloed heeft op schaalvergroting op tuinbouwbedrijven gespecialiseerd in beschermde teelten en een positieve invloed heeft op schaalvergroting op akkerbouwbedrijven. Een ander opvallend verschil is dat de invloed van winstgevendheid die afwezig is bij akkerbouwbedrijven.

Bedrijfsprestatie

De noodzaak om te innoveren and de bedrijfsstrategie continu aan te passen aan de ene kant en het risico verbonden aan verkeerde beslissingen met betrekking tot innovatie en strategische verandering aan de andere kant creëert de behoefte om meer empirisch inzicht te krijgen in de relaties tussen prestatie, percepties, innovatie en

schaalvergroting. In hoofdstuk 3, Data Envelopment Analysis is gebruikt om technische efficiëntie en schaalefficiëntie als indicatoren voor de bedrijfsprestatie te bepalen. TOBIT is vervolgens gebruikt om het niveau van technische efficiëntie en schaalefficiëntie te verklaren, en OLS om de jaarlijkse productiviteitstoename te verklaren. De belangrijkste verklarende variabelen zijn sociaal-economische variabelen, structurele veranderingen (innovatie en schaalvergroting), en percepties ingedeeld overeenkomstig de SWOT-analyse. Deze studie omvat zowel de beslissingen (structurele veranderingen) als de mogelijke oorzaken voor verandering (percepties) wat de studie meer omvattend maakt. De empirische focus is gericht op data van Nederlandse glastuinbouwbedrijven in de periode 1991 – 1998.

De resultaten laten zien dat innovatie geen invloed heeft op het niveau van technische efficiëntie en schaal efficiëntie. Schaalvergroting heeft een significant positieve invloed op technische efficiëntie en heeft geen invloed op schaalefficiëntie. Zowel innovatie als schaalvergroting hebben een directe, significant positieve invloed op verandering in technische efficiëntie en schaalvergroting heeft een significant positieve invloed op verandering in schaalefficiëntie. De sociaal-economische structuur heeft veel meer invloed op het niveau van zowel technische als schaalefficiëntie. Jonge ondernemers zijn technisch efficiënter dan oudere ondernemers. Een lange termijn perspectief en investeringen, zoals weergegeven door een lage solvabiliteit verbeteren de schaalefficiëntie. Percepties hebben een significantie invloed op zowel technische efficiëntie als schaalefficiëntie. Positieve percepties met betrekking tot bedrijfskenmerken en ontwikkelingen, die een direct verband hebben met productie technologie, dragen significant bij aan een hogere technische efficiëntie. Positieve percepties met betrekking tot bedrijfskenmerken en ontwikkelingen daarbinnen (die een direct verband hebben met de schaalgrootte van het bedrijf) dragen significant bij aan de verklaring van een hogere schaalefficiëntie. Beide resultaten ondersteunen het idee dat significant positieve percepties de interessegebieden van de ondernemer weergeven.

Zowel innovatie als schaalvergroting hebben een significant positieve invloed op de productiviteitstoename en op verandering in de technische efficiëntie; het heeft geen invloed op technische verandering.

De algemene conclusie van hoofdstuk 3 is dat variabelen die tamelijk stabiel zijn in de tijd zoals de sociaal-economische structuur van het bedrijf en de percepties van de ondernemer bijdragen aan de verklaring van het niveau van technische

efficiëntie terwijl incidentele veranderingen zoals innovatie en schaalvergroting significant bijdragen aan de verklaring van verandering in technische efficiëntie en schaalefficiëntie.

Bedrijfslevenscyclus

Hoofdstuk 4 geeft de resultaten weer van een empirische studie naar de invloed van de bedrijfslevenscyclus op doelstellingen, percepties en strategieën. Cluster analyse is gebruikt om vier fasen (start, groei, consolidatie en afbouw) te onderscheiden. De leeftijd van de jongste ondernemer, de moderniteit van de duurzame goederen, het investeringsniveau gedurende de afgelopen drie jaren en de solvabiliteit zijn gebruikt als indicatoren voor de bedrijfslevenscyclus. Verschillen in doelstellingen, percepties en strategieën tussen de vier groepen zijn geanalyseerd met behulp van de niet-parametrische Kruskal Wallis en Mann-Whitney testen.

De resultaten van de studie in hoofdstuk 4 laten zien dat het zin heeft de verschillende fasen van de bedrijfslevenscyclus te onderscheiden. De cluster analyse resulteert in 4 verschillende fasen, die overeenkomen met de bedrijfslevenscyclus concepten zoals beschreven in Boehlje en Eidman (1984), Boehlje (1992) en Kay en Edwards (1994).

De fase van de bedrijfslevenscyclus heeft invloed op belangrijke aspecten van het strategische besluitvormingsprocessen. Met name het belang van bepaalde strategieën varieert met de fasen van de bedrijfslevenscyclus. Verder laten de resultaten zien dat starters tamelijk optimistisch zijn met betrekking tot externe ontwikkelingen en bedrijfskenmerken. Zij hebben de ambitie om zich op een milieuvriendelijke manier te gedragen. Zodra ze in de groeifase komen wordt milieuvriendelijk gedrag minder belangrijk. Verbetering van de bedrijfsstructuur en investeringen in klantcontacten krijgen nadruk om de lange termijn continuïteit van het bedrijf te garanderen. In de consolidatiefase proberen bedrijven efficiënt te produceren en worden in toenemende mate gevoelig voor maatschappelijke wensen. Bedrijven in de afbouwfase bekorten hun tijdshorizon; zij missen optimisme en zijn meer geïnteresseerd in het onttrekken van kapitaal aan het bedrijf. Hun pessimisme kan het gevolg zijn van een lage winstgevendheid, de afwezigheid van toekomstperspectieven of de afwezigheid van een opvolger.

De resultaten geven ook aan dat bedrijven in de groeifase minder gevoelig zijn voor maatschappelijke wensen dan bedrijven in de start- en consolidatiefasen. Het

gevolg is dat het beïnvloeden van maatschappelijk wenselijke veranderingen op het bedrijf, die grote investeringen vragen dient plaats te vinden in de startfase. Een aanvullend onderzoek gedurende een langere periode is nodig om na te gaan of deze effecten op de lange termijn houdbaar blijven. Alleen dan kan beoordeeld worden of de bereidheid om maatschappelijke wensen in de bedrijfsstrategie een rol blijft spelen in besluitvorming met betrekking tot investeringen. Deze inzichten stellen ondernemers in staat om de juiste beslissingen te nemen en kunnen beleidsmakers helpen om te differentiëren op basis van de bedrijfslevenscyclus.

Bedrijfsontwikkelingen gericht op het besparen van energie

Hoofdstuk 5 beschrijft een diepgaand onderzoek naar de invloed van percepties van externe ontwikkelingen en bedrijfskenmerken, en ondernemersstrategieën op de adoptie van energiebesparende technieken. Zowel aanwezige technieken als toekomstplannen om energie te besparen zijn geanalyseerd om na te gaan of er barrières bestaan in het besluitvormingsproces die de ondernemer verhinderen energiebesparende maatregelen te nemen. Data verzameld in mondelinge enquête zijn gecombineerd met data uit het Bedrijven InformatieNet en geanalyseerd met Probit modellen.

Ceteris paribus is de aanwezigheid van energiebesparende technieken is waarschijnlijker op bedrijven in de consolidatiefase. De aanwezigheid van belangrijke energiebesparende technieken maakt het noemen van technische energiebesparende mogelijkheden minder waarschijnlijk. Een hoge energie-intensiteit, een hoge productiestrategie en dus een en lage input en een energiebesparende strategie dragen bij aan de waarschijnlijkheid van de aanwezigheid van energiebesparende technieken. De verschillende categorieën van energiebesparende oplossingen geven de (waargenomen) situatie van de bedrijven. Het noemen van technische mogelijkheden is waarschijnlijk als belangrijke energiebesparende technieken nog niet toegepast worden; het noemen van een mogelijkheid waarin energiemaatregelen vermeden worden is waarschijnlijk als ondernemers positief zijn over de kenmerken van het bedrijf, maar minder positief over de bedrijfsprestatie en toekomstige ontwikkelingen met betrekking tot energiebesparende methoden. De bijdrage van strategieën aan de verklaring van de aanwezigheid van energiebesparende technieken en de bijdrage van percepties aan de verklaring van toekomstplannen ten aanzien van energiebesparing geven aan dat de algemene percepties diepgaand geanalyseerd moeten worden om te

beslissen welke toekomstplannen overeenkomstig de bedrijfsstrategie moeten worden uitgevoerd.

Conclusies

De resultaten van dit proefschrift kunnen aan de hand van de volgende conclusies worden samengevat.

- Winstgevendheid heeft een positieve invloed op de waarschijnlijkheid van zowel vernieuwing van het bedrijf als schaalvergroting in de glastuinbouw. Innovatie en schaalvergroting hebben een directe positieve invloed op productiviteitsgroei in de glastuinbouw. Dit creëert een loop met een positieve terugkoppeling: bedrijfsontwikkelingen verhogen de bedrijfsprestatie terwijl een hoge bedrijfsprestatie aanzet tot bedrijfsontwikkelingen.
- Positieve percepties met betrekking tot kenmerken van het bedrijf en ontwikkelingen, die een direct verband hebben met de productietechniek, hebben een significante relatie met de technische efficiëntie. Positieve percepties met betrekking tot kenmerken van het bedrijf en daarmee verbandhoudende ontwikkelingen (die een direct verband hebben met de schaalgrootte van het bedrijf) hebben een significant verband met de schaalefficiëntie.
- Ondernemers zijn het meest bezorgd over de bedrijfscontinuïteit op de lange termijn in de groeifase van het bedrijf. Het belang van contact met cliënten, en het relatief geringe belang van het tonen van de productiewijze aan de maatschappij geven aan dat garanties om een positieve cashflow belangrijk is in de groeifase, wanneer er grote investeringen worden gedaan.
- Ondernemers in de afbouwfase zijn voornamelijk geïnteresseerd in het onttrekken van vermogen aan het bedrijf. Dit wordt ondersteund door het grote belang van een lage kostenstrategie (gemiddeld 4.29 op een vijf-punts likert schaal).
- Strategieën dragen bij aan de verklaring van de aanwezigheid van energiebesparende technieken; percepties dragen bij aan de verklaring van toekomstplannen. Deze conclusies geven aan dat de algemene percepties diepgaand geanalyseerd moeten worden in overeenstemming met de

bedrijfsstrategie om te besluiten welke toekomstplannen geïmplementeerd moeten worden.

- De analyse van strategische besluitvorming zal verdiepen wanneer paneldata van managementvariabelen en panel data met betrekking tot persoonlijke kenmerken, bedrijfsstructuur en bedrijfsprestatie simultaan worden verzameld.

Curriculum vitae

Johannes Bremmer is geboren op 2 augustus 1971 te Gouda. Na het volgen van de lagere school werd het VWO doorlopen op de Reformatorische Scholengemeenschap ‘De Driestar’ te Gouda. Geïnspireerd door het werken op het ouderlijk bedrijf, een boomkwekerij, werd na het behalen van het diploma in 1989 de studie Tuinbouw aan de Landbouwuniversiteit gevolgd. Afstudeervakken werden gedaan bij Tuinbouwplantenteelt, Algemene Agrarische Economie en Agrarische Bedrijfseconomie. Het laatste afstudeervak, gericht op de ontwikkeling van een milieueconomisch bedrijfsmodel voor de fruitteelt werd gecombineerd met een stage op het Proefstation voor de Fruitteelt (het huidige PPO) in Wilhelminadorp. De studie werd afgerond in 1995, waarna militaire dienst volgde. Na enkele maanden gewerkt te hebben op de boomkwekerij van zijn ooms volgde begin 1997 de aanstelling tot wetenschappelijk onderzoeker bij het LEI met als aandachtsveld de bloembollenteelt. Dit werd in 1998 uitgebreid met de boomkwekerij. Eveneens in 1998 werd een promotietraject opgestart in samenwerking met Wageningen Universiteit wat resulteerde in het voorliggende proefschrift. Met ingang van 1 januari 2004 is hij parttime in dienst van de directieraad van de Social Sciences Group (waarvan het LEI deel uitmaakt) als coördinator van het onderzoek voor het ministerie van Landbouw, Natuur en Voedselkwaliteit.

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