Bio-economic modelling of conversion from conventional to organic arable farming

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Abstract

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Growing environmental concern in society combined with policy stimuli has encouraged farmers to switch from conventional to organic production methods. However, despite the growing concern not many farmers made the switch from conventional to organic production. In order to stimulate the conversion, policy makers need more information about the process of conversion. The main objective of this research was to gain insight into the decision of Dutch arable farms to convert from conventional to organic production. The main method used was to develop a modelling approach that can be used for (1) analyzing the conversion from conventional to organic arable farming systems from an economic and environmental point of view and (2) determining the effects of influential factors and policies on the choice of farmers to convert from conventional to organic farming systems. The study was applied for a typical arable farm in the central clay region in the Netherlands. First, a comparison of the conventional and organic arable farming system was made from technical, economic and environmental point of view by developing linear programming (LP) models for both farming systems. The results show that organic farming leads to less intensive land use, better environmental and better economic results. Second, based on these two LP models, the conversion period between conventional and organic farming was included in the model by means of dynamic linear programming model (DLP). The results show that using a ten years planning horizon, despite the economically difficult conversion period, organic farming is still more attractive from economic point of view. However, in the case when additional constraints are included the conversion to organic farming is not always economically optimal. Next, special attention was given to the effect of future yield and price uncertainty before, during and after the conversion years. For this purpose a discrete stochastic dynamic utility-efficient programming (DUEP) model was developed based on DLP model. The results showed that for a risk-averse farmer conversion is not optimal, unless policy incentives are applied such as taxes on pesticides or fertilizers or subsidies on organic products, or unless the market prices for organic products get more stable.

Keywords: Organic Farming, Arable Farming, Conversion Process, Bio-economic Modelling, Linear Programming, Dynamic Linear Programming, Dynamic Utility-Efficient Programming, Risk Attitude, Yield and Price Risk, The Netherlands

Preface

Budapest, Summer 2000 was the first time I met Ruud Huirne, who later that year, in Autumn, welcomed me to the Business Economics Group at Wageningen University as an Erasmus student. The nice working environment, the international atmosphere and good opportunities for sports and other activities made me attached to Wageningen within a short time. After a few months working in the group, Ruud gave me the opportunity to start a PhD project, which I was very happy to accept. Ruud as a promoter and Paul Berentsen as a co-promoter and daily supervisor gave me enormous support during these years. Ruud, I would like to thank you for your kind hospitality since my first day in Wageningen, for giving me the opportunity to join your research group and for your excellent scientific guidance and valuable advices. Paul, thank you that your door was always open and you were always ready to help whatever problem I faced. I cannot express how much your unique direct daily supervision and useful advices helped me to tackle the problems during my PhD. Thank you a lot, I am very grateful for that. I would like to thank also Marco de Wolf from Applied Plant Research who helped me with the collection of the data for my project and with whom I became friends during these visits. Furthermore, I would like to thank Brian Hardaker and Wijnand Sukkel for their valuable comments on my thesis articles. I would like to give many thanks to my Hungarian supervisor, Katalin Takács-György, who cared a lot about my project and my personal development, and gave great support with her advices.

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I would like to express my gratitude to all my friends I met in Wageningen, especially, Maarten Paul, Frank, Pablo, Ajay, Willy, James and Armelle, who were always there for me. I would like to thank my sport colleagues: John at the Sportcentre de Bongerd for his positive radiation and Buis and Ejal for their “keihard” trainings, who were trying to keep me fit. Special thanks for my trainer at home in Hungary, Zsolt Somogyi, who gave me lots of strength during my visits and encouraged me to continue my sport life at high level next to my thesis and education. Many thanks to the Hungarian Community in Wageningen (WaMBaK – Wageningeni Magyarok Baráti Köre), who brought a piece of home by organizing common dinners, cultural, sport, travelling and other activities. Especially thanks for Kova, Toto, Orsi, Zsófi, Dénes, Szilvi, Kriszta, Árpi and András.

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There are many people I could not list here and I would like to thank for contributing to my work and to my personal development during these years.

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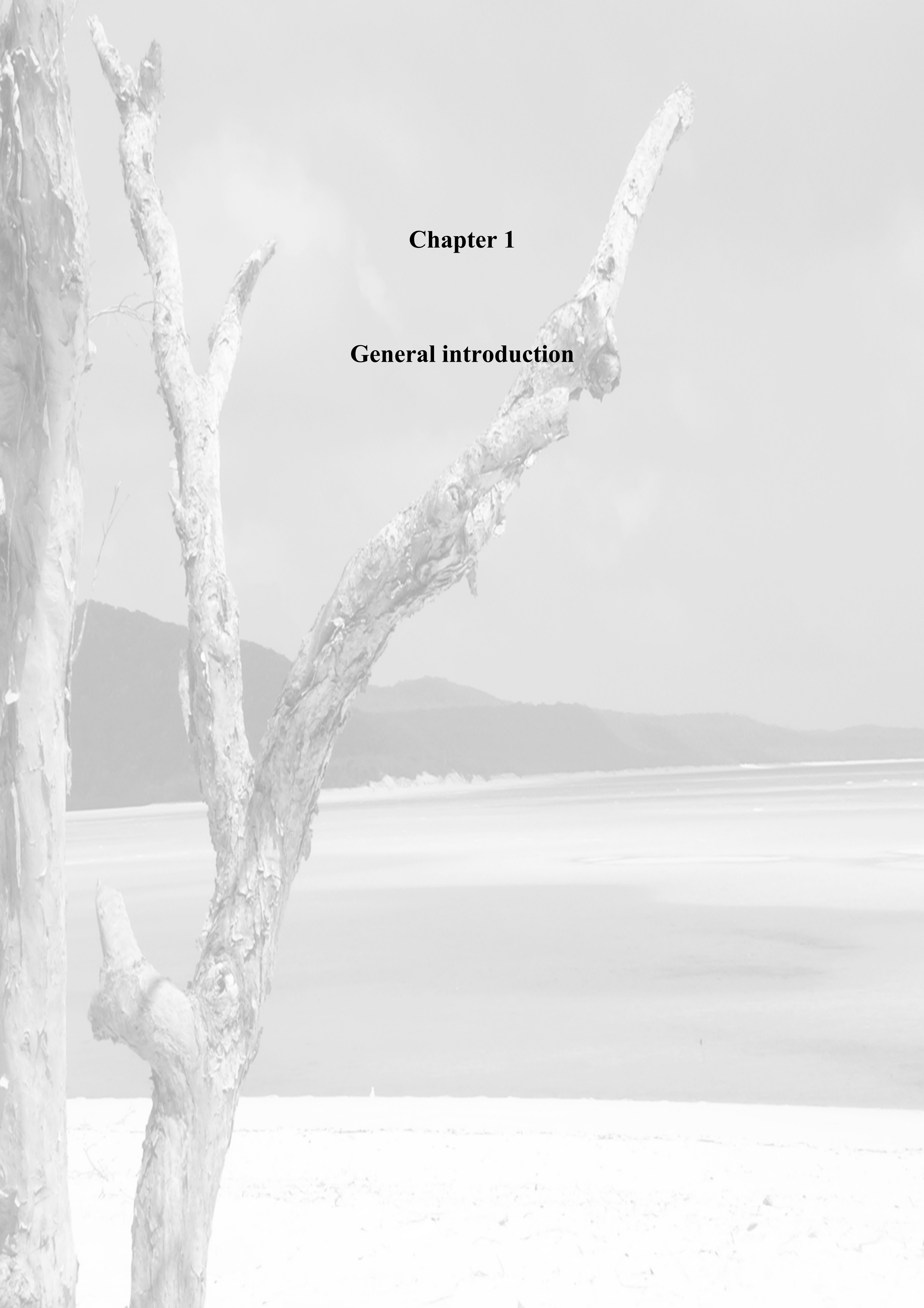
Szvetlána Ács
Wageningen, July, 2006

Contents

Chapter 1

General introduction



1.1 Background and scope

Society and governments in many countries show an increasing concern about food production due to environmental problems, animal welfare and human health problems (Walker *et al*., 2005; Weersink & Wossink, 2005; Wolf *at al*., 2005; Tilman *et al*., 2002). Environmental problems related to agriculture are often related to flows of nutrients (nitrogen and phosphate) to the environment and emissions of ammonia and carbon dioxide that contribute to the acid rain problem and the greenhouse effect. Human health problems are apparent through the occasional finding of residues from e.g. pesticides and herbicides in food. These environmental and human health problems in the food chain have induced many governments in the world to promote more sustainable farming systems. Organic farming is recognised in the European Union as one possible way to improve the sustainability of agriculture (Rigby & Cáceres, 2001; Padel *et al*., 2002). The main aim of organic farming is to create a sustainable agricultual production system including economic, environmental and social sustainability (Padel, 2001). In organic farming, maximum reliance is placed on self-regulating ecological or biological processes and renewable resources, whereas reliance on external inputs is reduced as far as possible (Lampkin, 1994). Organic farming claims to have the potential to provide benefits in terms of environmental protection, conservation of non-renewable resources, improved food quality, reduction in output of surplus products and the reorientation of agriculture towards areas of market demand (Lampkin, 1994). Some European governments have recognized these potential benefits and responded to them by encouraging farmers to adopt organic farming practices, either directly through financial incentives or indirectly through support of research, extension and marketing initiatives.

Organic farming in the European Union (EU) showed rapid growth in the last few decades due to policy incentives and consumer demand (Dabbert *et al*, 2004). However, the overall significance of organic farming in the EU context is still quite small in terms of land area used. In 2004 it was 3.5% of the total EU utilised agricultural area (UAA) (FIBL, 2005). In some member states, such as in the Netherlands, the rapid growth in the nineties has slowed down after the end of the century. In the Netherlands, as in many European countries, an action plan was developed to promote organic agriculture (Yussefi & Willer, 2002). In 2000 the Dutch government set an ambitious target that by 2005 five percent and by 2010 ten percent of the total agricultural area should be organically managed (Melita, 2001). However, the conversion from conventional to organic farming was progressing more slowly and in 2005 the organic land area was only 2.49% (Eurostat, 2006). In spite of this, the target of ten percent by 2010 still remains (MINLNV, 2005). In order to stimulate the conversion, policy makers need more detailed information about the process of conversion. Factors that motivate and hamper the conversion of farms have to be investigated in more detail.

After livestock production, which occupies 57% of the total UAA, arable farming is the second most important sector in the Netherlands in terms of utilized land area, with 25% of the total UAA (LEI, 2005). The largest sector in organic farming in the Netherlands is the livestock production sector with 44.8% of organic UAA, followed by horticulture and arable farming sector with 24% and 22%, respectively. The remaining part of the organic area is occupied by fruit and other organic production such as mushrooms, planting materials and herbs. The biggest share of organic area for livestock production can be explained, besides by the increasing consumer demand, by the relatively easier conversion of dairy farmers to organic production compared to the conversion of other sectors (Melita 2001). The arable sector requires more attention because it is unclear why some farms converted and others converted back during the last few years, reducing the level of initial growth considerably.

1.2 Motives and barriers for conversion

Based on literature, the factors that motivate the conversion can be distinguished as economic and non-economic factors. Economic motives include attempts to solve existing financial problems as well as the desire to secure the long-term existence of the farm. They cover cost saving through organic production as well as premium price marketing (Lampkin 1994; MacRae, R.J. 1990; Lockeretz & Madden, 1987). Non-economic motives include husbandry and technical reasons and personal reasons (Padel, 2001). Husbandry and technical concerns include animal welfare and animal health problems, soil fertility and erosion problems. Personal reasons include general concerns about food quality, stewardship, conservation, environment and rural development, and in some cases personal and family health problems. Motives to convert to organic farming are different between types of farmers (Darnhofer *et al*., 2005) and have changed over time from husbandry related concerns to economic reasons, from religious and philosophical concerns to environmental and political ones (Padel, 2001). Although economic motives are not the most important motives for the farmers to convert, it is widely seen as an important factor determining the acceptance of organic farming by conventional farmers (Lampkin & Padel, 1994). Therefore, information about economic performance is essential for individuals as well as for policy decision-making.

Factors that hamper the conversion can be grouped in production, market, institutional and social barriers. The main production barriers include lack of technical and financial information and higher perceived risk associated with conversion (Padel, 2001; Padel & Lampkin, 1994). Besides these financial difficulties during the conversion period, increased labour need in organic production, yield uncertainty during and after the conversion and learning process are also considered important production factors that hamper the conversion (Padel, 2001; Padel & Lampkin, 1994; Van Mansvelt & Mulder, 1993). Market barriers include uncertainty concerning future market availability for organic products and price risk due to the small-scale, immature nature of organic market and the lack of government intervention to stabilise prices (Lampkin & Padel, 1994). Institutional barriers include refusal of loans and insurance for organic products, legislative and certification constraints (Padel, 2001). Social barriers are a fear to become an outsider or to get involved in intergenerational conflicts; however, this is becoming less relevant with the increase of social acceptance of organic farming in general (Lampkin & Padel, 1994).

1.3 Conversion process

A key factor inhibiting conversion to organic farming, despite the premium market and the other benefits, is concern about the implications of conversion. A period of two years, known as the conversion or transition period, is needed to change a farm from conventional to organic. During this period the farmer should aim to (Lampkin & Padel, 1994):

- Change the management to maintain animal and plant health with the limited inputs available according to organic production standards;
- Build up soil fertility by establishing a rotation with legumes so that crops can be produced without synthetic nitrogen fertilizer or large amounts of purchased manures.

The necessary changes depend on the conventional cropping intensity and the condition of the farm before conversion. Conversion is a complex process involving a high degree of innovation and learning of the farmer, as well as temporary income loss. Extra costs follow from conversion-related investments in machinery and/or buildings and information gathering expenses. A loss of revenue arises from yield reductions, due to biological and learning processes, which is not compensated by premium prices during the statutory two-year conversion period.

Another problem arises from the fact that farmers, who would decide to convert and make these investments, do not have a guarantee that their income will be higher in the long run. This means that farmers besides the conversion difficulties have to deal with the problem of future yield and market price uncertainty of their produced organic products (Padel 2001; Dabbert & Madden 1986).

In this research the focus is on economic performance and difficulties of conversion of a typical conventional arable farm converting to organic production system given the current institutional and policy regulatory environment in the Netherlands. Several constraining factors during conversion process and the effect of yield and price uncertainty during and after the conversion period on income and conversion planning are investigated in more detail.

1.4 Objective of the research

The study aims to gain more insight in the economics of conversion. Many empirical studies using data analysis has been done already, therefore the focus here is on the analysis of conversion from a normative point of view. This research attempts to answer the following three sub-questions:

1. Why do the farmers not convert?
2. What are the important influential factors of conversion? What is the magnitude of them?
3. What types of incentives can be useful to stimulate conversion?

The main objective of this research was to answer the above questions by means of (1) developing a modelling approach that can be used for analyzing the conversion from conventional to organic arable farming systems from economic and environmental point of view and (2) determining the effects of influential factors and policies (incentives) on the choice of farmers to convert from conventional to organic farming systems. The models were developed for a typical arable farm in the central clay region in the Netherlands. This region has been chosen because the most organic arable farms are situated here and because of availability of data.

Four phases were identified in the research project (see Figure 1.1 for phase 2 to 4):

1. A thorough review of scientific literature on economics of conversion in order to identify the most suitable method to analyse the conversion process.
2. The development of a static bio-economic linear programming model at farm level in order to compare conventional and organic arable farming systems from economic and environmental point of view.
3. The development of a dynamic linear programming model in order to analyse the conversion process from conventional to organic farming system taking into account the factors influencing conversion.
4. The inclusion of production and price uncertainty of crops and analysis of the effects of these uncertainties taking into account farmers risk attitude on the willingness to convert.

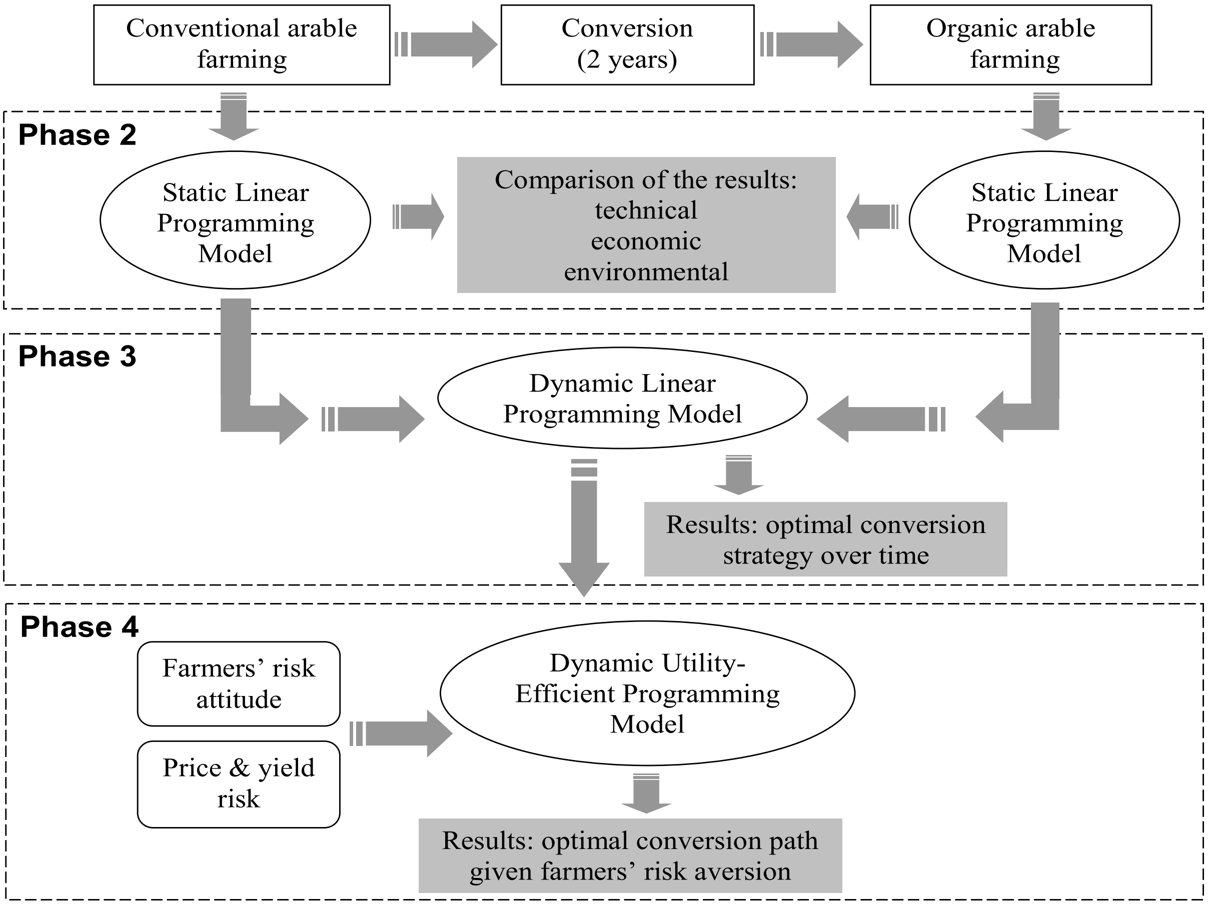


Figure 1.1 Research outline

1.5 Outline of the thesis

In Chapter 2 a review of scientific literature on the evaluation of technical, economic and environmental implications of conversion from conventional towards more sustainable production, i.e. organic farming is presented. Methods and results of different studies are compared and the advantages and disadvantages of different approaches (empirical and normative) are analysed and discussed to determine their suitability for modelling conversion at farm level.

In Chapter 3 a comparison of the conventional and organic arable farming system is made by using a normalised situation (same area, soil type, climate, etc.). The chapter describes a linear programming model of a conventional arable farm and of an organic arable farm in the central clay region of the Netherlands. The setup of these two models is presented and the technical, economic and environmental results are analysed and compared (see Figure 1.1).

In Chapter 4 the conversion period between conventional and organic farming is included in the model by means of dynamic linear programming model (DLP) (see Figure 1.1). The DLP describes the conversion process of a farm over time by maximizing the net present value over a ten-year planning horizon. In this chapter the model is presented and next, it is used to analyse different factors influencing the conversion, such as extra depreciation costs, hired labour availability, organic market price uncertainty and minimum labour income requirement.

In Chapter 5 yield and price uncertainty before, during and after the conversion years is included in the DLP model of Chapter 4 (see Figure 1.1). The developed discrete stochastic dynamic utility-efficient programming (DUEP) model is described. This model maximizes the expected utility of the farmer depending on the farmers' risk attitude. Uncertainty is based on average group results in practice for a number of years. The results of the model for a basic situation are presented and analysed followed by the results of a sensitivity analysis for different factors such as policy incentives, market stabilization for organic products or learning effect of farmers.

In Chapter 6 the methodological issues of the thesis and the applicability of the method, interpretation of the results and comparison of the results with that of other studies are discussed. Further, some policy implications on organic farming support are put forward. Finally, the chapter ends with main conclusions of the thesis.

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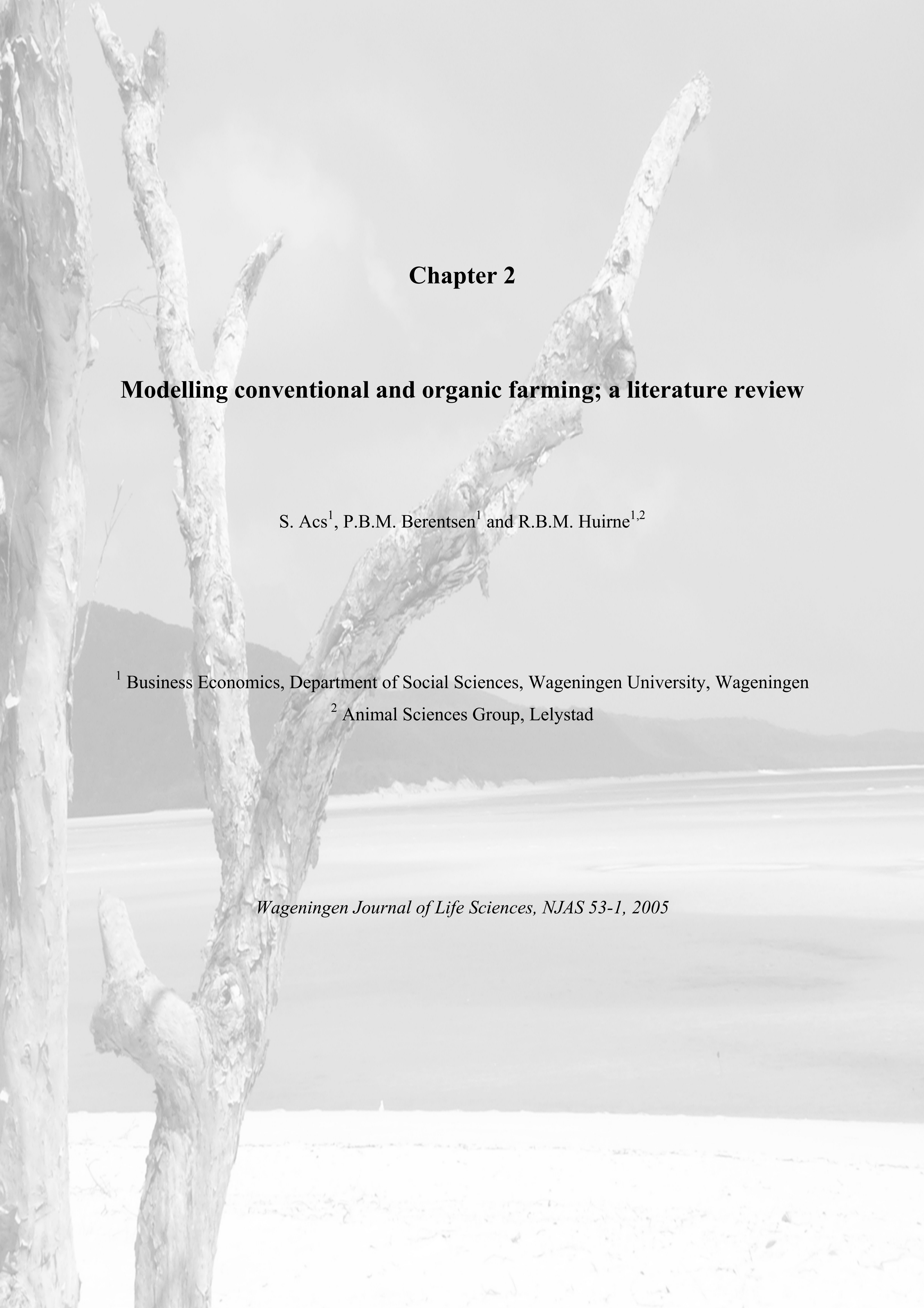

Chapter 2

Modelling conventional and organic farming; a literature review

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Abstract

Literature shows a significant development of organic farming in Europe but with considerable differences between countries. These depend on general agricultural policy (the set of regulations and laws), specific policy incentives, and also on differences in consumer behaviour. This paper reviews scientific literature on the evaluation of the technical, economic and environmental aspects of conversion from conventional towards organic production. The methods and results of empirical and normative modelling studies at the farm level, with special regard to farm management and policy, are analysed. Empirical modelling studies show the importance of incentives and agricultural policy, and the usefulness of integrated modelling for determining the effects of different policies on farm management. Normative modelling shows the effects of new policy instruments and technology, and allows the high level of detail needed for what-if analysis. Normative models of conversion to organic farming confirm the importance of incentives and the agricultural policy context.

2.1 Introduction

Organic farming claims to have the potential to provide benefits in terms of environmental protection, conservation of non-renewable resources, improved food quality, reduction in output of surplus products and the reorientation of agriculture towards areas of market demand (Lampkin, 1990). Some European governments have recognized these potential benefits and responded to them by encouraging farmers to adopt organic farming practices, either directly through financial incentives or indirectly through support of research, extension and marketing initiatives. However, farmers' decisions on whether or not to make the switch from conventional to organic farming have not been studied extensively thus far.

The study reported in this paper is a part of a larger project that focuses on developing a farm-level model that can be used to support farmers and government in the transition process from conventional to organic farming systems in economic and environmental terms. The model will be used to determine the effects of different policies on the conversion to organic farming systems.

The objective of this paper is to present a review of scientific literature on the evaluation of technical, economic and environmental implications of conversion from conventional towards more sustainable production, i.e. organic farming. Methods and results of different studies will be compared and the advantages and disadvantages of different approaches will be analysed.

The paper starts with definitions of organic farming and the way these definitions are operationalized into policy. Next, some data and background information concerning the history of organic farming in the EU and in the Netherlands are given. After that, empirical and normative modelling research is analysed to determine their suitability for modelling conversion from conventional to organic farming. This analysis is based on articles in peer-reviewed scientific journals. Finally, conclusions will be drawn concerning modelling of conversion from conventional towards organic farming.

2.2 Defining organic farming and conversion to organic farming

2.2.1. Aims and definitions of organic farming

There are many definitions of organic farming. Mannion (1995) refers to it as a holistic view of agriculture that aims to reflect the profound interrelationship between farm biota, agricultural production and the overall environment. Scofield (1986) stresses that organic farming does not simply refer to the use of living materials, but emphasises the concept of 'wholeness', implying the "systematic connection or co-ordination of parts in one whole." As Scofield points out, the concerns that motivated the early adopters of organic farming, include issues of soil health and structure, the exhaustible nature of artificial fertilizers, and human health.

According to the Codex Alimentarius (Le Guillou & Scharpé, 2001), organic farming involves holistic production management systems (for crops and livestock) emphasizing the use of management practices in preference to the use of on-farm inputs. This is accomplished by using, where and when possible, cultural, biological and mechanical methods in preference to synthetic materials.

One of the most significant expositions of the aims and principles of organic farming is presented in the International Federation of Organic Agriculture Movement's basic standards for production and processing (Anon., 2002). In the words of the principle aims of IFOAM, organic farming even involves a clear vision of a major change in society in order to make organic farming possible:

> "(…) to interact in a constructive and life-enhancing way with natural systems and cycles; (…) to consider the wider social and ecological impact of the organic production and processing system; (…) to progress toward an entire production, processing and distribution chain which is both socially and ecologically responsible."

Lampkin & Padel (1994) provide a more operational definition of organic farming. They state that the aim of organic farming is:

> "to create integrated, humane, environmentally and economically sustainable agricultural production systems, which maximize reliance on farm-derived renewable resources and the management of ecological and biological processes and interactions, so as to provide acceptable levels of crop, livestock and human nutrition, protection

> from pests and diseases, and an appropriate return to the human and other resources employed".

In some respects, this definition stands as the complete opposite to conventional productivist agriculture, which implies extensive use of artificial inputs such as fertilizers and pesticides designed to increase productivity in food production.

2.2.2. Practical aspects of organic farming

Some practical consequences of organic farming concerning crop and livestock production can be described by the following.

In crop production, the soil fertility and the biological activity should be maintained by use of green manure, leguminous plants and an ample crop rotation scheme. Fertilising takes place with manure of organic origin – no synthetic fertilizer is allowed. For crop protection against pests and diseases, besides ample crop rotation schemes, natural enemies are used. Weed control is based on the selection of varieties and mechanical protection methods.

Livestock production focuses on animal welfare, animal health care and organic feeding. Farm animals must be kept in a natural way with sufficient run-out, space, light and litter in the stable. For each animal minimum indoor and outdoor room should be available. Nutrition, care and housing should offer the animals an optimal natural resistance against diseases. Natural and homeopathic medicines have preference. The foodstuffs should be organically produced, and only a restricted number of additives is allowed (CABI, 2004).

2.2.3. Conversion aspects of organic farming

The agri-environmental measures introduced by EU Council Regulation 2078/92 (Anon., 1992) encourage conversion to and maintenance of organic farming by providing financial compensation to farmers for any losses incurred during conversion. In the European Union, organic production of agricultural products is regulated by Council Regulation 2092/91 (Anon., 1991). This regulation sets out strict requirements which must be met before agricultural products, whether produced in the EU or imported from third countries, can be marketed as organic. In particular, it severely restricts the range of products that can be used for fertilizing and for plant pest and disease control, and requires each member state to set up a certification body and an inspection system to certify compliance with these principles. The principles must normally have been followed for at least two years before sowing or, in the case of perennial crops, at least three years before harvesting, before the products can be sold as organic. During this period the farm is said to be 'in conversion' (Hau & Joaris, 1999).

Two types of conversion can be distinguished (Lampkin & Padel, 1994):

1. Staged (step-by-step) conversion. Every year a certain area of the farm is converted to organic farming. Some certification bodies do not accept this type of conversion.
2. Single-step conversion. The whole farm converts to organic farming at the same moment. This enables the farm to gain access to premium prices sooner, but means that all the risks, learning costs and financial impacts of conversion are concentrated into a short period of time, while for arable farming rotation disadvantages can arise because not all of the farm can be put in fertility-building crops at the same time.

In the case of livestock production, the animals also have to be converted from conventional to organic production. The conversion period depends on the animal type and varies from 6 weeks for layers to 12 months for meat cattle (Anon., 2004).

Lampkin and Padel (1994) drew some general conclusions about conversion based on their EU-wide study. During the conversion (transition) period a farmer should aim to:

1. Improve soil fertility by establishing a rotation with legumes, so that crops can be produced without inorganic nitrogen fertilizer or large amounts of purchased manure;
2. Adjust the stocking rate to the natural carrying capacity of the farm, so that livestock can be kept without large amounts of purchased concentrates and/or forage;
3. Change the management system to maintain animal and plant health with the limited inputs available according to organic production standards.

Necessary changes depend on the intensity and the condition of the farm before conversion. Usually some investment in machinery and/or buildings is required in order to meet organic standards. After the conversion period the farmer can apply for full organic certification and will usually be allowed to use a symbol and gain access to premium prices when available.

In the early 1990s, an analysis of the experiences of farmers who had converted their farms to organic systems indicated that the main problem (Lampkin, 1990) encountered during the conversion process is:

1. Shortage of forage on livestock farms (due to a reduction in yields and increased reliance on home-grown forage);
2. Excess protein in rations of livestock herds leading in some instances to health problems;

3. Problems with weed control (notably docks, couch and thistles);
4. High workloads in peak periods;
5. Financial difficulties due to lack of access to price premiums until conversion is complete, conversion-related investments and 'disinvestments' and information-gathering costs for production and marketing (Lampkin & Padel, 1994).

2.2.4. Growth of the organic farming sector

During the 1980s, organic farming received political attention in many European countries through political recognition of the production system (i.e., standards, certification systems and labels) (Lampkin *et al*., 1999a). Public financial support for organic farmers was introduced for the first time in Europe (in Denmark) in 1987 to cover economic losses during the two-year conversion period (Michelsen, 2001). During the 1990s, political interest in organic farming moved to the level of the EU, which introduced a common set of production standards for organic plant production in 1991 (EU Regulation 2092/91) (Anon., 1991). In 1999 this was supplemented by common standards for organic livestock production (EU Regulation 1804/99) (Anon., 1999) and by an option for financial support of organic farmers. The latter followed from the measures accompanying the reform of the Common Agricultural Policy in 1992 (EU Regulation 2078/92) (Anon., 1992). In the following years, member states implemented various organic farming policies according to this legislative framework (Lampkin *et al*., 1999a). Since 1999, organic farmers in all EU countries have been receiving support under the agri-environmental programmes that are granted under the rural development regulation of Agenda 2000 (Häring & Dabbert, 2004).

In the Netherlands, among different subsidy regulations of the Ministry of Agriculture, Nature and Food Quality relevant to organic farming, there is a regulation supporting the conversion to organic production (*Regeling Stimulering Biologische Productiemethode*, RSBP). The RSBP is implemented by *Dienst Landelijke Service* (LASER). This regulation provides financial support during the conversion period in order to compensate the loss in income, according to the Conversion Scheme (Lampkin *et al*., 1999a). However, there is an additional condition that one must produce organically for at least five years. The subsidy is given per five years per hectare. For the future development of organic farming in the Netherlands, as in some other European countries, an action plan was developed to promote organic agriculture. As part of this action plan, marketing of organic products, advisory services and consumer information is supported (Yussefi & Willer, 2002). The action plan developed by the Dutch government (*Plan van Aanpak Biologische Landbouw 2001–2004*) in 2000 includes an important target. Five percent of the total agricultural area should be organically managed by the year 2005 and 10% by the year 2010 (Yussefi & Willer, 2002).

In 1985 the area of organic production amounted to 100,000 ha in the whole of the EU The number of organic farms was 6,300 or less than 0.1 percent of the total number of farms. Organic production areas and number of organic farms of five EU-countries with substantial organic production and of the Netherlands are shown in Figure 2.1 and Figure 2.2, respectively. Differences in the size of organic farming between countries can be explained partly by the differences in specific policy incentives (Lampkin *et al.*, 1999b) and partly by the differences in consumers' behaviour (Anon., 2003). More than half of all the organic farms were located in France and Germany. Since then organic farming in the EU has experienced a dynamic development, especially in the 1990s. From 1993 to 1998 the organic farming area nearly tripled (Foster & Lampkin, 2000). By the end of 1999, the number of farms in the EU had increased to more than 127,000 holdings with 3.3 million hectares, or nearly 1.5% of all holdings and 2.4% of the total agricultural area. In Austria and Sweden, organic farming reached rather significant shares of 10 to 15% of total agriculture in the late 1990s, either in terms of the number of farmers or total agricultural area. An explanation for the growth of organic farming is that during the 1980s and 1990s it received growing public attention throughout Europe as part of the general interest in socially responsible alternatives to the particular type of societal modernization, which accelerated after the World War II (Michelsen *et al.*, 2001).

In the Netherlands in the 1990s the growth in the number of organic farms increased considerably. Between 1993 and 1997 an average of 60 farms per year were converted. In 1998 and 1999 more than 200 farms converted per year, which is equivalent to an annual growth of more than 25%. In the last two years the growth rate dropped to 14% in 2000 and 8% in 2001 (Melita, 2001). In July 2001, 1,47% of the total agricultural area of the Netherlands was organically managed.

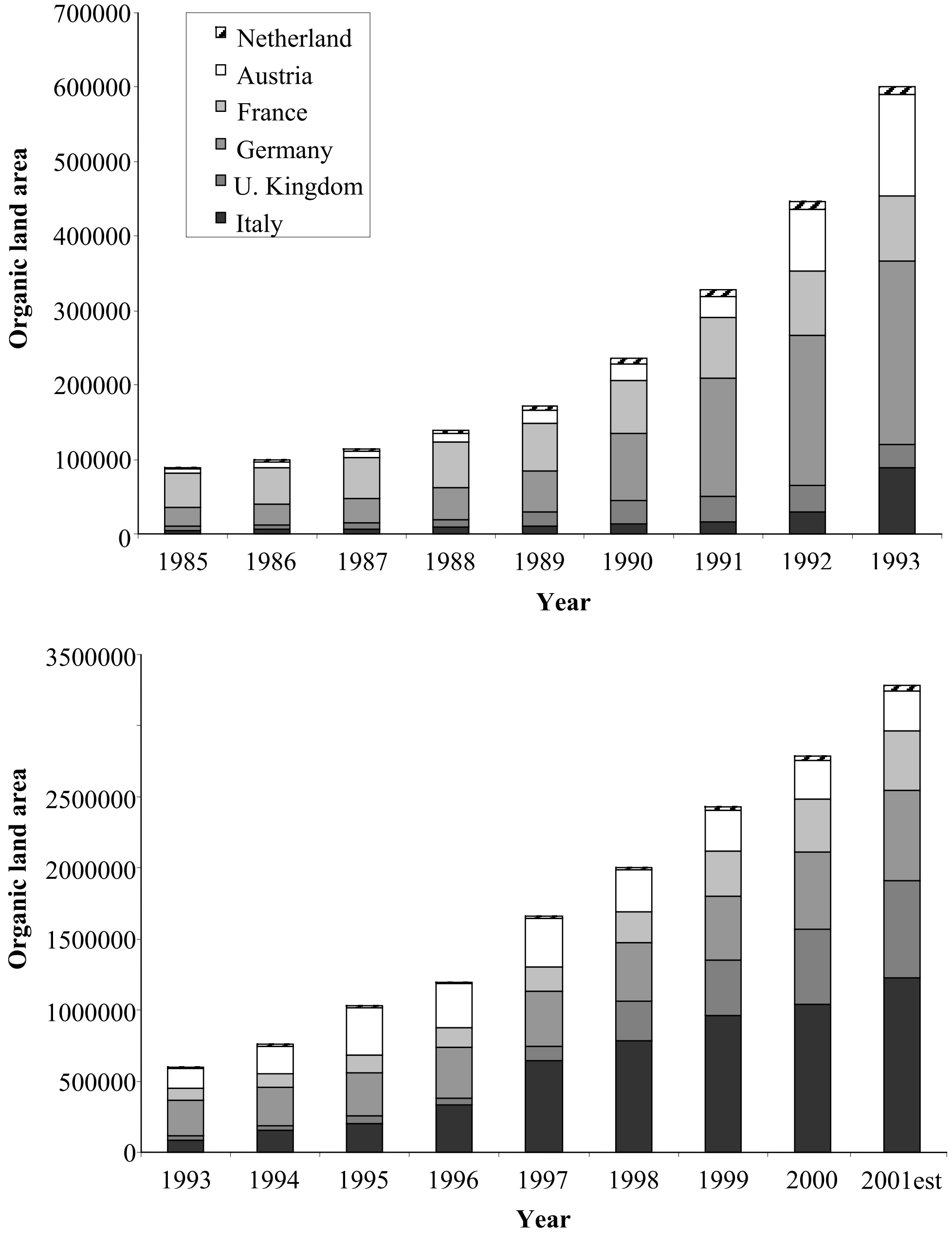

Figure 2.1 Organic land area (ha) in six EU-countries over the period 1985-2001

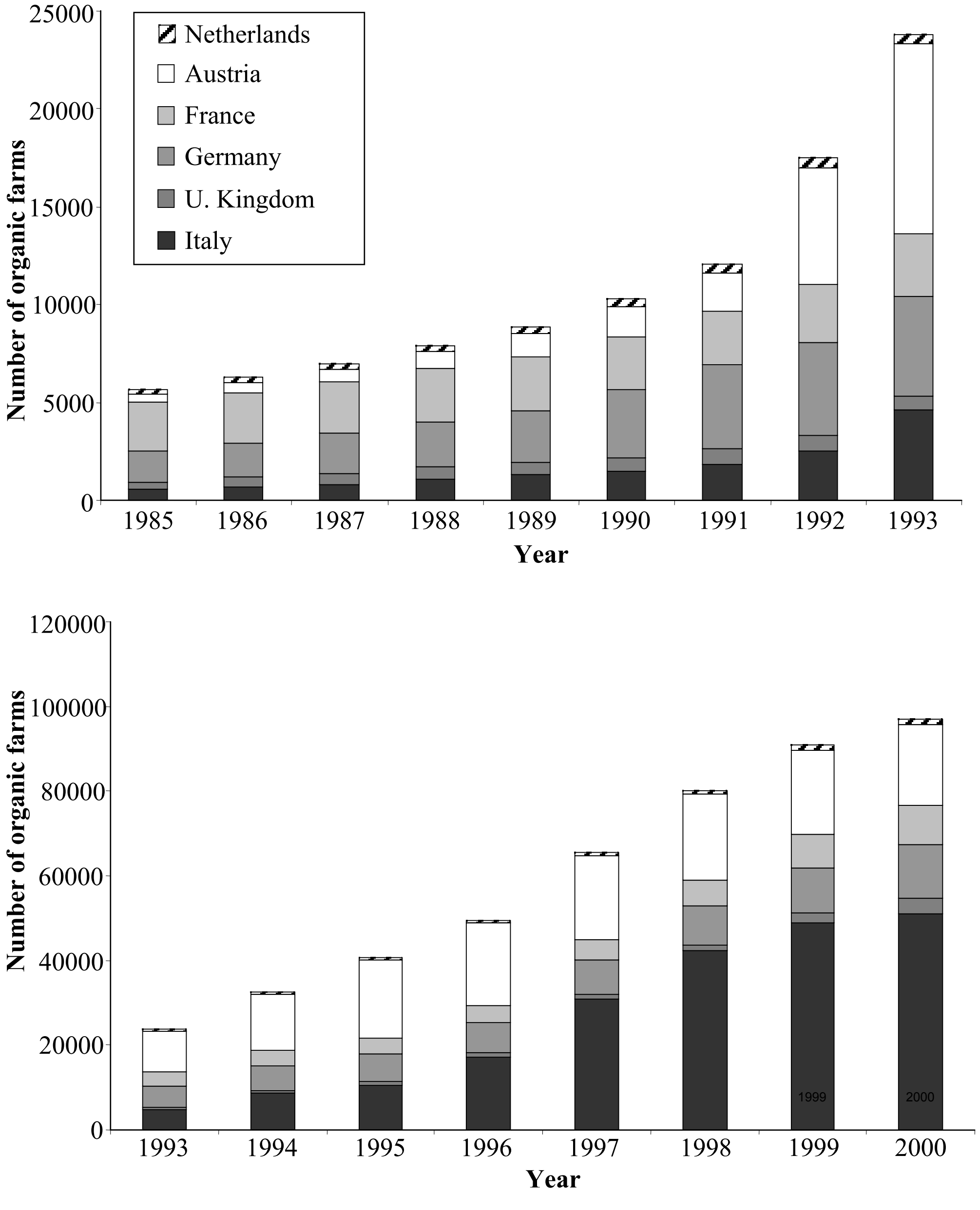

Figure 2.2 Number of organic farms in six EU-countries over the period 1985-2000

2.3 Modelling conventional and organic farming

When the relationship between agricultural production methods and economic and environmental sustainability at the farm level is examined we can distinguish two main categories of models: empirical and normative models.

Empirical models are understood here as econometric models. Econometric models are statistical representations of farm-level systems, often as aggregate systems of equations for input demand and output supply. Econometric models allow for statistical testing of economic and/or technical relationships (Pindyck & Rubinfeld, 1998; Wallace & Moss, 2002).

Normative models are mechanistic optimization and simulation models. Optimization and simulation models are both systems of equations and/or inequalities designed to replicate farm-level activities related to production, marketing and finance. A distinction often made between optimization and simulation models is that the former involve explicitly the specification of an objective function (e.g. profit maximization), while this is not the case for simulation models (Hazell & Norton, 1986; Weersink *et al*., 2002).

Farm modelling, both empirical and normative, is an important tool for farm planning and extension, research planning and evaluation, and policy analysis (Klein & Narayanan, 1992). Lee (1983) distinguishes three specific needs of farm modelling: (1) understanding likely responses of farms to specific economic conditions and policy provisions, (2) understanding the likely distributive effects of these conditions and provisions, and (3) providing additional detail and likely behavioural responses not well specified in macro models. According to these purposes of farm modelling two main types of farm model can be distinguished:

1. Models to support farm management;
2. Models to support policy making.

Models to support farm management concern particular effects of different management practices on the income of the farmer and on the environment. They analyse how different input combinations and constraints influence the output results of the farm.

Models that focus on policy analysis aim to clarify the effect of different policy instruments on management decisions and through it on economics and environment (Baum & Schertz 1983). In such a way different policy alternatives can be compared. Alternatives include, for example, taxes, subsidies, transferable permit schemes, insurance and credit instruments (Falconer, 1998; Oskam *et al*., 1998).

2.3.1 Empirical modelling

There are many econometric studies dealing with economic and environmental aspects of conversion to more sustainable farming systems such as organic farming. They are summarised in Table 2.1, and it is clear that the majority of the reviewed econometric studies are oriented towards supporting policy making.

Cooper (1997) made an attempt to estimate the minimum incentive payments a farmer would require in order to adopt more environmentally friendly “best management practices” (BMPs). This was done by using contingent valuation method (CVM) survey data (farmers’ responses concerning the adoption of BMPs given hypothetical incentive payment values per acre) in combination with actual market data (farmers’ actual responses on the amount of incentive payments) from four watershed regions in the United States. Combining actual market data with the CVM data adds information to the analysis, thereby most likely increasing the reliability of the results compared to analysing the CVM data only. Traditional discrete choice analysis was applied to analyse the combined data. Adoption rates (percentage of farmers adopting BMP) predicted with the combined data model are significantly higher than those predicted using the traditional discrete choice analysis based on CVM data only. Hence, the author concluded that using traditional CVM analysis results to determine payments to attain a given level of adoption is likely to result in overpayment.

Oglethorpe and Sanderson (1999) aimed to explain how a utility maximising economic modelling framework can be linked to an ecological modelling system in order to do *ex ante* assessment of the ecological impact of certain key agricultural management parameters. Two models, Subjective Expected Utility Maximising Model (SEUM) and Vegetation Environmental Management Model (VEEM) were initially developed for independent analyses. Data pertaining to a survey of farm sites were used to analyse the types of relationships which emerge between agricultural management parameters and grassland vegetation. A specific case-study site was selected for assessment of ecological and economic performance of potential policy scenarios. The results of the analysis highlight the high relevance of such an integrated modelling system for environmental policy decision support.

Table 2.1 Overview of empirical modelling studies

Study	Country	Orientation	Subject	Method
Cooper (1997)	USA	Policy analysis	Calculate minimum incentive payment to adopt 'best management practice'	Traditional discrete choice analysis of contingent valuation survey data and market data
Oglethorpe & Sanderson (1999)	UK	Farm management policy analysis	Analysing economic and environmental effect of environmental policy	VEMM[1] SEUM[2]
Lohr & Salomonsson (2000)	Sweden	Policy analysis	Determine factors that influence required conversion subsidy	Utility difference model
Pietola & Oude Lansink (2001)	Finland	Policy analysis	Analyse conversion factors economic incentives	Bellman equation Probit model Monte Carlo simulation
Wynn *et al*. (2001)	UK	Policy analysis	Analysing factors that influence the entry into Environmentally Sensitive Area	Multinomial logit model Duration analysis

[1] VEMM - Vegetation Environment Management Model

[2] SEUM - Subjective Expected Utility Maximising Model

Lohr and Salomonsson (2000) focused on analysing the factors that determine whether a subsidy is required to motivate organic conversion by using a utility difference model with Swedish data. Survey data were collected by questionnaires. Several hypotheses were tested related to factors that affect the necessity of subsidy for conversion. Results showed that farmers requiring higher subsidies managed larger, less-diversified farms, and were more concerned with the quality of organic inspection and of technical advice. Access to more market outlets and information sources substituted for subsidy level in the farmers' utility function. From these results Lohr and Salomonsson concluded that services rather than subsidies may be used to encourage conversion to organic agriculture.

Pietola and Oude Lansink (2001) focused on analysing the factors determining the choice between conventional and organic farming technology in Finland and on the probability of choice given these factors. They examined farmers' responses to economic incentives that aim to stimulate a switch to organic farming technology, using data on observed farmer behaviour. A Bellman equation was used to analyse the factors determining the choice between conventional and organic farming technology. The choice probabilities were estimated in a closed form by an endogenous Probit-type switching model using maximum likelihood estimation (MLE). Finally a Monte Carlo simulation was applied to simulate maximized random return streams. The results suggested that decreasing output prices in conventional production and increasing direct subsidies trigger the switch to organic farming. The switch is also more likely on farms having large land areas and low yields. Intensive livestock production and labour-intensive production have a lower probability of switching to organic farming. The results of this study can help in designing policies that target farmers' choice of production technology.

Wynn *et al.* (2001) aimed to model the entry decisions of farmers and the speed of entry to Environmentally Sensitive Areas (ESA) in Scotland. A multinomial logit model was used for modelling entry decisions and a duration analysis was made to quantify the relative speed at which the farmers joined the ESA scheme. Models were based on a survey of 490 farmers sampled from across all ten ESAs in Scotland. The rather straightforward results indicated that non-entrants were less aware of and less informed about the scheme than entrants. Furthermore, the probability of entry was increased when the scheme prescription fitted the farm situation and when the costs of compliance were low. The duration analysis suggested several factors accelerating scheme entry: an interest in conservation, more adequate information and more extensive systems. They concluded that the logit and duration models were reasonably successful in explaining the probability and speed of entry to the scheme, respectively.

2.3.2 Normative modelling

In the reviewed studies concerning normative modelling models supporting farm management and models supporting policy making are found (see Table 2.2).

In the first management-oriented study De Koeijer *et al.* (1995) examined whether mixed farming systems offer more perspectives for an economically and environmentally sustainable agriculture than specialized farms. They used static linear programming to analyse the effect of an intensive co-operation between two specialized farms and also multiple goal programming to determine the trade-off between income and environmental pollution in several farming systems. They concluded that intensive co-operation between arable and dairy farm offers important economic advantages.

Berentsen *et al*. (1998) aimed to quantify economic and environmental consequences for intensive and extensive dairy farms typical for the province of Utrecht, the Netherlands, when converting to organic dairy farming. For this analysis a static linear programming model was used with the objective function of maximising labour income of the farm. From the results it appeared that the extensive farm benefited from conversion while the intensive farm lost income. The environmental consequences of intensive and extensive dairy farming systems were quite different. The environmental consequences for the organic farms showed a much lower nitrogen surplus (nitrogen fixation was left out) and a phosphate surplus that was at best equal to that of the conventional farm. Especially on the extensive farm manure from other farms was needed to supply nitrogen. Due to fixed ratios between phosphate and nitrogen in manure this leads to overfertilization with phosphate.

De Buck *et al.* (1999) analysed the role of risk in the adoption by farmers of new systems by means of a model that determines differences in production risks between conventional and sustainable farming systems. The model consists of two main parts: (1) crop husbandry models (HMs) for several husbandry activities at the crop level, and (2) an LP model at the farm level. The HMs generate management tracks by means of decision rules, based on the tactics in crop husbandry and weather uncertainty. Combining outcomes of the HMs, the LP model selects optimal management tracks on an annual basis. In the LP model, tactics are re-assessed by means of the HMs, using information of the LP solution. This iterative procedure enables production risks of conventional and sustainable farming systems to be compared, considering fixed, allocatable resources for the whole farm firm. The model can be used (1) to estimate risks of different farming systems, omitting innovations in the sector, using all possible natural conditions as model input, (2) to objectively compare farming systems under similar farm and management situations and (3) to evaluate new techniques on their suitability for a farming system. This paper shows that these methods are very useful and flexible in linking agro-ecological knowledge with farm management models. The authors concluded that, ideally, an optimising algorithm for the HM modules, consisting of dynamic networks, would be Dynamic Programming.

The other group of normative models is policy-oriented. In several studies Wossink *et al.* (1992) and Wossink and Renkema (1994a, 1994b) used a static linear programming model with an environmental component (nutrient loss and pesticide use) to evaluate the effects of alternative environmental policy instruments (such as taxes, subsidies and transferable pollution licenses), and to examine how environmental, price and market policies change arable farming at the farm and regional level. They concluded that linear programming is a good tool for analysing the interactions between production intensity, environmental aspects and farm income, and for comparing the implications of different policy options at farm level.

Donaldson *et al*. (1995) examined the effects of Common Agricultural Policy (CAP) price changes on income and environment on arable farms in two regions, in south-east England and south-west France. For this policy analysis an integrated agronomic and economic model was used. An agronomic crop growth model was used to generate yield and pollution data. These data were incorporated into the economic recursive linear programming model. The economic model was run from 1990/91 to 1994/95 in recursive fashion. The results indicated that modal farms in both regions did not have lower incomes following implementation of CAP reforms in 1992/93 as compared to the previous years. However, in reality farms in south-east England appear to be penalised by the reforms when compared to the ‘no reform’ situation. In the French situation, farm income was higher with CAP reform than without. In south-east England the farms appeared to be penalized by the reforms when compared to the ‘no reform’ situation. Donaldson *et al*. attributed this to the fact that crop yields in this region were 40% higher than those used to calculate the average regional yields (used in the calculation of area payments). In the French model, farm income was higher with CAP reform than without as a result of the very high area payment on some of the irrigated crops, and the much lower discrepancy between actual yields in the region and those yields used to calculate the area payments. With CAP reforms, modelling results of reality indicated an increased area of lower (10-30%) nitrogen-input crop production in both cases. This is associated with lower rates of nitrate loss. The authors concluded that this approach, which combines a crop growth model with an economic linear programming model, was very suitable for identifying the effect of relative price changes resulting from the CAP reform on farmers' resource allocation.

Hasler (1998) made an analysis of environmental policy measures aimed at reducing nitrogen leaching at the farm level for typical Danish crop farms and livestock holdings. The objective was to estimate the cost-effectiveness of the measures (four different levy rates on commercial nitrogen fertilizer) in reducing nitrogen leaching. Cost-effectiveness was expressed as costs per kg reduction in nitrogen leaching. The reductions in nitrogen leaching levels from the measures were compared with the political target. Hasler used static linear and non-linear programming to model the effects of levies on nitrogen leaching. The results indicated that the imposition of levies on commercial nitrogen fertilizer would provide incentives for reducing fertilization and for substituting of commercial nitrogen fertilizer with livestock manure.

Falconer and Hodge (2000) aimed to evaluate the implications of pesticide taxation on the management practices of farmers by using a static linear programming model for a case-study arable farm. The effects of input taxation on pesticide use and income of the farmers were analysed. The model suggested that pesticide use could be reduced significantly while actually increasing farm income through conversion to low-input farming. They concluded that if producers adhere to current systems, a pesticide tax at politically acceptable levels introduced as a stand-alone measure would perform poorly. Pesticide taxation should be part of a package of measures including, in particular, education and training to encourage and assist farming system change.

2.4 Discussion and conclusion

Environmental-economic farm modelling is considered a useful instrument for gaining insights into the interactions of production management, environmental aspects and farm income, and for comparing the implications of different policy instruments. The number of recent scientific publications dealing with this type of modelling, however, is not really high. This type of research is typically carried out in north-western European countries such as the Netherlands and UK. The number of studies dealing with conversion from conventional towards organic farming is even lower. Most of the studies deal with analysing the consequences of farming practices or political measures.

Table 2.2 Overview of normative modelling studies

Study	Country	Type of farm	Main subject	Method	Dynamic or static	Data source
Farm management oriented						
Koeijer *et al*. (1995)	Netherlands	Arable/dairy (cooperation)	Trade-off between economics & environment	Linear programming & multiple goal programming	Static	Typical Netherlands
Berentsen *et al.* (1998)	Netherlands	Dairy	Economic and environmental consequences of conversion	Linear programming	Static	Typical Utrecht region
De Buck (1999)	Netherlands	Arable	Production risk in conventional and sustainable farming	Crop husbandry models Linear programming	Static Dynamic	Dutch FADN[1]
Policy oriented						
Wossink *et al.* (1992, 1994a, 1994b)	Netherlands	Arable	Policy analysis environmental regulation policy instruments	Linear programming (MIMOSA system)	Static	Representative Netherlands
Donaldson *et al.* (1995)	UK, France	Arable	Analyse the effect of CAP[2] reform on income & environment	Recursive linear programming	Static	Crop growth model EPIC[3] model
Hasler (1998)	Denmark	Crops & livestock	Cost effectiveness of measures to reduce nitrogen leaching	Linear programming	Static	Survey Account
Falconer *et al*. (2000)	UK	Arable	Effect of pesticide taxation on management & income	Linear programming	Static	Case-study

[1] FADN - Dutch Farm Accountancy Network
[2] CAP - Common Agricultural Policy
[3] EPIC - Erosion Productivity Impact Calculator

A difficulty that often arose while analysing the studies was the low level of detail of the model descriptions. In some cases this made understanding the studies quite difficult.

There are some major differences between empirical and normative modelling.

Econometric models give an average view based on the dataset used (i.e., certain types of farms, sector). Normative models can be based also on an average dataset within one region or one sector, but can use also typical or specific farm data (which is not necessarily average for the all farms in that region). The main difference is in the purpose and the use of these models. Econometric models mainly search for the factors which are influencing a certain dependant variable. Normative models use a given dataset to explore the effect of future changes. Using this modelling technique 'what-if' analysis can be made by including new variables (e.g. new taxes or subsidies) in the model to see how they affect the decision making of farmers.

The empirical studies mainly focus on determining the main factors influencing the conversion to more sustainable farming systems and the effect of different policies on the decision making of farmers. In most cases econometric analysis is well suited to analysing the agricultural policy context. The ability to aggregate from individual units to a larger scale in a statistically consistent manner is a major advantage (Weersink *et al.*, 2002). However, econometric models have some shortcomings. First, the level of detail is usually rather low. Second, econometric modelling is by definition hindsighted: the models are based on historical data and cannot deal easily with new technologies or new types of policy. In principle the conclusions based on such analyses are valid only for the data (i.e. outputs and inputs) in the period of observation (Falconer & Hodge, 2000).

Normative studies deal with the economic and environmental consequences of different management practices and also with the effects of different policy scenarios on the decision of farmers concerning conversion to more environmentally friendly production methods. Normative modelling makes it possible to analyse the effect of different policy incentives on farm management in a more detailed way. By this type of modelling new technology and new types of policy can be analysed which makes it suitable for 'what-if' analyses (Van Ittersum *et al.*, 1998). In these studies mathematical programming is used in particular. The main conclusion of these studies is that mathematical programming is a suitable tool for analysing the interactions between, on the one hand, management measures and production intensity, on the other hand, environmental aspects and farm income. Moreover, it is a useful tool for determining the implications of different policy options at the farm level, as in the trade-off between economic and environmental aspects.

The majority of the normative studies did not include time in the model. For modelling conversion of farms from conventional to organic farming systems the inclusion of time is however important. There are two main reasons for inclusion of the time aspect. One reason is that there is a possibility for farmers to switch stepwise (in case of crop farming), which gives them more time to learn the new production method. It also ensures income through still allowing production of conventional products next to the in-conversion products (which still sell for conventional prices but must be produced organically) during the conversion period. By modelling over time it is possible to see in which year what area of certain crops would be the best to produce (i.e. from an economic or/and environmental point of view) in an organic way and how it would develop over the years. The other reason is that there is the possibility of analysing the effect of different policy incentives before, during and after the conversion period. In a dynamic model these instruments can be included (e.g. different amounts of taxes or subsidies in a certain year of the conversion). In accordance with Sparkers *et al*. (2003) it can be stated that for this reason dynamic linear programming is very suitable for modelling the conversion period of farms. The requirement of economic and environmental objectives can be covered by the use of multiple objectives in a linear programming model (Zander & Kächele, 1999; Ten Berge, 2000; Kropff *et al*., 2001).

From the analysis it appears that farmers also include considerations other than strictly economic ones in the decision whether or not to convert. Especially, behavioural aspects, like, the risk attitude and risk perception of farmers are important to mention. These aspects could be included in a linear programming model using quadratic risk programming or dynamic stochastic programming methods (Hardaker *et al*., 2004).

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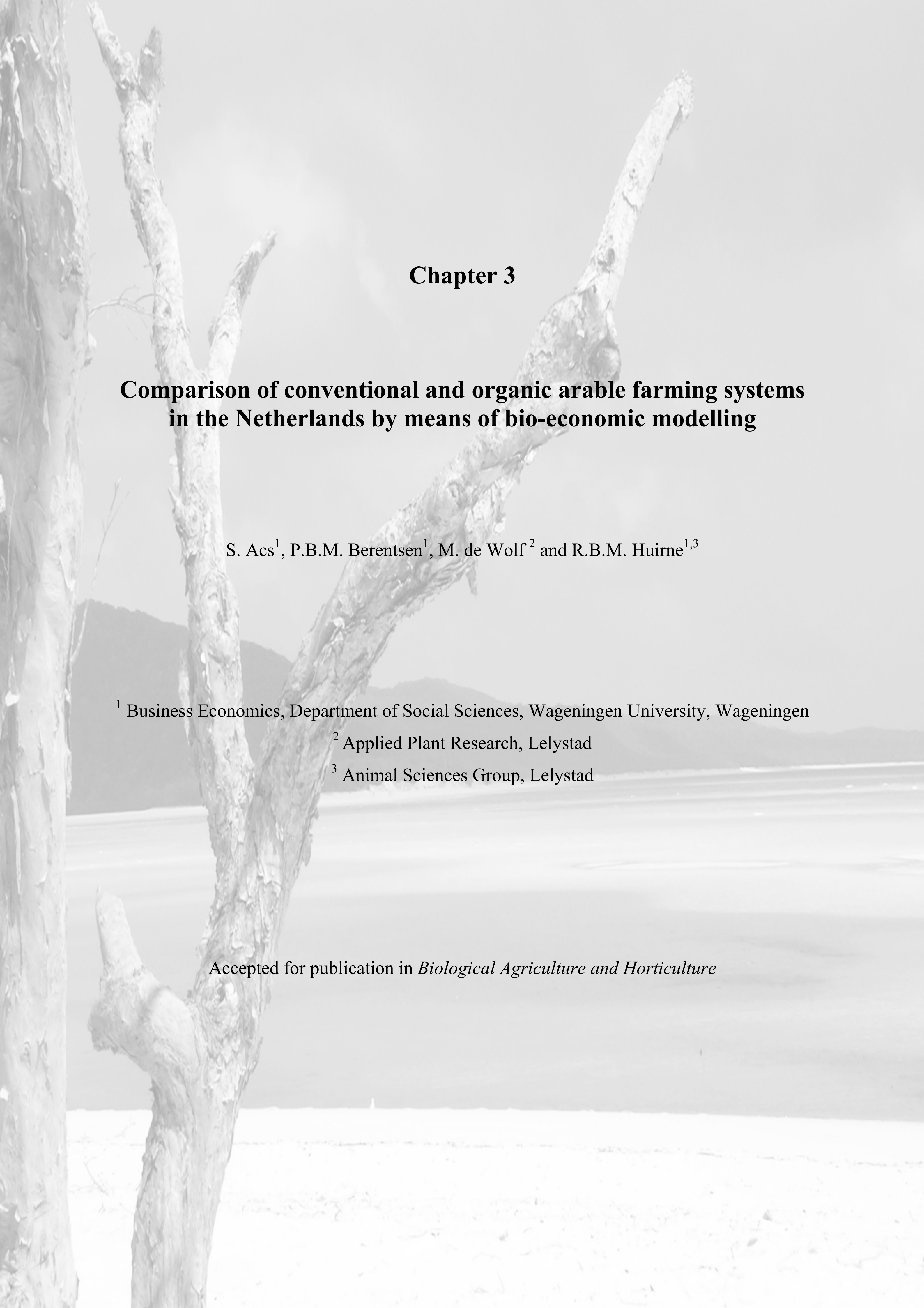

Chapter 3

Comparison of conventional and organic arable farming systems in the Netherlands by means of bio-economic modelling

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Abstract

Growing environmental concern in society combined with policy stimuli has encouraged farmers to switch from conventional to organic production technologies. However, so far not many have made this switch. This raises the question, what could lie behind the decisions of farmers concerning conversion. A first step in studying this decision is to compare farming results in an organic situation with conventional farm results from technical, economic and environmental point of view. In this paper a linear programming model of a conventional arable farm and an organic arable farm are presented. The models include environmental externalities such as losses of nutrients and pesticide use, the levels of which can be influenced by using different production structures (cropping plans). With the conventional model two different crop rotations (3-year and 4-year), and with the organic model one rotation (6-year) are analysed and the results of these three situations are compared. The example farm modelled is typical for the central clay region in The Netherlands. The results show that organic farming leads to less intensive land use, better environmental results and better economic results. Expenditure on hired labour is much higher in organic farming which also leads to higher variable costs. Prices for organic products are higher than for similar conventional products, but lower yields and the less intensive cropping plan mitigates the effects on total revenues.

3.1 Introduction

Organic farming is recognized in the European Union as one possible way to improve the sustainability of agriculture (Häring *et al.*, 2001; Rigby & Cáceres, 2001; Padel *et al.*, 2002). Growing environmental concern in society combined with policy stimuli and economic prospects has encouraged farmers to switch from conventional to organic production technologies.

During the 1990s the organic sector in the European Union grew rapidly to 3% of agricultural area in 2000, caused in part by policy support measures in member states and the EU (Padel *et al.*, 2002). In the Netherlands, as in many European countries, an action plan was developed to promote organic agriculture. As part of this action plan, marketing of organic products, advisory services and consumer information is supported (Yussefi & Willer, 2002). In 2000, the Dutch government set an ambitious target that by 2005 5% and by 2010 10% of the total agricultural area is to be organically managed (Melita, 2001). However in 2002 this figure was only about 2.19% (Willer & Yusselfi, 2004). The conversion from conventional to organic farming systems is progressing more slowly than the Government expected.

There are several factors that can influence the willingness of farmers to convert, such as economic and non-economic factors. Economic factors are crucial for farmers who want to stay in business. So an important question is whether organic farming performs better from an economic point of view than conventional farming, that is, within the stricter environmental constraints.

Many studies have dealt with the comparison, based on empirical results, of these two farming systems (Lampkin & Padel, 1994). Selection of the groups in such research has a strong influence on the results. The problem in these studies is that farms are compared that have different size, location and soil type. This does not give sufficient information about what happen if a particular farmer decides to convert.

In this paper, the two farming systems are compared by using a normalized situation (same area, soil type, climate, etc.). The objective of this paper is to make the comparison by use of a linear programming model. The model was applied to an example farm in the central clay region of the Netherlands. This farm can be considered a representative arable farm for this major arable region. The setup of these two models is presented and the technical, economic and environmental results are compared.

3.2 Model specification and data used for conventional and organic arable farms

3.2.1. General structure

The general structure of the conventional and organic arable farm models is shown in Table 3.1 and has the mathematical form of the standard linear programming model (Hazell & Norton, 1986):

Maximise $\{Z = c'x\}$
Subject to $Ax \leq b$
and $x \geq 0$
where:
x = vector of activities
c = vector of gross margins or costs per unit of activity
A = matrix of technical coefficients
b = vector of right hand side values

The groups of activities are shown at the top of the Table 3.1 under eight headings: production activities representing different crops, seasonal labour, purchase of fertilizer and manure, activities for calculating nutrient surplus, organic matter input and pesticide use.

The rows of the matrix indicate the type and form of the constraints included: land availability, rotation restrictions, supply and demand of fixed and of seasonal labour, nutrient balance calculation for MINAS (Dutch Mineral Accounting System) regulation, maximum manure input restriction for MTAS (Manure Transfer Agreement System) regulation, several counting rows for pesticide use and organic matter input to the farm.

The main difference between the two models is that purchase of fertilizer and pesticide concerns only conventional production. Purchase of pesticides is included in the activity ‘crop production for sale’. In the case of organic farming the fertilizing constraint includes only manure in addition to N-fixation by certain crops. More detailed differences between activities and constraints of the two models will be explained in the next section

.

Table 3.1 The general structure of the conventional and organic arable farm models

Activities	Crop production for sale	Seasonal labour	Purchase of fertilizer	Purchase of manure	Nutrient surplus	Unacceptable nutrient surplus	Organic matter input	Total pesticide use	Fixed costs	Right-hand side
Constraints										
Land availability	+1									≤ available land
Rotation restrictions	+1									≤ max. ha of each crop or group of crops
Labour in periods of 14 days	$+a_{ij}$	-1								≤ available fixed labour in hours
Seasonal skilled and unskilled labour in periods of 14 days		+1								≥ minimum seasonal labour use in hours
Fertilizer and manure requirements	$+a_{ij}$		$- a_{ij}$	$- a_{ij}$						≤ 0
Nutrient balances at farm level	$- a_{ij}$*		$+a_{ij}$	$+a_{ij}$	$- a_{ij}$					= 0
MINAS	$- a_{ij}$*		$+a_{ij}$	$+a_{ij}$		$- a_{ij}$				≤ nutrient surplus accepted by MINAS
MTAS				$+a_{ij}$						≤ max. manure regulated by MTAS
Linking production activities and pesticide use	$+a_{ij}$							-1		= 0
Organic matter input	$+a_{ij}$			$+a_{ij}$			$- a_{ij}$			= 0
Fixed costs									1	= 1
Objective function	Gross margin (Euro) excl. cost of fertilizer	Cost (Euro h^{-1})	Cost (Euro kg^{-1})	Cost (Euro t^{-1})		MINAS tax (Euro kg^{-1}) unacceptable surplus			Annual costs (Euro)	

a_{ij} - the technical coefficient that relates activity i to the constraint j

* Corrected for nitrogen fixation by legumes

The objective function of the LP model is to maximize the gross margin, i.e. total returns from crops sold minus variable costs, including fertilizer, pesticides, variable operations, seasonal labour and MINAS tax on unacceptable surplus. The fixed costs based on the costs of a farm with average land area and typical cropping plan for the region, are calculated separately from the LP model. The output of the model includes the corresponding optimal production plan, labour use, manure and fertilizer purchase, pesticide use and environmental effects of both farming systems.

To get the optimal solution for the LP model, CPLEX solver was used in GAMS (General Algebraic Modelling System) programming language. It should be noted that the LP-model is very flexible and can be easily adjusted (objective function, constraints, coefficients) to reflect any other region or situation.

3.2.2. Land

The farm analysed is typical for the central clay region, which is one of the major arable farming areas in the Netherlands. In this region after the land had been reclaimed from the sea, farm size ranged from 12 to 48 ha. Nowadays, 48 ha farms characterize the region. The available total land area for production per farm is a limiting resource factor for the farmers. In our analysis, the size and soil type of the example farm is therefore 48 ha and clay soil, respectively.

3.2.3. Crop activities

There are several crops which can be grown on the example farm in this area. Typical crops in the region selected for the conventional model include winter wheat, spring barley, seed and ware potato, sugar beet, seed onion and carrot. The organic model includes besides these crops, which are grown in an organic way, the following crops: spring wheat, winter barley, kidney bean, green pea, alfalfa, celeriac and grass-clover. In order to both maintain the organic matter content of the soil and fix nitrogen available after the main crop, green manure is also part of the rotation. Therefore, after cereals winter radish is grown in the conventional farm situation and clover in the organic situation. In the organic case also grass is used as green manure after kidney bean, sugar beet and seed potato.

Table 3.2 Average yields, revenues and costs per hectare for different conventional and organic crops (KWIN, 2002; De Wolf and De Wolf, 2004).

Crops	Conventional				Organic			
	Yield (t)	Price[1] (Euro/t)	Revenue[2] (Euro)	Costs[3] (Euro)	Yield (t)	Price[1] (Euro/t)	Revenue[2] (Euro)	Costs[3] (Euro)
Ware potato	56.8	100	5680	1681	27.5	260	7150	2255
Seed potato	38.7	200	7740	3245	26.0	370	9620	2226
Sugar beet	65.5	50	3344	1008	50.0	80	4058	884
Seed onion	58.4	90	5256	1975	35.0	250	8750	1284
Carrot	77.0	160	12320	9450	55.0	340	18700	12450
Winter wheat	8.7	130	1797	484	5.0	260	1926	439
Spring barley	6.3	140	1526	312	4.5	240	1691	393
Winter barley	-	-	-	-	3.8	310	1759	339
Spring wheat	-	-	-	-	5.0	310	2176	415
Kidney bean	-	-	-	-	2.2	1310	2817	624
Green pea	-	-	-	-	4.3	650	2763	658
Alfalfa	-	-	-	-	12.0	80	960	169
Celeriac	-	-	-	-	35.0	240	8400	2666
Grass-clover	-	-	-	-	10.0	70	700	141

[1] Price of main products

[2] Revenue of crops include: revenue of main product, straw and EU subsidy for cereals, revenue for sugar content

[3] Variable production costs do not include the costs of nutrients and labour. The costs of green manure production is included in the cost of seed potato, kidney bean, sugar beet and cereals

The input data concerning costs and revenues, crop yield, nutrient and pesticide use per crop on central clay soil for conventional crops were based on the Quantitative Information Handbook (KWIN, 2002). For organic crops these data were obtained partly from KWIN (2002) and partly from Applied Plant Research (PPO) (De Wolf and De Wolf, 2004). The data are 'normalized' values for an average 48-ha farm. The nutrient content of crops was obtained from Anonymous (1996).

Yields, revenues and costs for different conventional and organic crops are shown in Table 3.2. The first group of crops can be produced in a conventional and in an organic way, respectively. The second group of crops can be produced organically only. The revenues of the crops are calculated by multiplication of crop prices and yield per crop. The costs of crop production include costs of seeds and pot plants, pesticides, in the conventional case, and energy use, costs of contract work and other costs such as interest, insurance and N-mineral sampling.

3.2.4. Rotation requirements

Most of the conventional farmers in this region use 3-year or 4-year crop rotation on their land. Other crop rotations, i.e. 5-year or 6-year, also can be found but they are not typical for the region. The conventional LP model was set to choose between 3-year and 4-year crop rotation situations. For the organic model 6-year crop rotation was chosen, which characterises the organic farms in this area.

The design of a diverse crop rotation is the key to crop nutrition, weed, pest and disease control (Stockdale *et al.*, 2001). For agronomic reasons rotation restrictions were set for both individual crops and for groups of crops. Rotation constraints of conventional and organic individual crops can be seen in Table 3.3 (Loon *et al.*, 1993; Bus *et al.*, 1996, Visser & Zwanepol, 1993; Schoneveld & Zwanepol, 1991; Westerdijk & Zwanepol, 1994). Rotation constraints concerning organic farming are stricter than those for conventional farming.

Concerning conventional groups of crops: root crops were restricted to 75% of the cultivated area (Darwinkel, 1997; Timmer, 1999). For the groups of organic crops: root crops (ware and seed potato, sugar beet, seed onion, carrot and celeriac) and mow crops (cereals, kidney bean, green pea, alfalfa and grass-clover) can be cultivated separately on half of the area. Green legumes (green pea and alfalfa) and dry legumes (kidney bean) are set to the maximum of 4-year and 6-year of the cultivated area, respectively (Wijnands & Dekking, 2002a).

Table 3.3 Rotation constraints of individual conventional and organic crops in % of the land area used

Crops	Conventional	Organic
Ware potato	33.3	16.7
Seed potato	33.3	16.7
Sugar beet	25.0	25.0
Seed onion	20.0	16.7
Carrot	20.0	16.7
Winter wheat	100.0	50.0
Spring barley	100.0	50.0
Winter barley	-	50.0
Spring wheat	-	50.0
Kidney bean	-	16.7
Green pea	-	16.7
Alfalfa	-	33.3
Celeriac	-	16.7
Grass-clover	-	100.0

While designing crop rotation it is important to take into account the effect of crops on the yields of the subsequent crops in the rotation, especially in organic farming (Lampkin & Padel, 1994). These effects are implicitly included in the model as the data follow from an average crop sequence. Due to lack of data individual crop effects could not be included in the model.

3.2.5. Labour

Most field operations on crops (land preparation, planting/sowing, crop care, hand weeding and harvesting) have to be performed during a particular period of the year. Therefore, the year is divided into periods of 2 weeks. The amount of available family labour is assumed to be 1.1 full-time labour unit or 2255 h year^{-1} (De Wolf & De Wolf, 2004), which is an average family labour supply in this region for a 48 ha land area. The supply of family labour per period is assumed to be constant over the year. However, in peak periods the model can use a maximum of 158 h fortnight^{-1} by assuming that one labour unit works12 h day^{-1} (72 h week^{-1}) excluding Sunday.

Apart from family labour there is the option of hiring seasonal labour. It is assumed that the supply of hired labour is not restricted by the total regional supply. Seasonal labour can be employed any time of the year for 9 Euro h^{-1} and 18 Euro h^{-1} for unskilled (youth/students) and skilled labour, respectively (CAO, 2002). For some field operations for both farming systems, compulsory skilled or unskilled labour is needed, due to the fact that some farming activities require a minimum of two or more persons working at the same time. In that case, there is a minimum constraint for using hired labour for certain periods of each cropping activity. Information about the requirement per crop for skilled and unskilled labour and labour wages was gathered from Applied Plant Research (PPO) (De Wolf & De Wolf, 2004).

The requirements for general work were derived from Schoorlemmer & Krikke (1997). They give a standard of 400 h $farm^{-1}$ $year^{-1}$, plus 10 h ha^{-1} for arable farms and 15 h ha^{-1} for vegetable farms. Organic farms are considered to have a similar need for general work as vegetable farms, according to the high amount of labour used and number of crops grown on the farm (De Wolf & De Wolf, 2004). General work can be done whenever there is a surplus of labour.

3.2.6. Nutrient requirement and supply

Data for the nutrient requirements of the conventional cropping (nitrogen (N), phosphate (P_2O_5) and potassium (K_2O)) were taken from Van Dijk (2003). In the case of organic crops, phosphate and potassium requirements were calculated by the balance method: requirement = removal by products + safety margin – deposition. For phosphate, 20 kg ha^{-1}, and for potassium, 40 kg ha^{-1}, safety margin is used (De Wolf & De Wolf, 2004).

For nutrient supply, besides fertilizer purchase, various types of manure can be used: cattle, pig and poultry manure in the conventional situations and, in addition, cattle stable manure in the organic situation. In the organic farming all manure types have to satisfy the requirement that manure be produced organically, which in the model is associated with higher manure price. Certain types of mineral fertilizers are also permitted to use in organic farming (Skal, 2006). However, due to low applicability of these fertilizers in practice in the Netherlands (KWIN, 2002), this option is not included in the model. N-fixation can bring in nitrogen by cultivating kidney bean, green pea, alfalfa and grass clover. With the use of various manure types the model can optimize the NPK-supply. The price of manure for the conventional farm is assumed to be zero according to the current market situation and the price of fertilizer is 0.55 Euro kg^{-1} N, 0.52 Euro kg^{-1} P_2O_5 and 0.31 Euro kg^{-1} K_2O. For manure of organic origin the price is 9.08 Euro t^{-1} of manure (KWIN, 2002). Spreading of manure assumed to be done by contract workers. The cost of it for both farms is 4.54 Euro t^{-1} (KWIN, 2002).

The nutrient content of each type of manure was gathered from PPO and the effective nitrogen content was calculated by use of the working coefficient for nitrogen in manure (Van Dijk, 2003). For sugar beet and seed onion in organic farming, the manure should be supplied in autumn in order to have a good start for the crops at the beginning of the season. This means that the working coefficient for nitrogen from manure will be lower.

3.2.7. Environmental policy

In the Netherlands, environmental regulation has existed for a number of years. The relevant regulations for arable farming are Dutch Mineral Accounting System (MINAS) and Manure Transfer Agreement System (MTAS) regulations. MINAS focuses on the restriction of nutrient surpluses within the farm, specifically nitrogen and phosphate, and states an acceptable level of surplus at the hectare level (100 kg N and 25 kg P_2O_5 in year 2002). The total acceptable surplus at farm level is subtracted from the actual total surplus which leaves the unacceptable surplus. The farmer has to pay a levy in Euro kg^{-1} of unacceptable surplus, which is 2.3 Euro kg^{-1} in the case of nitrogen and 9 Euro kg^{-1} in the case of phosphate (MANMF, 2004). MTAS sets a limit to the amount of manure that can be used on the farm. This limit is based on N content and is 170 kg N from manure per ha.

The models include a number of rows that register the losses of nitrogen, phosphate and potassium to the environment. Real nutrient balances at farm level calculate the total amount of nutrient input and output, and consequently, total nutrient losses. Input comes from seeds, fertilizer, in the conventional case, manure and N-fixation. Output is the amount of nutrient content in the crop, which leaves the farm.

In the case of MINAS the input and output calculation is different from the real nutrient balance calculation. In MINAS N-fixation and the nutrient output by crops are based on standards. N-fixation for kidney beans amounts to 30 kg ha^{-1}, for green pea 50 kg ha^{-1}, for alfalfa 160 kg h^{-1} and for grass-clover no nitrogen fixation is calculated. For nutrient output MINAS uses a standard of 165 kg ha^{-1} for N and 65 kg ha^{-1} for P_2O_5 for all crops excluding alfalfa and grass-clover, where the standard is 5.8 kg N, 1,4 kg t^{-1} P_2O_5 and 5.9 kg N, 1,4 kg P_2O_5 ton^{-1} of dry matter content, respectively (MANMF, 2004). Compared with the real nutrient balance calculation MINAS does not include phosphate fertilizer input and the input coming through the deposition and seeds for cropping. In the models both real and MINAS nutrient balance calculation is included in order to analyze the differences at farm level.

3.2.8. Organic matter

Organic matter input to the farm is important in order to maintain the organic matter content of the soil. Both models calculate the organic matter input at soil level. Crop residues left on the field are also calculated as input. This is not as a restriction in the model, but just a simple input calculation in both cases in order to know how much the difference is between conventional and organic farming in the input of organic matter to the soil.

3.2.9. Pesticides

The amount of pesticides used for the protection against weeds, pests and diseases is calculated in active ingredients (a.i.), which is the weight of the toxic substance in the applied product in kilograms. In the model, the use of pesticides is calculated only for conventional products, because for organic production any use of synthetic chemical inputs is prohibited. Non-synthetic pesticides are allowed in organic farming but due to its occasional use in practice it is not included in the calculation of crops gross margin. The data for pesticide use on each crop at hectare level were collected from KWIN (2002). There is an additional row, which calculates the total pesticide purchase at farm level.

3.2.10. Fixed costs

The fixed costs, excluding labour costs, for a 48 ha farm in the central clay region are calculated separately from the LP model (Table 3.4). Given input factors such as the size of the farm, basic machinery, buildings and other costs standardized costs are calculated for this specific region from the results of real farms (Wijnands & Dekking, 2002a; Wijnands & Dekking, 2002b).

Table 3.4 Fixed costs (Euro year^{-1}) for a 48 ha farm in the central clay region, excluding labour

Fixed costs	Conventional	Organic
Fixed machinery	32912	31716
Land	26608	26608
Buildings	38392	44928
Other costs	4512	6174
Total fixed costs	102424	109426

The fixed costs, excluding labour, are 102 424 Euro year^{-1} in case of a conventional farm and 109 426 Euro year^{-1} in case of an organic farm. The costs include the cost of land, buildings, fixed machinery and other costs such as maintenance of ditches as contract work and other general costs per farm. The difference between these two farm setups comes from basic differences in cropping plans between conventional and organic farming, different machinery settings, e.g. no use of chemical equipment in organic farming, and other building requirements, e.g. storage.

3.3 Results

In order to compare conventional and organic farming under current policy and environmental regulations in the Netherlands, three situations are analysed and compared using the same example farm. There are two optimal situations calculated for the example farm using the conventional farm model (3-year and 4-year crop rotation) and one using the organic farm model (6-year crop rotation). Technical, economic and environmental results of these situations are analysed and compared.

3.3.1 Technical results

The optimal production plans for conventional and organic farm models in 3-year, 4-year and 6-year crop rotation plans are presented in Table 3.5. In all three situations seed onion is produced on the maximum area because of its high gross margin. Seed potato also has high gross margin per hectare but, because of its higher labour need compared to ware potato, and due to the total household labour limit (2255 h year^{-1}), in both conventional situations seed potato is produced only on a part of the potato grown area. The rest is occupied by less labour intensive ware potato. Furthermore, rotation restrictions on root crops (75 and 50% in the conventional and the organic case, respectively) and on individual crops determine the cropping plan.

Table 3.5 Optimal production plan of conventional and organic farms for 3-year, 4-year and 6-year crop rotation plans

Crops	Area (ha)		
	Conventional		Organic
	3-year rotation	4-year rotation	6-year rotation
Conventional/Organic			
Winter wheat	16.0	12.0	0.0
Seed potato	6.9	8.3	8.0
Ware potato	9.1	3.7	0.0
Sugar beet	0.0	4.8	0.0
Seed onion	9.6	9.6	8.0
Carrot	6.4	9.6	8.0
Organic			
Spring wheat	-	-	8.0
Kidney bean	-	-	8.0
Green pea	-	-	8.0
Total area	48	48	48

In organic farming, more crops are included in the rotation than in the conventional case due to the 6-year rotation requirement in organic farming. Organic carrot, next to the organic seed potato and seed onion, also occupies the maximum amount of area restricted by the individual rotation constraint and together by the root crops rotation constraint. Besides these three crops, cereals (spring wheat) and legumes (kidney bean and green pea) are also taking part in the optimal production plan. Kidney bean and green pea are also constrained by the individual crop rotation. Legumes have lower gross margins compared to the organic root crops but they supply additional nitrogen as an input to the farm, which leads to a smaller manure purchase for the farmer. Spring wheat is the less profitable crop in the rotation and it occupies the rest of the land area on the farm.

Technical results on labour use, nutrient application, organic matter input and pesticide use in conventional and organic production can be seen in Table 3.6. The labour requirement is much higher in the case of organic farming than in conventional situations. Especially the amount of unskilled hired labour is quite different in these two farming systems, mainly because of weed control by hand in organic farming. From organic crops, seed onion and carrot require the most labour, mainly during the summer time. This amount is around 320-340 h fortnight^{-1} and 250-280 h fortnight^{-1} for seed onion and carrot, respectively. By adding up all the labour needs in the summer period for all the crops grown, the total labour requirement is around 660-800 h fortnight^{-1}. This means that in this period at least 7-8 additional units of labour with 80 h fortnight^{-1} are needed, next to the family labour with 158 h fortnight^{-1}. In the conventional situation 1 additional labour unit is required at a maximum during the whole year of production.

Table 3.6 Optimal resource use in conventional and organic farming

Resources	Conventional		Organic
	3-year rotation	4-year rotation	6-year rotation
Labour use (h)			
Total	2541	2667	6277
Fertilizer purchase (kg)			
N	3652	2580	0
P_2O_5	1920	2688	0
K_2O	3616	4752	0
Manure purchase (t)			
Poultry	268	268	139
Organic matter input (kg ha^{-1})	1149	1089	1197
Pesticides use (kg a.i.)	130	126	0

The results for nutrient supply in the conventional situation show that besides poultry manure, fertilizer is also applied. In both conventional situations the applied manure is limited to 268 t farm^{-1} due to MINAS restriction in the model. Phosphate surplus is limited to 30 kg ha^{-1}, above that tax should be paid. The additional need of nutrients is supplied by fertilizer. In organic farming only poultry manure is used. The total amount of nutrient application is lower than in the conventional case. This is due to the more extensive farming system, N-fixing crops and green manure crops used in the organic rotation.

To be able to compensate for the yearly decomposition of organic-matter, 1500 to 2000 kg ha^{-1} of effective organic matter should be supplied (Dekker, 2004). Effective organic matter is the amount of organic matter which is still present after 1 year. Organic matter input to the soil in the conventional situation is much lower. In organic farming the input level is slightly higher due to crop residues and green manure that are left on the field after harvest of the main crop. But this amount is still below the recommended level. Pesticide is used only in the conventional case, because in organic farming no chemical pesticides are permitted.

3.3.2 Economic results

The economic results (Table 3.7) follow from the technical results. The revenue of the farms comes from the sales of crops and crop residues, i.e. straw. Although, the yields are lower in organic farming, the higher prices for organic products are resulting in higher returns from organic crop production compared to that in conventional situation.

Table 3.7 Optimal resource use in conventional and organic farming

Component	Economic results (Euro year^{-1})		
	Conventional		Organic
	3-year rotation	4-year rotation	6-year rotation
Revenue			
Returns from crops	263118	291664	358609
Costs			
Costs of crop production	124839	153526	141252
Hired labour	5049	6606	41992
Manure and fertiliser	5346	5508	1894
Total variable costs	135234	165640	185138
Gross margin	127884	126024	173471
Gross margin (Euro ha^{-1})	(2664)	(2625)	(3614)
Fixed costs	102424	102424	109426
Family labour income	25460	23600	64045
Family labour income (Euro ha^{-1})	(530)	(492)	(1334)

The costs of organic crop production are approximately the same as in conventional farming. Important cash crops such as seed potato and seed onion have lower, but other crops such as carrot have higher production costs than in the conventional situation. In organic farming the cost of hired labour is about seven times higher than in conventional farming, but the costs for manure and fertilizer are lower due to the more extensive farming and no fertilizer use.

The difference between the returns and variable costs is higher in organic farming than in conventional situations. This difference leads to higher gross margin in organic than in conventional farming. Given the fixed costs, which are slightly higher in organic farming, a family labour income which results is considerably higher in organic farming.

3.3.3 Environmental results

Nutrient balance and losses of nitrogen and phosphate in kg ha^{-1} in both organic and conventional situation are shown in Table 3.8. Real nutrient surplus is calculated as the difference between total nutrient input by manure, fertilizer, seeds, deposition and N-fixation at farm level and output with each crop from the farm. For MINAS, input via manure, nitrogen fertiliser and N-fixation is calculated. For MINAS output standards of 165 kg ha^{-1} N and 65 kg ha^{-1} P_2O_5 are used.

Analysing the real nutrient balance in all three farm situations shows that for the organic farm the nitrogen input is lower than in both conventional farm situations. This is mainly due to the lower amount of manure purchase and no fertilizer use in organic farming. The nitrogen output is also lower in the organic situation. This leads to a lower nitrogen surplus in the case of organic farming compared with both conventional farm situations. In the case of phosphate in organic farming, the input and output are both less than in both conventional situations. The amount of phosphate surplus is about one third of that of conventional. The lower nutrient surpluses in organic farming show a better environmental result compared to conventional farming.

Table 3.8 Nutrient balance in conventional and organic farming

	Nutrient balance (kg ha^{-1})					
	Real balance			MINAS balance		
	Conventional		Organic	Conventional		Organic
	3-year rotation	4-year rotation	6-year rotation	3-year rotation	4-year rotation	6-year rotation
Nitrogen						
Input	276	253	168	246	224	105
Manure	170	170	88	170	170	88
Fertilizer	76	54	0	76	54	-
Seed	5	4	5	-	-	-
Deposition	25	25	25	-	-	-
Fixation	-	-	50	-	-	17
Output	161	146	73	165	165	165
Surplus	116	107	95	81	59	-60
Phosphate						
Input	138	154	53	95	95	49
Manure	95	95	49	95	95	49
Fertilizer	40	56	0	-	-	-
Seed	1	1	2	-	-	-
Deposition	2	2	2	-	-	-
Output	56	56	26	65	65	65
Surplus	82	98	27	30	30	-16

Comparison of real and MINAS nutrient balances shows that in the case of nitrogen MINAS calculates lower input for all three farming situations. Analysing the nitrogen output from the farm shows that MINAS is overestimating the nitrogen output due to the use of a standard output for all types of crops. In all three farming situations for nitrogen no unacceptable surplus arises according to MINAS.

In the case of phosphate, the MINAS system calculates lower input, it does not include phosphate from fertilizer purchase, and overestimates the amount of output, especially in organic farming. In both conventional situations the amount of manure is limited by MINAS. A maximum 30 kg ha^{-1} surplus is allowed, above this amount nutrient tax is charged to the farmer for every extra kilogram of surplus. In this situation it is more profitable to apply artificial fertilizer to fulfil the nutrient requirement of the grown crops. In general the real nutrient surpluses in conventional farming are higher than that calculated by MINAS.

3.3.4 Sensitivity analysis

The stability of the optimal plan of the model follows from the analysis of shadow prices in the model output results and by making sensitivity analyses. Shadow prices of different crops show by how much crops not currently in the optimal plan should be more profitable in order to get into the optimal production plan of the model. The resulting shadow prices show that the revenues from crops that are not in the optimal plan should be substantially higher in order to be included in the optimal production plan. This is concerning all three farming situations.

The shadow price of land in the organic farming model shows that if the farmer has one more hectare of land then his/her income will increase by 3401 Euro. In the case of conventional farming this shadow price is 2604 Euro and 2559 Euro for 3-year and 4-year rotations, respectively. In reality, rent of an extra hectare of land is less than 1000 Euro, which means it would be profitable to get some additional area for cultivation if available. These results also show that the land is one of the strongest constraints in the model.

Sensitivity analysis of the wage for hired labour show a slight effect on the cropping plan of both conventional farm situations. By decreasing the unskilled labour wage, more hectares of seed potato get into the optimal plan instead of ware potato. Seed potato is more labour intensive and has higher gross margin in Euro ha^{-1} than ware potato. The increase of labour wage has the opposite effect on the cropping plan. In the organic situation a decrease of unskilled labour wage has no effect on the optimal cropping plan, but an increase brings more hectares of cereals instead of carrot into the production plan. From shadow prices and sensitivity analysis we can conclude that changes in prices and production parameters do not have much effect on the optimal production plan.

3.4 Discussion and outlook

Representative results from organic farming in practice are only available for recent years, as organic farming on a large scale is a recent phenomenon. Representative results from 1999-2002, published by the Agricultural Economics Research Institute (2003), show that income from organic arable farms is higher than from conventional arable farms. The difference varies from some 30000 Euro in 2001 to only some 2000 in 2002. This is considerably smaller than the difference resulting from the model calculations. Detailed results show that prices of crops vary considerably over the years, both for conventional and organic farming. Furthermore, especially with regard to organic farming, the average cropping plan in practice differs considerably from the cropping plan in the model results. In practice the area of crops with high profit, and probably high risk, is lower than in the model results. A final reason for the smaller income difference between the practice and the model of organic farming is its smaller scale. In 2002 the average organic arable farm in the Netherlands used 41 ha, whereas the average conventional farm used 46 ha.

The conclusion that organic farming is more profitable than conventional farming follows also from studies carried out in other European countries and the United States, which show higher revenues and lower variable costs in organic production. (Langley at al., 1983; Van Mansvelt & Mulder, 1993); Stockdale *et al*., 2001; Mahoney *et al.*, 2004). From this the question arises: why do not more farmers convert? The answer to this question has to do with a number of factors. Factors influencing the economic performance of the farm like the financial difficulty of the conversion period from conventional to organic farming, the need for more hired labour in organic production, the risk and uncertainty of yields and market prices during and after conversion (Van Mansvelt & Mulder, 1993; Lampkin & Padel, 1994). Besides these economic factors social pressures (i.e, community peer pressures, intergenerational pressures), institutional pressures (i.e. banks, landlords), learning process on the part of the farmer and ideological aspects can also be important factors that hamper conversion (Padel, 2001; Schifferstein & Ophuis, 1998; Lampkin & Padel, 1994). In this discussion the focus is on factors related to economic performance of the farm.

3.4.1 Conversion period

The conversion period is one of the main problem for the farmer wanting to convert to organic farming (Sparkes *et al*., 2003). It takes 2 years, during which crops must be grown in an organic way but can be sold only at conventional product prices. During this period also a lot of changes investments and disinvestments are needed which can cause financial problems for the farmer. Longer rotations with fewer cash crops, a basis for organic management, means that especially in the conversion period income problems can arise (Van Mansvelt & Mulder, 1993). The effect on income of conversion to organic production depends also on the farm type and location. Extensive farms in marginal regions are more likely to benefit from conversion than intensive farms in fertile regions (Dabbert *et al*., 2004). According to some research in the Netherlands (Hoorweg, 2002), the payback time after conversion to organic arable farming depends on the farmers' initial situation. Farmers with short crop rotations (3-year) have a longer payback period then those who have longer (4-year or 5-year) crop rotations. This is because more specialized farms have to invest more, especially in machinery, to convert to more extensive 6-year organic crop rotation.

3.4.2 Hired labour

In organic farming the labour need is much higher than that of conventional farms. Problems mainly arise from the willingness of farmers to work with more employees on the farm. The organization also requires more skills of the entrepreneur. In some regions, where there is a lot of organic farming or other labour intense crops, the availability of labour can also be a problem. This is mainly because of the low skill requirements and the usually boring work, mainly by hand, which must be done on organic farms, i.e. weed and pests control, harvesting by hand. The willingness of people, even schoolchildren, to do this kind of work is quite low (De Wolf & De Wolf, 2004).

3.4.3 Yield and price risk

In the Netherlands the yield risk of organic farming is usually higher than that of conventional farming (LEI, 2004; Van Bueren *et al*., 2002). This is due mainly to a lower nitrogen-input and in some cases to pests and diseases (Van Bueren *et al*., 2002). A 50% less yield in organic farming for a cash crop such as seed potato would bring down the labour income from 64040 to 25560 Euro farm^{-1} year^{-1} in organic farming, which is close to the labour income level of conventional farming. The fact that yields in organic agriculture fluctuate much more than in conventional systems according to Van Bueren *et al*. (2002) has been considered one of the most important factors that limits the growth of the organic market share. However, according to Lamkin & Padel (1994) the conclusion that organic yields fluctuate more than in conventional systems is not certainly a 'fact', there is evidence the opposite direction.

Uncertainty about the organic market access is a problem which can inhibit farmers from converting to organic farming. Prices fluctuate considerably due to organic market conditions such as the small-scale and the immature nature of the organic market and the lack of government intervention to stabilise prices (Lampkin and Padel, 1994). If, after the conversion period, farmers cannot sell their products as organic for higher prices, after they have produced it in an organic way, their income would also drop considerably. At the moment in The Netherlands the market for some organic products is saturated. Lately, many farmers have converted to organic farming and there is now overproduction, meaning that they cannot sell their products at organic prices as assumed in our organic model, but only at lower prices. Lower prices make organic farming less attractive. Model calculations showed that if organic farmer would get conventional prices for all his organically produced products then the labour income would decrease to -72312 Euro instead of 64040 Euro, with seed potato (8ha), sugar beet (8ha), seed onion (8ha), spring wheat (12 ha) and alfalfa (12 ha) in the crop rotation

Considering all the above mentioned factors influencing conversion to organic production further research is needed in order to study the decision to convert from conventional to organic farming. The factors mentioned in the discussion should be taken into account while studying the decision. A static comparison of the two farming systems may lead to unrealistic conclusions about the decision to convert as it ignores important factors, such as conversion process and uncertainty of future yields and future market prices.

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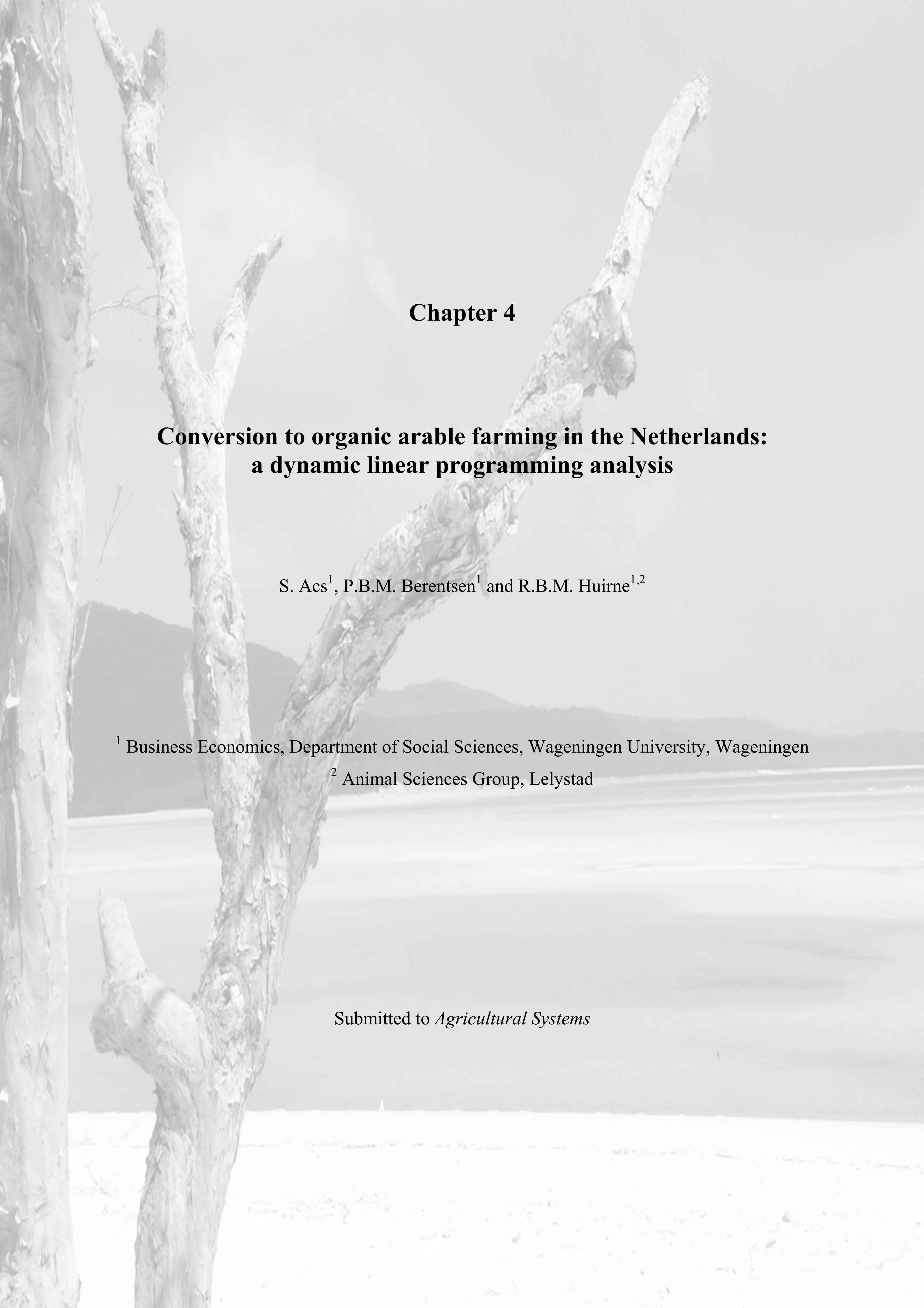

Chapter 4

Conversion to organic arable farming in the Netherlands: a dynamic linear programming analysis

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Abstract

Several studies show that organic farming is more profitable than conventional farming. However, in reality not many farmers convert to organic farming. Policy makers and farmers do not have clear insight into factors which hamper or stimulate the conversion to organic farming. The objective of this paper is to develop a dynamic linear programming model to analyse the effects of different limiting factors on the conversion process of farms over time. The model is developed for a typical arable farm in the Netherlands central clay region, and is based on two static liner programming models (conventional and organic). The objective of the model is to maximise the net present value over a ten-year planning horizon. There are three phases in the model: conventional, conversion and organic farming. The solution of the model provides a decision strategy for the farmer for the whole planning horizon for each year. It provides the optimal cropping plan, labour allocation, nutrient and pesticide purchase, nutrient losses, organic matter input, and information on production costs and revenues. It shows whether partial or complete conversion, one-step, or stepwise conversion is more profitable. The results of the analysis of a basic scenario show that conversion to organic farming is more profitable than staying conventional. In order to arrive at the actual profitable phase of organic farming the farmer has to pass through the economically difficult two-year conversion period. Sensitivity analysis shows that if depreciation 25% higher than conventional fixed costs occurs due to machinery made superfluous by conversion, conversion is less profitable than staying conventional. Also the availability of hired labour, which can be constrained in peak periods, has a strong effect on the cropping plan and the amount of area converted. Further analysis shows that a slight drop (2%) in organic prices lowers the labour income of the farmer and makes conversion less profitable than conventional farming. For farmers a minimum labour income can be required to 'survive'. The analysis shows that constraint on minimum labour income makes stepwise conversion the best way for farmers to overcome economic difficulties during conversion.

4.1 Introduction

One of the policies of the Dutch government is to increase the area of organic production. However, there is a great lack of information among policy makers and farmers on the economic potential of organic arable production in the Netherlands. Analysing conventional and organic arable farming systems separately has resulted in many studies showing that organic farming in several cases is more profitable than conventional farming (Eltun *et al.*, 2003.; Mahoney *et al.*, 2004; Acs *et al.*, 2006). But, actually, not many farmers are converting organic farming system. In Acs *et al.* (2006) several factors were mentioned that might influence the decision of farmers to convert to organic production. In this study the focus is made on factors influencing the economic performance of the farm such as financial difficulty in the conversion period due to lack of access to premium prices, investment costs of new machinery/buildings and extra depreciation costs for subsequently unused fixed capital (disinvestment); effect of the "learning curve": information-gathering costs of starting organic production and marketing, and consequent lower revenues due to management inefficiency (lower yields) in the first years of conversion; labour availability constraint in peak periods due to the greater labour requirement in organic farming; risk associated with future yield and market price uncertainty for organic products. All these reasons are well known, but not many studies have examined the actual extent to which they can affect the conversion decision.

Different modelling approaches have been used to study conversion, but the majority of normative studies have not included the time aspect in the model (Acs *et al.*, 2005). The inclusion of time is however important for two reasons. First, the conversion process from conventional to organic farming takes at least two years. Besides one-step conversion (conversion of all land area at once), farmers can also choose stepwise conversion. This gives farmers more time to adapt to the new production method and ensures income by still allowing production of conventional products next to the in-conversion products during the conversion period. The second reason for including the time dimension is to analyse the effect of different policy incentives before, during and after the conversion period.

Acs *et al.* (2006) analysed conventional and organic arable farming in the Netherlands from a technical, economic and environmental point of view. This study showed that in equilibrium states organic farming is much more profitable than conventional. The current paper includes in the model the conversion period between conventional and established organic farming. Consequently, the resulting dynamic linear programming model describes the conversion process of a farm over time. The model is presented and next, it is used to analyse different factors influencing the conversion as mentioned above, such as extra depreciation costs, hired labour availability, organic market price uncertainty and minimum labour income requirement.

4.2 Method

4.2.1. Model specification

In order to analyse the conversion from a conventional to organic farming system over time a Dynamic Linear Programming (DLP) model was developed for a typical arable farm in the central clay region of the Netherlands. The general structure of the dynamic linear programming model is summarised as follows (Hazell & Norton, 1986):

$$\text{Maximise}\, Z = \sum_t \delta_t \left[(c_t{}' x_t) - f_t \right], \quad \text{where } \delta_t = \left(1/(1+i) \right)^{t-1} \tag{1}$$

Subject to: $A_t x_t \le b_t$

and $x_t \ge 0$

where:

Z – discounted labour income

t – year [1, …., 10]

i – discount rate

x – vector of activities

c – vector of gross margins or costs per unit of activity

f – vector of fixed costs per year

A – matrix of technical coefficients

b – vector of right-hand side value

Activities and constraints are included in each period (year) for all the relevant decisions and many of them are duplicated from one year to the next (*e.g.*, annual crop activities). The link between the years is provided by the conversion of the land area and the objective function.

The planning horizon has been arbitrarily limited to ten years in order to examine the conversion process of the farm. Ten years is long enough not to influence the results of conversion – usually conversion is completed after 3-6 years (MacRae *et al.*, 1990). The conversion itself takes two years if the farmer decides to convert at once, but longer in the case of stepwise conversion. This means that in this planning horizon the farm will or will not (partially or completely) convert, depending on the sum of the discounted labour income calculated over the 10 years.

The activities in the model are production activities representing different crops, seasonal labour, purchase of fertiliser and manure, activities calculating nutrient surplus, organic matter input and pesticide use.

The constraints of the model are land availability, rotation restrictions, conversion restrictions, supply and demand of household and seasonal labour, nutrient balance calculation for MINAS (Dutch Mineral Accounting System) regulation, maximum manure input restriction for MTAS (Manure Transfer Agreement System) regulation, several counting rows for pesticide use and organic matter input to the farm.

There are some technical constraints on the dynamic aspect of the model. The first year in the model is restricted to conventional production only. This restriction was imposed in order to compare the conventional production plan with the conversion and organic production plan. From the second year on the model can convert to organic production. In case land goes into conversion, it will be so for two years, and then become organic land area. The model determines how much land should go from conventional into conversion. In the model the conversion is restricted to a one-way direction, excluding the possibility of converting back to a conventional system.

The objective function of the model is to maximise the sum of discounted labour income over the 10-year planning horizon, where the annual labour income is discounted to the 1st year. In the basic scenario we assume a 4% discount rate. Labour income includes revenues from crops produced, minus variable and fixed costs. Variable costs are direct crop-production costs (variable operations, pesticide use, energy use, contract work, marketing costs and other costs), costs of purchased nutrients (manure and fertilisers), hired labour costs and nutrient taxes. Fixed costs include costs of land, machinery and buildings.

The DLP model was built in GAMS (General Algebraic Modelling System) programming language and solved by the CoinCbc solver.

4.2.2. Input data for the model

Input data for the model was taken from a 48 ha typical conventional and organic arable farm in the central clay region of the Netherlands. This farm can produce conventional and organic crops. In the case that the farmer decides to produce in the conventional way he can choose from winter wheat, spring barley, ware potatoes, seed potatoes, sugar beet, onion, and carrot (see Table 4.1). In the case he decides to convert to organic farming he has to farm two years in the organic way and for conventional prices before he can receive organic prices, and the organically grown crops are the same crops as grown conventionally plus others such as spring wheat, winter barley, kidney bean, green pea, alfalfa, celeriac, and grass-clover during and after conversion (see Table 4.2). The latter crops are not included in the conventional plan because they are not produced conventionally in this region. Organically produced crops grown during the two-year conversion period are called “conversion crops”, and after conversion, “organic crops”.

Table 4.1 Yield, costs, revenues, labour and nutrient requirements of conventional crops per hectare per year (Source: KWIN, 2002)

Crops	Conventional					
	Revenue	Yield	Costs[1]	Labour need	Nutrient requirement	
	Euro	Ton	Euro	Hour	N (kg)	P_2O_5
Ware potato	5680	56.8	1681	26.4	255	120
Seed potato	7740	38.7	3245	95.3	125	120
Sugar beet	3344	65.5	1008	19.2	150	80
Seed onion	5256	58.4	1975	37.7	110	120
Carrot	12320	77.0	9450	29.3	80	120
Winter wheat	1797	8.7	484	10.4	210	20
Spring barley	1526	6.3	312	9.6	65	20

[1] Direct production costs - do not include the costs of nutrients and labour

All the individual crops and groups of crops have their own rotation constraints which are mainly agronomic. For conventional production 1:3 crop rotation is used for the whole land area, which characterises the region. For conversion and organic production 1:6 crop rotation is used. This more diverse crop rotation is a requirement of organic farming. An additional constraint is the requirement of legume crops in the organic rotation – a minimum 1/6 of the area cultivated. This restriction assures a minimum area in legume crops which contribute to soil organic matter, nutrient supply (nitrogen fixation) and improved yield in following organic crops (Power, 1987; Dabbert, S. & Madden, 1986). It is also suggested by advisors and commonly practised (Parr *et al.*, 1983; De Wolf & De Wolf, 2004).

Table 4.2 Yield, costs, revenues, labour and nutrient requirements of conversion and organic crops per hectare per year (Source: KWIN, 2002)

	Conversion	Organic	Conversion and organic				
Crops	Revenue	Revenue	Yield	Costs[1]	Labour need	Nutrient requirement	
	Euro	Euro	Ton	Euro	Hour	N (kg)[2]	P_2O_5 (kg)
Ware potato	2750	7150	27.5	2255	20.6	150	48
Weed potato	5200	9620	26.0	2226	77.1	50	47
Sugar beet	2558	4058	50.0	884	86.1	80	160
Seed onion	3150	8750	35.0	1284	316.5	50	43
Carrot	8800	18700	55.0	12450	185.7	40	57
Winter wheat	1246	1926	5.0	439	13.0	125	62
Spring barley	1241	1691	4.5	393	12.1	25	60
Winter barley	1046	1759	3.8	339	12.1	75	53
Spring wheat	1326	2176	5.0	415	13.5	75	62
Kidney bean	1505	2817	2.2	624	25.6	50	20
Green pea	1063	2763	4.3	658	22.5	10	25
Alfalfa	840	960	12.0	169	2.2	0	133
Celeriac	2450	8400	35.0	2666	134.9	140	74
Grass-clover	550	700	10.0	141	5.5	0	105

[1] Direct production costs - do not include the costs of nutrients and labour

[2] N-fixation by legumes is included separately as an input (kidney bean 100, green pea 200, alfalfa 528, grass-clover 160 kg/ha)

The model input data on conventional, conversion and organic revenues, costs, labour, nutrient and pesticide use per crop on clay soil were collected from the Quantitative Information Handbook (KWIN, 2002). This information (except on pesticide use) per crop per hectare is summarised in Table 4.1 and 4.2. The revenues from the crops are calculated by multiplication of crop prices and yield per crop. The direct costs of crop production include the costs of field operations (land preparation, planting/sowing, crop care, hand weeding and harvesting), costs of pesticide (in the conventional case) and energy use, and other costs such as interest, insurance and N-mineral sampling. These costs do not include the costs of nutrients and labour. For conversion crops, organic production yields, organic costs, labour and nutrient use and conventional crop prices were used.

Since most field operations on crops have to be performed during a certain period, the year is divided into periods of two weeks. The available amount of family labour is assumed to be 1.1 full-time labour (2255 hours per year), which is an average labour supply in this region for a 48-ha arable farm (De Wolf & De Wolf, 2004). The family labour supply per period is assumed to be constant over the year. In peak periods however household labour can supply a maximum of 158 hours per fortnight. Apart from family labour there is skilled and unskilled seasonal hired labour. Hired labour can be employed any time of the year for different field operations (land preparation, planting/sowing, crop care, hand weeding and harvesting). There are operations which need more qualified labour (skilled labour), while for others unqualified labour (*i.e.*, youth, students) can also be used. Household labour is assumed to be skilled. Some operations require at least two persons working at the same time, which results in a minimum constraint on the hired labour needed for skilled and unskilled labour. The costs of hired labour differ: 18 Euro/hour is paid for skilled and 9 Euro/hour for unskilled labour (CAO, 2002).

In general organic crops require significantly more labour than conventional crops, mainly due to the greater amount of work done by hand (*i.e.*, weed control, pest control, harvesting by hand) increased crop supervision etc. However, some crops such as seed and ware potato need less labour in organic production, since hand weeding is less work than chemical application. This greater labour demand also means more general work for farmers, i.e. maintenance of machinery, fields, administration: 1120 hours per farm in conversion and organic production years compared to 800 hours in conventional farming (Schoorlemmer & Krikke, 1997; De Wolf & De Wolf, 2004). In the basic scenario it is assumed that the availability of hired labour is unrestricted, and that there is no additional need for the family labour to get extra information/education concerning organic production methods, which requires more time and costs during the conversion period (no “learning curve” effect).

The fixed costs, based on those of a farm in this region with a 48-ha land area – basic machinery, buildings and typical cropping plans – are calculated separately from the LP model. These costs are related to the type of farming: conventional fixed costs (102424 Euro/year) are valid for conventional production and organic fixed costs (109426 Euro/year), for conversion and organic production years (Wijnands & Dekking, 2002a, Wijnands & Dekking, 2002b). There was no distinction made between conversion and organic fixed costs because fixed costs mainly depend on the production method used and the average cropping plan on the farm. In this case, in both conversion and organic production, the organic production method is applied.

In order to convert to organic farming farmers have to adjust their technology to the new production system and invest in new machinery/buildings. Machinery made superfluous by conversion can cause disinvestment if there is little or no possibility of selling them. In the basic scenario however is assumed that no disinvestment takes place.

More detailed information concerning input data on rotation constraints, household labour use, fixed costs, nutrient balance, and organic matter input in conventional and organic production methods can be found in Acs *et al*. (2006).

4.2.3. Model output

The solution of the model provides a decision strategy at the farm level, including the number of hectares of each crop to be grown every year, and how many hectares to convert in the case of conversion. Next to the optimal production plan it provides information on labour allocation, nutrient and pesticide purchase, nutrient losses, organic matter input to the farm and the economic consequences of production.

4.2.4. Input data for the model

First, calculations are made for the basic scenario as discussed in the previous sections. Next, a sensitivity analysis determines the effects of some additional limiting factors on the results by means of parametric programming. In this analysis the break-even point, farm conversion or non-conversion, and the type of conversion (partial or complete, and one-step or stepwise) is determined.

Disinvestment

The assumption was made that, in the basic scenario, no disinvestment occurs during conversion from conventional to organic farming. With disinvestment the farmer has to calculate an extra depreciation cost, which means an increase in fixed costs during the years after switching to organic production. To investigate the effect of extra depreciation costs on the farmer's labour income and on the decision whether to convert or not to organic farming a new scenario is analysed, called "disinvestment". In this scenario an extra depreciation cost for the conversion years (two years after the switch) were applied. The break-even point is determined by a stepwise increase in the extra depreciation costs.

Hired seasonal labour availability

In the basic model no limit on hired-labour availability was assumed. In some regions (with a lot of organic farming or other labour-intense activities) the availability of labour can be a problem, mainly because of the low skill requirements and the usually boring work (done mainly by hand) on organic farms. In order to analyse the effect of the seasonal labour availability in the region, the hired-labour availability is stepwise increased per fortnight. This new scenario is called the “hired-labour limit”.

Lower organic prices

In the basic scenario it was assumed that the farmer gets higher prices for organic products than for conventional, and that the prices are certain. However, in practice, organic market uncertainty and price risk is an important factor in the decision to convert or not. In order to analyse how a drop in prices (*i.e.*, the farmer cannot receive higher organic prices) would influence the conversion, a “lower organic price” scenario is tested. The prices of organic products are decreased stepwise.

Minimum labour income requirement

In the basic set-up of the model, we assumed no minimum labour income requirement for the whole planning horizon. However financial difficulty during conversion to organic farming can be substantial due to lower yields and higher costs. To test this, a minimum bound is set for the labour income for each year. In order to find the break-even point at which the farmer switches to organic production, this minimum bound is increased stepwise. This scenario is called “minimum labour income”.

4.3 Results of the DLP model

The results of the basic model are described as follows. First, the optimal cropping plan from the model is presented. Second, the technical results (such as labour, nutrients and pesticide use) are analysed. Third, economic results are examined. Next the results of the sensitivity analysis are presented. The environmental results of the conventional and organic farming as such are described in Acs *et al*. (2006).

4.3.1 Optimal cropping plan

The optimal cropping plan of the farm over a 10-year planning horizon can be seen in Table 4.3. The optimal strategy for the farm would be to convert the whole land area to organic production in the second year (the first year is fixed as conventional). This means two years of cultivating organically for conventional prices. Afterwards the farmer gets organic prices for organic production.

Table 4.3 Optimal production plan of the farm over 10-year planning horizon (ha/year)

Crop	Year		
	1	2-3	4-10
Conventional			
winter wheat	16	-	-
seed potato	6.9	-	-
ware potato	9.1	-	-
seed onion	9.6	-	-
carrot	6.4	-	-
Conversion			
spring wheat	-	16.0	-
seed potato	-	8.0	-
seed onion	-	4.0	-
sugar beet	-	12.0	-
alfalfa	-	8.0	-
Organic			
spring wheat	-	-	8.0
seed potato	-	-	8.0
seed onion	-	-	8.0
carrot	-	-	8.0
kidney bean	-	-	8.0
green pea	-	-	8.0

In the first conventional year, winter wheat, seed potato, ware potato, seed onion and carrot are produced in a three-year crop rotation. Seed potato and seed onion brings the highest gross margin compared to other conventional crops. Seed potato is produced only on a part of the potato area cultivated because of its need for more labour than ware potato and the total household labour limit of 2255 h/year. The rest is occupied by the less labour-intensive ware potato. Seed onion is grown on the maximum land area constrained by the rotation restriction. Furthermore, rotation restrictions on root crops (75% and 50% in the conventional and the organic case, respectively) and on individual crops determine the cropping plan. On the rest of the area the economically less attractive carrot and winter wheat are grown.

In the second year, according to the model, the farm converts at once and the crops are cultivated organically. During the two years of conversion a different cropping pattern is planned, with spring wheat, seed potato, seed onion, sugar beet and alfalfa, an optimal plan for the farmer from the economic point of view. The differences, compared to the conventional cropping plan, consist in the crop rotation restrictions, which are 1:6 (as in organic years) instead of 1:3, the minimum legume requirement of 1/6 of the area, the lower yields, conventional prices, and the difference in the costs of production for the same types of crops (see Table 4.3).

After the two years of conversion higher prices are available for organically produced crops. This is the main difference between conversion-year crops and crops produced in the organic year. In the organic year carrot and green pea are produced instead of sugar beet. Carrot and green pea are included in the rotation in organic years because of the higher gross margin for them compared to sugar beet.

In a comparison of the DLP model results with static LP results from Acs *et al.* (2006), the conventional first-year results and the organic-year results of the DLP model are the same as the results from the static LP model for conventional and organic farm, respectively.

4.3.2 Technical results

The output of the model shows that the household labour is fully used in the whole 10-year planning horizon. In conversion from conventional to organic farming there is an increase in the labour demand because of the more diverse crop rotation, greater amount of manual work and general work during the organic production years. In conversion years seed onion, even with the lower production area, requires 2-3 times more labour in the summer period than in the conventional year. The new crop, sugar beet, also requires more labour. In organic years next to carrot (which increases from 4 to 8 ha) seed potato is the most labour-intensive crop. Both crops need the most labour during July and August due to mechanical weed control.

Figure 4.1 shows the skilled and unskilled labour requirements over the years. In conversion years less skilled labour is needed for crops such as sugar beet, kidney bean and spring wheat than in the conventional year. In organic years more, mainly unskilled, labour is required by crops such as seed onion and carrot: around 320-340 hours and 250-280 hours per fortnight in peak periods for seed onion and carrot, respectively. By adding up all the labour needed in the summer period for all the crops grown, the total labour requirement is around 660-800 hours per fortnight (Figure 4.2). This means that in this period at least 7-8 additional units of labour (one unit is 80 hours per fortnight) are needed, next to the family labour (158 hours per fortnight). By comparison, in the conventional production year only one additional labour unit at most is required during the whole year of production.

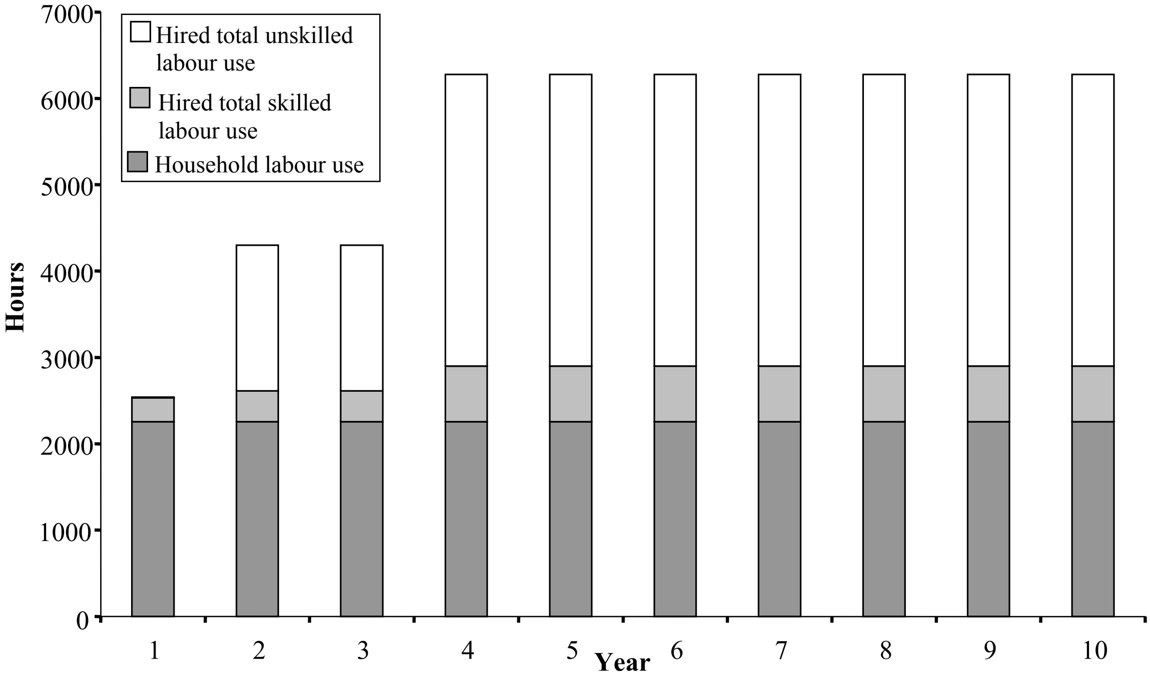

Figure 4.1 Total labour use before, during and after conversion

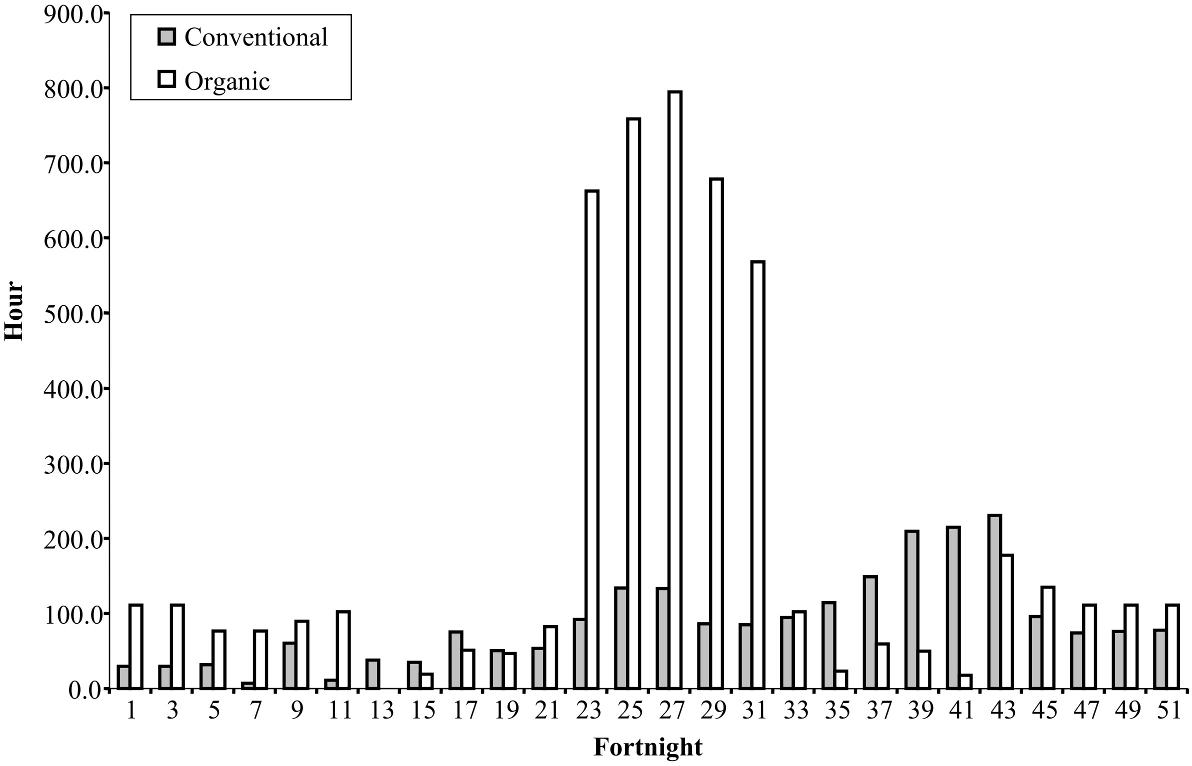

Figure 4.2 Labour use per fortnight (14 days) in conventional and organic farming

The optimal allocation of nutrient as fertiliser and manure, and pesticide for the 10-year planning horizon per year can be seen in Table 4.4. In conventional and conversion years manure purchases are greater than in organic crop rotation, due to the different cropping pattern. Pesticide use is not allowed in organic farming.

Table 4.4 Optimal allocation of nutrients and pesticide for the 10-year planning horizon

	Unit	Year		
		1	2-3	4-10
Nutrients				
Fertiliser				
N	kg	3652	0	0
P_2O_5	kg	1920	0	0
K_2O	kg	3616	0	0
Manure				
Poultry	t	268	246	139
N	kg	8181	7504	4240
P_2O_5	kg	4560	4183	2363
K_2O	kg	6035	5536	3128
Organic matter				
Organic matter input	kg	55175	62257	57470
Pesticide				
Pesticide level	kg a.i.	130	0	0

4.3.3 Economic results

The economic results (Figure 4.3) show that organic crop production brings two times more labour income than conventional production. In light of this most farmers would probably convert to organic, if not for the attendant economic challenge posed by the two-year conversion period with lower yields at lower, conventional prices and consequent negative labour income. Farm revenue comes from sales of crops grown on the farm. In the conversion years revenue is much lower than that of conventional and organic years, because of the different cropping plan, lower (organic) yield and conventional prices during the two years. Although yields are lower in organic farming, the higher prices for organic products after conversion result in higher returns from organic crop production in comparison to returns in conventional and conversion years.

Farm variable costs refer to the direct costs of crop production (see Table 4.1 and Table 4.2), as well as costs of hired labour, manure and fertiliser purchases. In the conversion years variable costs are two times lower than in conventional years. The lower variable costs in conversion years result from “cheaper” crops grown in this period, *i.e.*, the lower revenues from these crops. The higher variable costs in organic years after conversion come from cultivation of carrot instead of sugar beet, and of other legumes such as kidney bean and green pea, which are more expensive to grow than alfalfa. The variable costs in organic years are approximately the same as in conventional farming. In organic years important cash crops such as seed potato and seed onion have lower, but other crops such as carrot bring higher production costs than in the conventional situation.

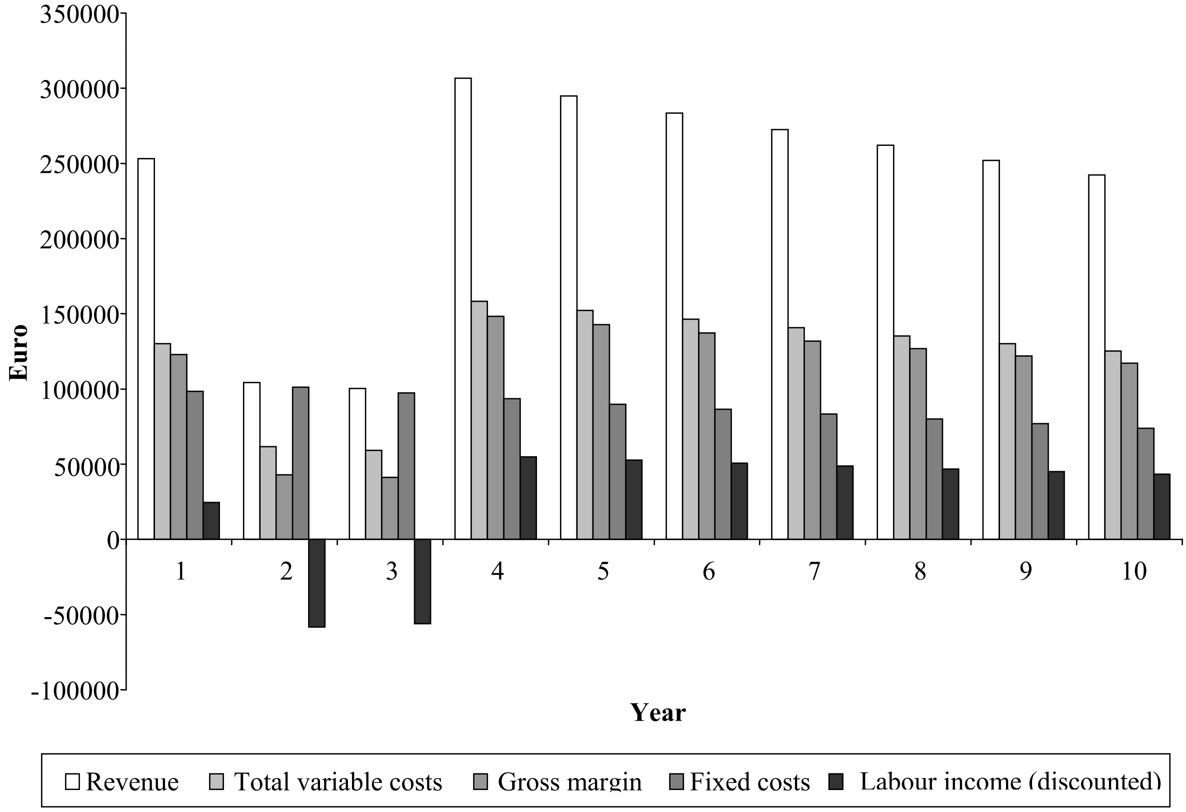

Figure 4.3 Economic results from the DLP model at 4% discount rate

In the conventional year 92% of the variable costs are direct costs of crop production, and only a small amount is for hired labour and nutrient purchase, while in the conversion and organic years this figure is 62% and 76%, respectively. In these years 32% and 23% of the costs are for hired labour and the remaining few percent, for nutrient purchase. These differences are explainable by the omission of pesticide use, which lowers the direct costs of crop production, and the greater labour requirement in organic farming. The costs of manure and fertiliser are lower due to the more extensive farming and the total omission of chemical fertilisers in organic production.

From the economic results the payback period for organic conversion (the time needed to repay initial investments) (Barry *et al.*, 2000), can be calculated. In this case it is the number of years required to repay the costs of conversion by growing organically instead of conventionally. In the current situation this period is 8 years from the moment of the switch to organic farming.

4.3.4 Sensitivity analysis

Sensitivity analysis was used to determine the effects of four limiting factors on the basic model results by means of parametric programming. In this analysis the break-even points, whether the farm converts or not, and the type of conversion (partial or complete, and one-step or stepwise) were determined. The main results can be seen in Table 4.5.

Table 4.5 Ranges in different types of conversion for four different situations

Break-even points	Disinvestment	Hired-labour limit	Lower organic price	Minimum labour income
	% of conventional fixed costs	hour/fortnight	% reduction	Euro
Complete conversion (basic)	0 - 25%	≥ 400*	0 - 2%	≤ -20000**
Partial conversion	-	160 - 400	-	-20000 to 0**
No conversion	≥ 25%	0 - 160	≥ 2%	≥ 0

*cropping plan differs from the basic situation
**stepwise conversion

The first limiting factor in the analysis is called “disinvestment”. Extra depreciation was assumed to last for two years after the switch to organic farming. If the extra depreciation cost is between 0-25% of the conventional fixed costs, then complete conversion takes place. The results differ from the basic scenario only in the amount of discounted labour income, which falls as extra depreciation costs rise. If the extra depreciation cost is higher than 25% of the conventional fixed costs, then there is no conversion to organic farming. In the case of conversion, only one-step and complete conversion takes place.

The second limiting factor in the analysis is called “hired-labour limit”. In this scenario a restriction was put on hired-labour availability per fortnight in hours. The basic scenario remains unchanged when the hired-labour availability is higher than 640 hours/fortnight, that is, 8 labour units (where 80 hours = 1 hired-labour unit). If more than 400 hours/fortnight hired labour available, then there is still total conversion to organic farming, but in that case the cropping plan differs from the basic scenario. Celeriac is added to the rotation, which taking a part of the area of seed onion. The latter requires more than twice as much labour, especially during peak periods. If 160 to 400 hours/fortnight of hired labour available, then there is partial conversion to organic farming (58-95% of the total cultivated land area). The conversion and organic cropping plan differs from the basic scenario. In conversion years, besides the current conversion crops, celeriac is added to the crop rotation. This means less cultivation of seed onion, which is more labour intensive than celeriac. In organic years instead of seed onion celeriac is cultivated. If there is 0-160 hours/fortnight hired labour available then there is no conversion to organic farming. In the case of conversion, it is one-step conversion.

The third limiting factor in the analysis is called "lower organic price". In this scenario the effects of the reduction of organic product prices are analysed. If the prices for all organic products drop less than 2%, then there is still total conversion to organic farming. The results are the same as in the basic scenario; only the revenues are lower for organic products. If the prices for all organic products drop more than 2%, then there is no conversion to organic farming. In the case of conversion, it is one-step conversion. Partial conversion is not an optimal solution for any level of organic price reduction.

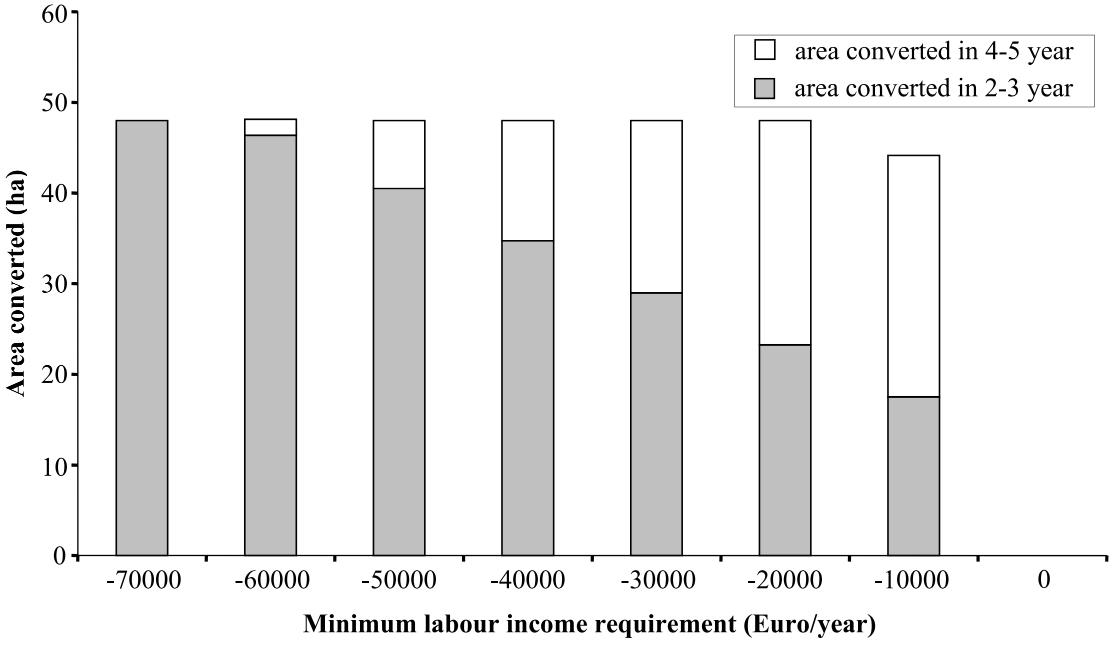

Figure 4.4 Effect of minimum labour income requirement on conversion

The fourth limiting factor in the analysis is called "minimum labour income". In this scenario a minimum constraint was put on the minimum labour income requirement. If the labour income is lower than -20000 Euro/year then there is complete conversion to organic farming. If the minimum labour income requirement is higher than -20000 but lower than 0 Euro/year, then there is partial conversion to organic farming (92% of the total cultivated land area). If it is higher than 0 Euro/year then there is no conversion to organic farming. In the case of conversion, it is stepwise conversion. Figure 4.4 shows the area converted in the 2nd-3rd years and 4th-5th years for each minimum labour income requirement level. In all these cases the cropping plan remains the same and proportional to the basic scenario.

4.4 Discussion and conclusion

This study is based on a typical farm characteristic of the central clay region of the Netherlands. The study illustrates by using DLP model how a conversion from conventional to organic farming could occur. The results of the analysis of the basic scenario show that, in the long run, conversion to organic farming is more profitable. However, in order to get this higher income the farmer has to “survive” the economically difficult two-year conversion period of lower yields and conventional prices.

If additional constraints are included in the analysis, conversion to organic farming is not always economically optimal. The results of the analysis show that extra depreciation costs lower the labour income during the conversion period. If these costs are high enough (>25%), conversion becomes less profitable than conventional farming. The availability of hired labour has a strong effect on the cropping plan and the area converted. This means that the regional labour supply should be taken into account in decisions on conversion to organic farming. The model is quite sensitive to organic price changes. A slight drop in prices (>2%) makes conversion less profitable than conventional farming. A constraint on the minimum labour income requirement suggests that stepwise conversion is best to overcome the economic difficulties of the conversion period.

The model is based largely on average empirical data, and incorporates only specific average production technology, which, in reality, can differ among farms, which might obtain different prices, costs, yields, and incomes. The most profitable rotations change as the prices of crops and inputs change, and this could also influence a decision on conversion to organic farming. The analyses of such parameter changes however lie beyond the scope of this study.

Further, this modelling approach involves approximations and assumptions. For instance, yields, costs and resource requirements for organic crop rotations during a conversion period can only be estimated, because experience is limited. In our study we used organic yields, costs and resource requirements for conversion years. Further studies should be done analysing the effect of yield loss and its change over time during and after the conversion period. Nutrient requirements during the conversion phase were also assumed to be the same as for organic years, but a farmer could incur higher costs during conversion, for example, for additional weed-control cultivation, and this would further decrease profits during the conversion years.

The planning horizon was arbitrarily set to 10 years. A period of 20 years could be argued for example if the farmer who has to decide would be of the age of around forty and would want to stay in business for some 20 years. Additional calculations with a time horizon of 20 years do not result in a change of the optimal cropping plan. However, the economic consequence of using a longer time horizon shows a large increase in the difference between the discounted labour income from conversion and from staying conventional. The difference increases from 45,239 Euro for a 10 years time horizon to 256,658 Euro for a 20 years time horizon. Also the sensitivity analysis is influenced by the time horizon. Prices of organic products, for example, could be 6.5% lower in stead of 2% for a 10 years horizon before the optimal decision would be to stay conventional. An important argument against a longer time horizon is the increasing uncertainty about future supply and demand of both conventional and organic products and about the consequential product prices. Not every farmer would want to base the decision to convert on expectations about product prices using a 20 years time horizon.

Nevertheless, the conversion to organic farming has a positive economic result in the basic scenario of the model. After the inclusion of additional constraints such as extra depreciation costs or lower prices for organic products however, conversion from conventional to organic farming does become less attractive. In this situation governmental incentives (*e.g.*, taxes on chemical use, subsidies to organic production, investment subsidies for machinery and buildings, tax benefits or income support during the conversion period) might be helpful to motivate farmers to convert. The DLP model developed here could be useful in future investigations of the effects of different economic incentives.

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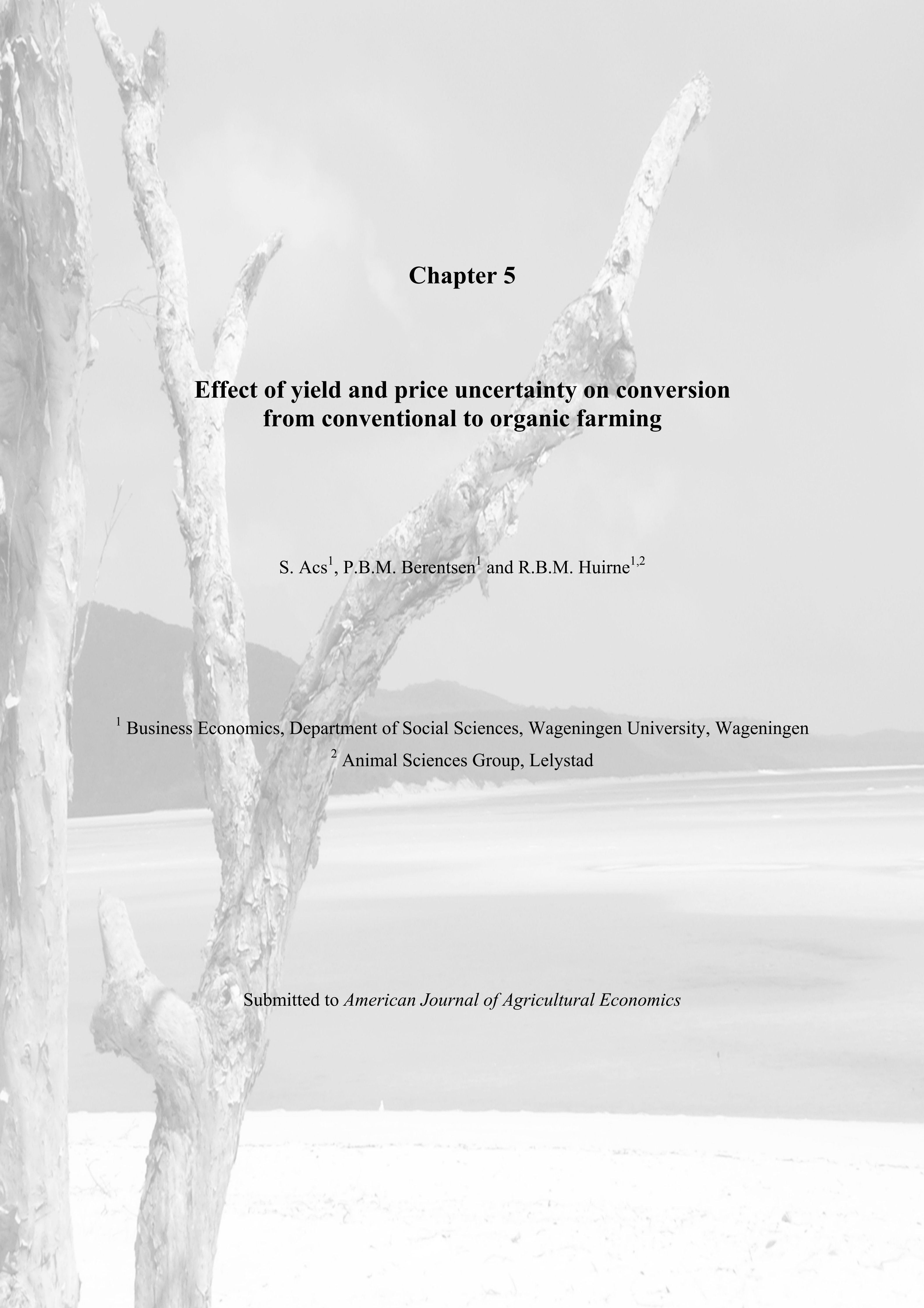

Chapter 5

Effect of yield and price uncertainty on conversion from conventional to organic farming

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Abstract

Although the benefits of organic farming are already well know, the conversion to organic farming does not proceed as the Dutch government expected. In order to investigate the conversion decisions of Dutch arable farms a discrete stochastic dynamic utility-efficiency programming (DUEP) model is developed with special attention for yield and price risk of conventional, conversion and organic crops. The model maximizes the expected utility of the farmer depending on the farmers' risk attitude. The DUEP model is based on a previously developed dynamic linear programming (DLP) model that maximized the labour income of conversion from conventional to organic farming over a ten-year planning horizon. The DUEP model was used to model a typical farm for the central clay region in the Netherlands. The results show, that for a risk-neutral farmer it is optimal to convert to organic farming. However, for a risk-averse farmer it is only optimal to convert if policy incentives are applied such as taxes on pesticides or subsidies on conversion, or if the market for the organic products gets more stable.

5.1 Introduction

Increased consumer awareness of food safety issues and environmental concerns in Europe has contributed to the growth of organic farming over the last few decades. However, the overall significance of organic farming in the European context is still quite small in terms of land area used. In 2002 it represented slightly more than 3 percent of the total EU utilised agricultural area (UAA) (Lampkin, 2002). In some Member States, such as in the Netherlands, the rapid growth in the nineties has slowed down after the end of the century. The desired target of five percent organic area of the UAA in 2005, set by the Dutch government in 2000, was not reached. It was only 2.47 percent (Eurostat, 2006). However, the target of ten percent by 2010 still remains (MINLNV, 2005). In order to reach the target more insight is needed into factors which hamper and stimulate the conversion of farms.

Previous studies showed that organic arable farms can achieve very similar or even higher income levels than comparable conventional farms. (Langley *et al*., 1983; Offermann & Nieberg, 2000; Morris *et al*., 2001; Acs *et al*., 2006a; Acs *et al*., 2006b). These results cannot explain the stagnation of conversion over the last years. An aspect that needs more attention in the models is uncertainty concerning yields and prices, which poses a risk to farmers. Furthermore, it has been common to assume, often implicitly, that decision makers are indifferent to risk and uncertainty. However, assuming no risk aversion seems to be not the best option when it is well known that risk aversion is widespread (Hardaker *et al.,* 2004).

Some studies suggest that the main sources of risk for both conventional and organic farmers are the output price and production risk (Martin, 1996; Harwood *et al.,* 1999; Meuwissen *et al*., 2001). In arable farming in the Netherlands there is a large variation between the years in crops' gross margin of conventional, conversion and organic crops (LEI, 2004). This is mainly caused by large revenue (yield and output price) variation across the years. Differences in variation between conventional, conversion and organic crops are caused mainly by different management practices (i.e. restrictions on pesticide use and fertilizer) and by different market opportunities and prices for the products (Lampkin & Padel, 1994; Pannel *et al*., 2000). This suggests that it is important to take into account the variation of revenue while analysing the conversion to organic farming.

There is quite some literature on inclusion of risk in agricultural farm models (Hardaker *et al*., 2004). To incorporate uncertainty in a mathematical programming model, two frequently used modelling practices can be taken into account. One is quadratic risk programming (QRP) and the other is utility-efficient programming (UEP) model. They both maximise expected income of a risk averse decision maker subject to a set of resource and other constraints (Markowitz, 1952; Freund, 1956; Hardaker *et al*., 2004). The advantage of QRP is that it requires only a vector of means and the variance-covariance matrix of the revenues (depending on yields and prices) per unit of possible cropping activities. However, the properties of QRP, such as the normality distribution assumption on crop related yields and prices (net revenues), and the use of quadratic utility function are not necessarily appropriate (Hardaker *et al.,* 2004). In contrast, UEP, as a non-parametric method, is free of distribution assumptions and includes the joint distribution of yield and prices by means of so-called "states of nature" (specific combinations and probabilities of possible outcomes). In contrast to QRP, in UEP a number of types of utility function can be incorporated. Utility-efficient programming was applied by Flaten and Gudbrand (2006) on organic dairy farms but the model was used to predict one year. In this paper the previously developed dynamic linear programming model (Acs *et al.,* 2006b) is extended with price and yield risk and a utility maximizing objective function (i.e. dynamic utility-efficient programming model).

The objective of this paper is to describe the developed model and to apply it, to the conversion process from conventional to organic farming, taking into account the risk of yield and price variation before, during and after the conversion years.

The paper starts with the description of the model. Here the inclusion of risk in the mathematical programming model, the general structure of the model, and the activities and constraints are described. Next, the data and the set up of the calculations are presented. Then, the results of the model for a basic situation are presented and analysed followed by a sensitivity analysis for different factors. The paper ends, with a discussion on the method and the results.

5.2 Method

5.2.1. Inclusion of risk in a mathematical programming model

In order to include risk in a mathematical programming model, two issues have to be taken into account: i) the uncertainty of the risky events, which can occur in the future; ii) the attitude of the farmer towards these risky events. The uncertainty in the model is represented by the probabilities of occurrence of each event. Each event represents a state of nature. The attitude towards risk is expressed by an assumed utility function of the farmer.

The arable farmer has the choice to stay conventional, to convert part of his land or convert all the land to organic production. The conversion period takes two years. The farmer can also choose to convert the land at once or step-wise (converting in parts). In the model only one-way conversion is permitted. It is assumed that if once the farmer decides to convert (a certain area) no backward conversion can take place.

When assuming certainty, one average state can be included in the model, as it was done in the previous DLP model (Acs *et al.,* 2006b). While including risky outcomes more states should be taken into account. Each stage – conventional, conversion and organic – has its own uncertainty. In the DUEP model, the states of nature are represented by the revenues of crops for a number of individual years depending on crop yield and price for the particular year. Each of the alternative states of nature occurs with a certain probability.

Most people are risk averse when faced with significantly risky incomes or wealth outcomes (Hardaker *et al.*, 2004). A person who is risk averse is willing to forgo some expected income for a reduction in risk, the range of acceptable trade-off depending on how risk averse that individual is. This trade-off can be included by converting expected income to the utility of the individual, which means that his attitude towards risk is included. Conversion of income to utility is done by using a utility function.

In utility-efficient programming, any convenient form of utility function can be used to represent the farmers' preferences (Patten *et al.*, 1988). Preferences vary between farmers; therefore, different assumptions can be used on their risk attitude in the range from risk neutral to extreme risk aversion. The assumption of risk aversion requires a concave utility function. In our analysis the common negative exponential function is used (Hardaker *et al.,* 2004): $U = 1 - \exp^{-Ra*z}$, where U is the utility of a certain person, Ra is the risk aversion coefficient of that particular person and z is the labour income. Concavity of this function is ensured, since, $U'(z) > 0$, and $U''(z) < 0$. This function exhibits constant absolute risk aversion. This means that preferences between payoffs (labour income) are unchanged if a constant amount is added to or subtracted from all payoffs.

According to Anderson and Dillon (1992) the degree of risk aversion of any individual with respect to wealth (w) may be characterized in terms of the relative risk aversion coefficient. The coefficient of relative risk aversion can be calculated as $Rr(w) = -wU''(w)/U'(w)$, where $U''(w)$ and $U'(w)$ represent the second and first derivatives, respectively, of the utility function of a person with respect to wealth ($U(w)$) (Mas-Colell *et al.*, 1995). This means that the risk aversion is reflected by the curvature of the individual's

utility function. The relative risk aversion can be grouped as follows (Anderson and Dillon 1992):
Rr(w)=0, risk neutral;
Rr(w)=0.5, hardly risk averse at all;
Rr(w)=1.0, somewhat risk averse (normal);
Rr(w)=2.0, rather risk averse;
Rr(w)=3.0, very risk averse;
Rr(w)=4.0, extremely risk averse.

Since the utility function used includes the absolute risk aversion coefficient *Ra*, a relationship is required between *Ra(w)* and *Rr(w)*. Hardaker *et al*. (2004) showed that *Ra(w)=Rr(w)/w* in which *w* is the wealth measure. Concerning the wealth measure *w*, congruence is required between this measure and the consequences of the decision to be analysed (Hardaker *et al*., 2004). This means that if the consequence of the decision is measured in terms of farm income, some kind of standardised farm income should be used as wealth measure w.

5.2.2. General structure of the model

The general structure of the dynamic utility-efficient programming model of the farm is formulated as follows:

$$MaxE[U] = \sum_{S} p_S U_S (REV_{Sy}, C_y, Ra), \qquad Ra \text{ varied} \qquad S \in [Sc, St, So] \qquad (1)$$

subject to:

$$A_y x_y \leq b_y \qquad (2)$$

$$x_y \geq 0 \qquad (3)$$

Where
E[U] – expected utility
S – states of nature; *S* ∈[*Sc, St, So*]
Sc – states of nature of conventional crops [*Sc1, Sc2, ..., Sc10*]
St – states of nature of conversion (transition) crops [*St1, St2*]

So – states of nature of organic crops [$So1, So2, So3$]

p_s – probability of each state of nature

U_s – expected utility per state of nature of different crop revenues

REV_{Sy} – revenues per year per state of nature

Ra – risk aversion coefficient, Ra > 0

y – year [y=1,2,…,10]

C_y – total costs per year (variable and fixed) for activities of x_y

x_y – vector of activities per year

A_y – matrix of technical coefficients per year

b_y – vector of right hand side value per year

The expected utility of the farmer over the ten-year planning horizon is maximized, which is a function of different crop revenues (determined by the states of nature), their variable costs, fixed costs and the risk aversion coefficient of the farmer (Equation 1). Maximization is subject to several activity constraints (Equation 2 and Equation 3). The model each year chooses between the activities (x), which together with the states of nature will determine the final outcome.

More specifically: following Von Neumann and Morgenstern (1947) the expected value is calculated from the utility values weighted by the corresponding probabilities (Equation 4).

$$MaxE[U] = \sum_{Sc} U_{Sc} * p_{Sc} + \sum_{St} U_{St} * p_{St} + \sum_{So} U_{So} * p_{So} \tag{4}$$

Where: $$\sum_{Sc} p_{Sc} = 1; \quad \sum_{St} p_{St} = 1; \quad \sum_{So} p_{So} = 1 \tag{5}$$

The utility values are calculated by using a non-linear utility function. As explained before, the discounted labour income is transferred into utility values using the negative exponential utility function: $U_S = 1 - \exp^{-Ra * z_s}$, where $S \in [Sc, St, So]$ and $z_s = \sum_y (GM_{Sy} - C_{Fy})$. The discounted labour income over 10 years per state (z_s) is the sum of the discounted gross margin per state of nature per year (GM_{Sy}) minus the discounted fixed costs (C_{Fy}) per year (costs of land, machinery and buildings) (Equation 6). The discounted annual gross margin is calculated as follows:

$$GM_{Sy} = \frac{\sum_L (REV_{SLy} - C_{Ly}) * LUS_{Ly}}{(1+i)^y}; \qquad S \in [Sc, St, So] \qquad (6)$$

Where: REV_{SLy} – revenue per state of nature per crop per year; C_{Ly} – variable costs per crop per year; LUS_{Ly} – land use system (cropping pattern) in hectare of each crop per year; L- crop type; i – discount rate (4%). The choice of activities determinates the revenues and the costs of farming. The revenues represent the discrete stochastic element in the model, which depends on the chosen crops and the states of nature of each crop. Variable costs include crop production costs (including costs of variable operations, pesticide use, energy use, contract work, marketing costs and other remaining costs), costs of purchased nutrients (manure and fertilisers), hired labour costs and nutrient taxes. The final production plan maximizes the probability-weighted average of the utilities of the discounted labour income of the cropping patterns over the ten years.

The matrix developed comprised 9845 activities and 11031 constraints. The model was solved using GAMS programming language and SBB solver (Brooke *et al.* 1988).

5.2.3. Activities and constraints

The main groups of activities (x) in the model are:

- Crop activities:
  Conventional: winter wheat, spring barley, ware potatoes, seed potatoes, sugar beet, onion, and carrot;
  Organic: winter wheat, spring barley, ware potatoes, seed potatoes, sugar beet, onion, carrot, spring wheat, kidney bean, green pea, alfalfa celeriac, grass-clover;
  Conversion: the same as organic crop activities with only difference that organic yields and conventional prices are used.
- Hired labour. There is an opportunity to hire unlimited amount of skilled and unskilled labour at any time of the year for 18 Euro/hour and 9 Euro/hour, respectively (CAO 2002).
- Manure and fertiliser purchase.
- Activities for calculating nutrient surplus, organic matter input and pesticides use.

The main groups of constraints are:

- Land availability. A 48 ha farm size is assumed, which is an average farm size in the central clay region in the Netherlands.
- Rotation restrictions. All the individual crops and groups of crops have their own rotation constraints which are mainly based on agronomic reasons. For conventional production 1:3 crop rotation is used for the whole land area, which is characterising the region. For conversion and organic production 1:6 crop rotation is used. This more diverse crop rotation is a requirement for organic farming. More detailed information concerning crop rotations can be found in Acs *et al.* (2006a).
- Conversion restrictions. Technical constrains concerning the dynamic aspect of the model. The first year the model is restricted to produce only in conventional way. This restriction was imposed in order to be able to compare the conventional production with the conversion and organic production plan. From the second year the model can convert to organic production. In case land goes into conversion, it will be in conversion for 2 years to become organic land area. The model decides how much land goes from conventional into conversion. In the model the conversion is restricted to one-way direction, so the model excludes the possibility to convert back.
- Household labour constraint. The available amount of family labour is assumed to be 1,1 full-time labour (2255 hours per year), which is an average labour supply in this region for 48 ha land area (De Wolf & De Wolf, 2004). Family labour supply per period is assumed to be constant over the year.
- Nutrient balance calculation for Dutch Mineral Accounting System (MINAS) regulation. MINAS calculates a nutrient balance at farm level per hectare. Above the acceptable level (100 kg N and 25 kg P_2O_5 per hectare in year 2002) the farmer has to pay a levy in Euro kg^{-1} of unacceptable surplus, which is 2,3 Euro kg^{-1} in the case of nitrogen and 9 Euro kg^{-1} in the case of phosphate (MANMF, 2004).
- Maximum manure input restriction for Manure Transfer Agreement System (MTAS) regulation. MTAS sets a limit to the amount of manure that can be used on the farm. This limit is based on nitrogen (N) content which is 170 kg N from manure per ha.
- Several counting rows for pesticides use and organic matter input to the farm

5.2.4. Data

Regarding crop revenues, based on available data, in our model ten states of nature were used for conventional crops (see Table 5.1), two for conversion (see Table 5.2) and three for organic crops (see Table 5.3). Each state has the same probability to occur: p_{sc}=0.1 for conventional, p_{st}=0.5 for conversion and p_{so}=0.333 for organic states of nature.

The data were obtained from the Farm Accounting Data Network (FADN) dataset from Agricultural Economics Research Institute (LEI) in the Netherlands. FADN data is a unique panel dataset, which includes crop-level information per farm. Data consists of yields and product prices over 300-400 farms per year for conventional crops, 80 farms for conversion and 32 farms for organic crops. Because prices and yields tend to change over time in a more or less consistent and predictable way, they were de-trended to account for inflation and technical progress (Barry *et al.,* 2000), with 2002 as the base year, just as in Acs *et al*. (2006b). This makes it possible to compare the outcome of results of Acs *et al*. (2006b) with the results of this paper. Prices were corrected for inflation by using the inflation index of prices (CBS, 2005). To account for technical progress crop yields were corrected for trend. The means and the standard deviations of these crop revenues observations were calculated (see Tables 5.1, 5.2 and 5.3). The mean and the standard deviations of this historical data were adjusted to the year 2002 while preserving the correlations and other stochastic dependencies embodied in the original information.

Regarding variable costs of crops, data was obtained from Quantitative Information Handbook (KWIN, 2002). Fix costs for conventional and organic farms were calculated from the results of real farms (Wijnands & Dekking, 2002). The direct costs (variable costs without nutrient and labour costs), labour and nutrient requirement per crop are summarized in Table 5.4. Detailed information about these input data and about fixed costs, crop rotation, household labour use and organic matter input can be found in Acs *et al*. (2006a and 2006b).

Table 5.1 Revenues of Conventional Crops per State of Nature De-Trended by Inflation to 2002 (Euro/ha)

Year	State of nature	winter wheat	seed potato	sugar beet	seed onion	carrot	spring barley	ware potato	Probability
1990	Sc1	1759	7282	3223	5764	13482	1496	5348	0.1
1991	Sc2	1818	7471	3026	3675	13394	1594	5229	0.1
1992	Sc3	1932	5839	3264	2918	9457	1591	3331	0.1
1993	Sc4	1819	6401	3152	3161	13098	1534	4912	0.1
1994	Sc5	1837	8911	3256	6082	14269	1443	9133	0.1
1995	Sc6	1858	9168	3353	7436	12977	1464	5955	0.1
1996	Sc7	1859	7069	3431	2699	15393	1654	3924	0.1
1997	Sc8	1634	7437	3846	6069	11899	1538	6016	0.1
1998	Sc9	1610	9805	3498	10720	11399	1415	8416	0.1
1999	Sc10	1845	8018	3390	4035	7833	1531	4537	0.1
Mean		1797	7740	3344	5256	12320	1526	5680	
SDs		102	1246	224	2508	2264	74	1838	

Source: LEI, 2004; own calculations

Table 5.2 Revenues of Conversion Crops per State of Nature De-Trended to 2002 (Euro/ha)

Year	State of nature	ware potato	seed potato	sugar beet	kidney been	green pea	spring barley	alfalfa	winter wheat	spring wheat	seed onion	carrot	celeriac	grass-clover	Probability
1995	St1	3291	5781	2602	1490	1002	1134	780	1227	1256	4654	7610	2275	423	0.5
1996	St2	2209	4619	2514	1520	1124	1348	900	1265	1396	1646	9990	2625	717	0.5
Mean		2750	5200	2558	1505	1063	1241	840	1246	1326	3150	8800	2450	570	
SDs		766	822	62	21	86	151	85	26	99	2126	1682	247	208	

Source: LEI, 2004; own calculations

Table 5.3 Revenues of Organic Crops per State of Nature De-Trended to 2002 (Euro/ha)

Year	State of nature	ware potato	seed potato	sugar beet	kidney been	green pea	spring barley	alfalfa	winter wheat	spring wheat	seed onion	carrot	celeriac	grass-clover	Probability
1997	So1	3258	6145	4985	3614	3034	1763	920	1905	2203	5773	20214	8400	700	0.33
1998	So2	16413	18875	4087	2817	2639	1662	680	1695	2071	17555	25497	11900	700	0.33
1999	So3	1780	3840	3102	2020	2616	1648	1280	2177	2254	2931	10389	4900	700	0.33
Mean		7150	9620	4058	2817	2763	1691	960	1926	2176	8753	18700	8400	700	
SDs		8056	8098	941	797	235	63	302	242	94	7754	7667	3500	0	

Source: LEI, 2004; own calculations

Table 5.4 Costs, labour and nutrient requirement of conventional, conversion and organic crops

Crops	Costs (Euro)[1]		Labour requirement (h)		Nutrient requirement (kg)			
	Conventional	Conversion / Organic	Conventional	Conversion / Organic	Conventional		Conversion / Organic	
					N	P_2O_5	N	P_2O_5
ware potato	1681	2255	26.4	20.6	255	120	150	48
seed potato	3245	2226	95.3	77.1	125	120	50	47
sugar beet	1008	884	19.2	86.1	150	80	80	160
seed onion	1975	1284	37.7	316.5	110	120	50	43
carrot	9450	12450	29.3	185.7	80	120	40	57
winter wheat	484	439	10.4	13	210	20	125	62
spring barley	312	393	9.6	12.1	65	20	25	60
winter barley	-	339	-	12.1	-	-	75	53
spring wheat	-	415	-	13.5	-	-	75	62
kidney bean	-	624	-	25.6	-	-	50	20
green pea	-	658	-	22.5	-	-	10	25
alfalfa	-	169	-	2.2	-	-	0	133
celeriac	-	2666	-	134.9	-	-	140	74
grass-clover	-	141	-	5.5	-	-	0	105

[1] Direct production costs do not include the costs of nutrients and labour

For the calculation of the absolute risk aversion coefficient (*Ra*), by means of formula: $Ra(z) = Rr(w)/w$, maximized labour income over 10 years planning horizon is used from DLP model results (Acs *et al.*, 2006b). In the basic DLP, model the maximized discounted labour income was 206503 Euro for conventional farming and 251724 Euro for converted organic farm (Acs *et al.*, 2006b). As shown before the relative risk aversion coefficient (*Rr*) can take the range between 0-4. In our analysis, the conventional optimized discounted labour income is taken as a base for the calculation of absolute risk aversion for the range from 0 to 4 of relative risk aversion. This means that the corresponding absolute risk aversion coefficient can take values between 0 and 0.000019.

5.2.5. Setup of calculations

Due to differences between farmers concerning their attitude towards risk, in our analysis, first, the whole range of risk aversion is investigated. The solutions are obtained by stepwise variation in risk aversion coefficient (*Ra*). Next, In the sensitivity analysis, the effect on conversion of policy incentives, market stabilisation and of learning are analysed. In this sensitivity analysis the focus is on a somewhat risk averse person (with *Rr*=1), which according to Anderson and Dillon (1992) is the risk attitude of a ‘normal’ person.

Policy incentives

The first policy incentive is a tax on pesticides. The amount of pesticides used for the protection against weeds, pest and diseases is calculated in active ingredients (a.i.), which is the weight of the toxic substance in the applied product in kilograms. Pesticides are used only for conventional crops, since the use of synthetic chemical inputs in organic farming is not allowed. This gives an option to imposing a tax on pesticide use in order to stimulate the farmers to convert to organic production. The amount of pesticides used for each crop activity is fixed in the model (i.e. it does not allow to use less pesticide which could have an affect on the output results). The model does not adapt to the changes in pesticide use. In this analysis the minimum amount of tax (in Euro/kg a.i.) necessary for conversion is determined.

Another option to stimulate conversion to organic farming is by using subsidies on organic production. Subsidies can take different form: i) subsidy at once, at the beginning of the conversion period; ii) conversion subsidies, given only during the conversion period which would serve as a compensation for switching costs (i.e. costs of investment/disinvestment, learning costs, lower revenues during this period); iii) subsidies for all organically produced crops starting from conversion years. All of these are hectare-based subsidies for the area converted. The minimum amount of subsidy required to convert is determined by the DUEP-model.

Market stabilization

In this analysis, we explore how the conversion would take place if the market for organic products would be more stable. It means less fluctuation in prices. From modelling point of view it means that the variation of organic crop revenues will decrease with a certain percentage after the conversion years. In our sensitivity analysis, we explore how much this decrease of the revenue variation should be before it is optimal for the farmer to convert to organic production.

Learning effect

During the conversion years, the farmer has to learn organic production practices. After a few years of experience the organic crops might give higher and more stable yield. In this scenario, this effect is investigated by raising the mean and decreasing the variance of organic crop revenues from the fourth year. The mean is assumed to rise by five percent and stay at this higher level the following years, and the percentage reduction in variance that is necessary for conversion is calculated.

5.3 Results

5.3.1 Basic results of DUEP model

The results show that the degree of risk aversion has strong effect on the optimal decision of a farmer to convert. While it is for the risk neutral farmer optimal to convert the whole area to organic production, it is for a hardly-risk-averse farmer (Rr = 0.5) more optimal to stay farming conventionally. In the case the farmer is even more risk averse ($0.5 \leq Rr \leq 4.0$) also no conversion is optimal.

Table 5.5 summarizes the maximal labour income, the amount of area converted to organic farming and the optimal cropping plan with different degree of risk aversion coefficients. Just for illustration purposes, three degrees of risk aversion are chosen to show the effect of risk aversion parameter: hardly risk averse (*Rr* = 0.5), somewhat risk averse (*Rr* = 1.0) and extremely risk averse (*Rr* = 4.0).

As risk aversion is increasing the optimal cropping plan changes. In conventional farming instead of more risky ware potato, seed potato is grown, instead of seed onion and carrot sugar beat and winter wheat is cultivated (this can be explained by the high standard deviations of revenues in Table 5.1).

Table 5.5 Optimal farm plan over time for different risk aversion coefficients

	Risk aversion			
Risk attitude	risk neutral[1]	hardly risk averse	somewhat risk averse	extremely risk averse
Ra	0	0.0000024	0.0000048	0.000019
Rr	0	0.5	1.0	4.0
Discounted labour income (Euro)	251724	139566	133410	79526
Conventional (ha)	0	48	48	48
Converted to organic (ha)	48	0	0	0
Total area (ha)	48	48	48	48
Optimal cropping plan (ha)				
Conventional (t=1)				
winter wheat	16.0	16.0	16.0	20.0
seed potato	6.9	11.4	11.9	13.5
ware potato	9.1	4.6	4.3	2.5
seed onion	9.6	-	-	-
carrot	6.4	4.0	3.8	-
sugar beat	-	12.0	12.0	12.0
Conventional (t=2-10)	-	same as t=1	same as t=1	same as t=1
Conversion (t=2-3)				
spring wheat	16.0			
seed potato	8.0			
seed onion	4.0		No conversion	
sugar beet	12.0			
alfalfa	8.0			
Organic (t=4-10)				
spring wheat	8.0			
seed potato	8.0			
seed onion	8.0			
carrot	8.0			
kidney bean	8.0			
green pea	8.0			

[1] The result is the same as for the DLP model (Acs *et al.*, 2006b)

The effect of risk aversion on the optimal labour income and expected utility can be seen in Figure 5.1. The dots (and the lines between) give the optimal outcome given the risk aversion coefficient of the farmer. As risk aversion is increasing both the labour income and the expected utility of the farmer is decreasing. It means that the more risk averse the farmer is the more he is satisfied with lower but more certain income. If the farmer is more risk averse the same labour income gives him lower expected utility as it can also be seen from the figure.

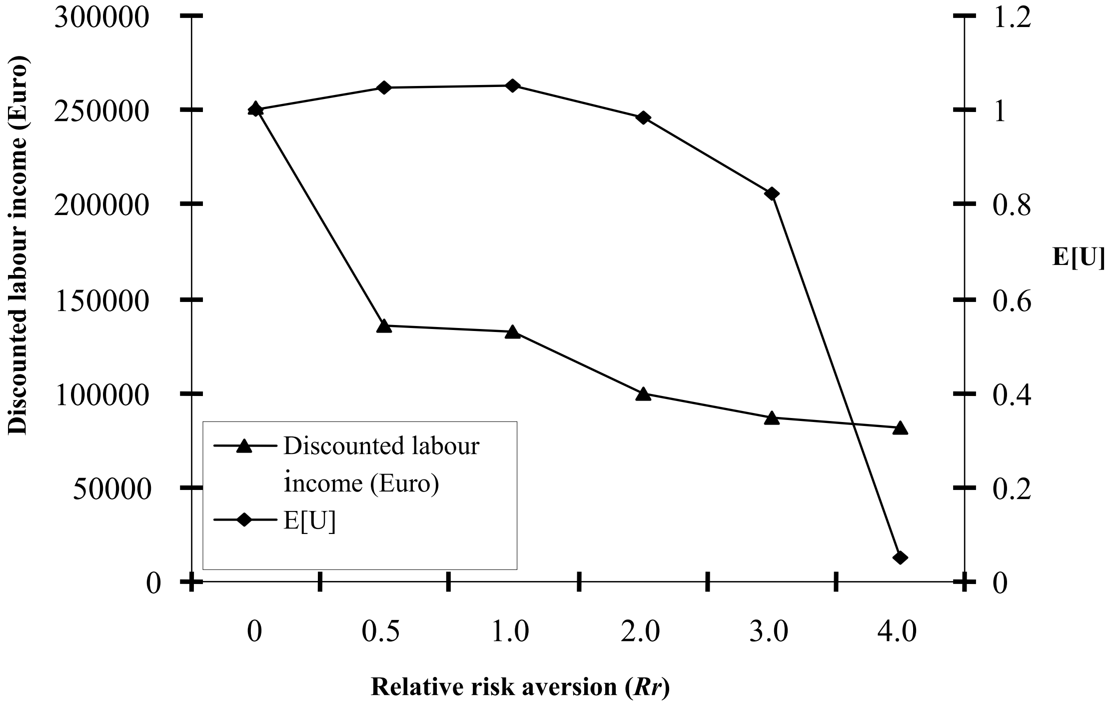

Figure 5.1 Effect of risk aversion on the optimal discounted labour income and expected utility

5.3.2 Sensitivity analysis

The basic outcome of the DUEP model shows that the no conversion takes place when risk is included. In the sensitivity analysis, different policy incentives and the effect of market stabilization and of learning are examined for a person with somewhat risk averse attitude (*Rr* = 1).

Taxes on pesticides

The sensitivity analyses show that while in basic situation for normal risk aversion no conversion would be optimal, in case the taxes exceed the amount of 23 Euro per kg active ingredient the farmer would prefer to convert the whole farm at once. Below that level no conversion would take place (Table 5.6).

Table 5.6 No conversion and conversion Ranges for different factors used in sensitivity analysis ($Rr = 1$)

	Tax on pesticides Euro/kg a.i[1].	Subsidy for organic production Euro/ha	Reduction of variance due to market stabilization %	Reduction of variance due to learning effect[2] %
No conversion	0 - 22	0 - 353	0 - 79	0 - 62
Conversion	≥ 23	≥ 354	80 - 100	63 - 100

Subsidies for organic production

Model calculations show that at least 354 Euro/ha subsidy would be needed for every year of organic farming starting from the year of conversion to make the farm converting to organic production. In this case, the whole farm would convert at once. In the case if the subsidy would be given at once, at the beginning of the conversion period then 2737 Euro/ha/year would be needed before conversion is optimal. If the subsidy would be given during the 2-year conversion period then 1396 Euro/ha/year would be required, given the 10-year planning horizon.

Market stabilization

The results of more stable market for organic products show that the variance of organic revenues has to be reduced by at least 80 percent of the current variance before the farm would convert to organic production. If the variance would be reduced by a smaller amount no conversion would take place.

Learning effect

The result of the analysis of the farmer's learning effect show that by assuming five percent rise in organic crop revenues from the fourth year, the variance of it should be 63 percent lower of the current variance in order to make the farm convert. This means that the somewhat risk averse farmer (Rr = 1) would require quite stable revenue with considerably lower risk compared to a risk neutral farmer (Rr = 0).

5.4 Discussion and conclusion

The developed method is suitable to model the conversion from conventional to organic farming including yield and price uncertainty of future conventional and organic crops. The dynamic aspect and the inclusion of stochastic elements into the model is one of the advantages of this modelling approach. This makes farm level analysis of conversion closer to the real situation compared with static and deterministic models. The model can also be used as a tool for policy makers to analyse the effect of certain incentives at farm level conversion. However, the model strongly depends on the data available for use.

In this research, survey data were used for assessing risk. For conversion and organic crop yields and prices there were only two and three year data observations available, respectively. There are two implications of this lack of data availability. This questions the reliability of the model results. More attention should be paid on survey data collection in the future. Data availability is improving by collection and publication of data from organic farming (FADN data collected by LEI, data from BIOM projects collected by PPO), especially for established organic systems. However, more observations are needed also from in-conversion farms in order to get more realistic model results.

The survey data used in this thesis concerning yield risk and also other evidence (Van Bueren *et al*., 2002) showed that in organic farming the variance of crop yields is higher compared to conventional farming. However, the conclusion that organic yields fluctuate more than in conventional systems is not certainly a ‘fact’, there is also evidence in the opposite direction (Lamkin & Padel, 1994). In the case organic farming would have more stable yield, compared to conventional farming, a risk averse farmer would convert ‘easier’ to organic production.

Calculations with the DLP model developed by Acs *et al*. (2006b) showed that one-step conversion of the whole farm area would maximize net present value in 10 years. This result is valid in the case when there is no risk aversion. When including risk aversion in the DUEP model no conversion takes place. Moreover, the optimal (conventional) production plan of the farm is affected. Other studies on inclusion of risk aversion into mathematical modelling showed that the cost of ignoring risk aversion may be small in short-run (tactical) decision problems in farming (Pannell *et al*., 2000; Lien and Hardaker, 2001; Flaten and Lien, 2006). Our results suggest that in considering risk aversion in the decision problems with a longer planning horizon (strategic decisions for several years) the effect of risk aversion can be considerable.

Sensitivity analysis showed that policy incentives such as taxes and subsidies and output price and yield stabilization influence the conversion to organic farming. The model results show that for a somewhat risk averse farmer in the case of taxes on pesticides 23 Euro tax per kg active ingredient would be required to convert to organic farming. This means that the conventional farmer will have to pay 25059 Euro tax for 10 years (2971 Euro/year). It would give him 19% lower income compared to the optimal labour income ($Rr = 1$).

In the case subsidies are implied, the model results show that subsidies needed for conversion of arable farms ($Rr = 1$) is higher then the actual subsidies paid to farmers between 2000-2003 in the Netherlands. The conversion subsidy at once was 1136 Euro/ha (MINLNV, 2000). The minimum required amount calculated by the model is 2737 Euro/ha, which is more than two times higher. This means that substantially more subsidy is required from the government than was given in the past in order to make the conversion decision of the farmer an economic justified one.

Analysis of the market stabilization for organic products and on the learning effect showed that the variation of expected revenue of organic products must be considerably lower then variation based on the past year dataset. Prices of organic crops might have great variability also in the future, due to the small-scale, immature nature of the organic market (easy substitutability of organic products with the conventional ones) and the lack of government intervention to stabilise prices (Lampkin and Padel, 1994). Yields are also subject to weather and other agronomic factors, which means that the yields stay rather uncertain also in the future. This suggests that better stimulation for conversion would be to use policy incentives, such as taxes or subsidies.

This study provides valuable insight into the farm-specific decision whether or not to convert to organic farming. The results show, that for a risk-neutral farmer it is optimal to convert to organic farming, however for a risk-averse farmer it is only optimal to convert if policy incentives are applied such as taxes on pesticides or subsidies on conversion, or if the market for the organic products gets more stable. The more risk averse the farmer is more incentive is needed to make the farmers convert to organic farming. Although this seems obvious, the risk aversion of the farmers is neglected easily. This model provides the basis to determine such incentives.

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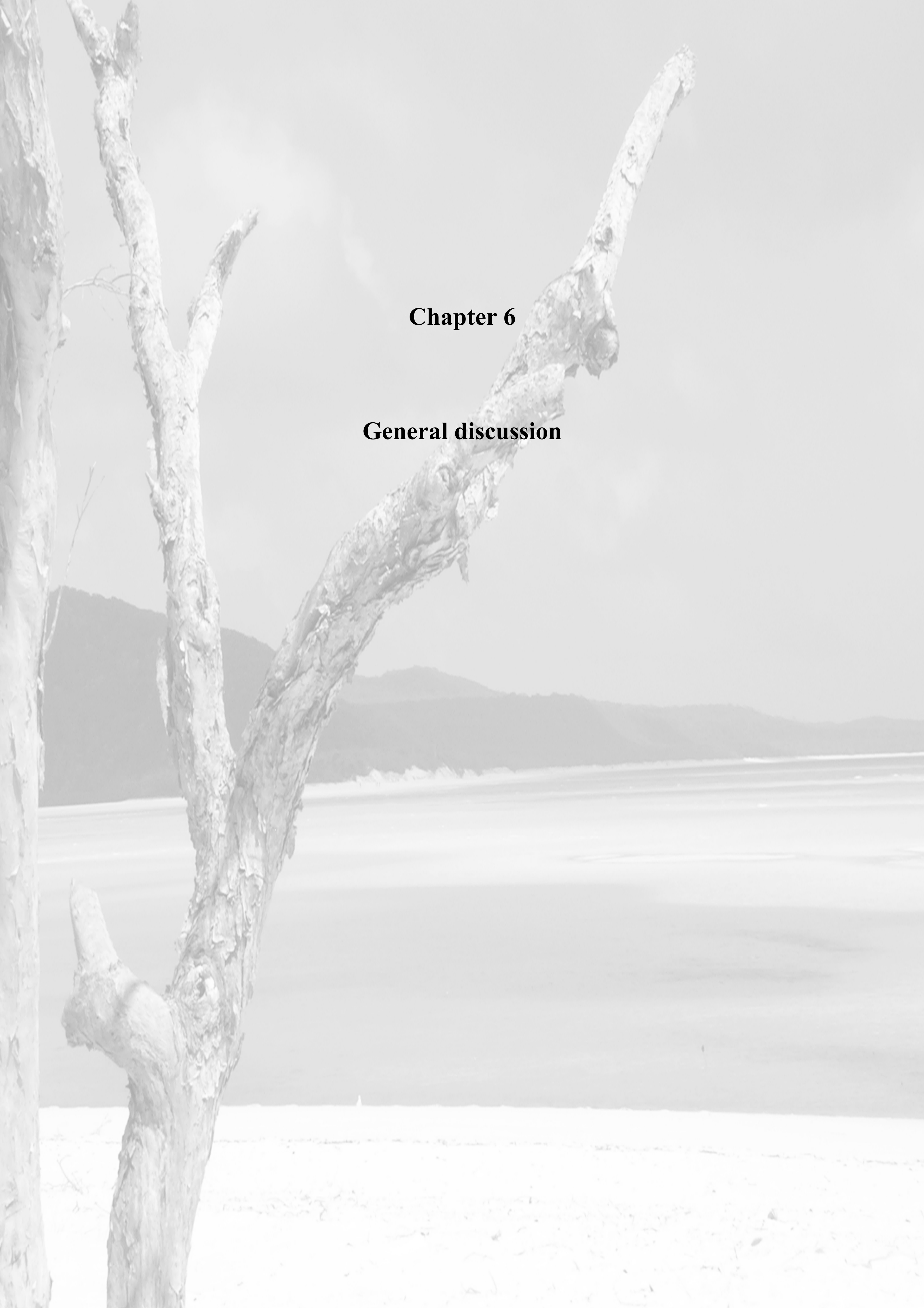

Chapter 6

General discussion

6.1 Introduction

The main objective of the research presented in this thesis was to gain insight into the conversion decision of arable farms from conventional to organic production. The main method used was (1) to develop a modelling approach that can be used for analyzing the conversion from conventional to organic arable farming systems from an economic and environmental point of view and (2) to determine the effects of influential factors and policies on the choice of farmers to convert from conventional to organic farming systems. Three questions were identified in this project:

1. Why do farmers not convert?
2. What are important influential factors with regard to conversion? What is the magnitude of them?
3. What types of incentives can be useful?

The developed modelling approach was applied to the central clay region of the Netherlands. This approach consisted of three phases. First, the conventional and organic farming systems were compared from technical, economic and environmental point of view by using a static linear programming (LP) model for each farming system. Second, in order to analyse the conversion phase of the process a dynamic linear programming (DLP) model was developed based on the two LP models. Third, to clarify the effect of production and price uncertainty of crops and the effect of farmers risk attitude on the conversion process a dynamic utility-efficient programming (DUEP) model was developed. Using these models the effect of different influential factors and policy incentives on the conversion was determined.

This chapter discusses research issues and draws the main conclusions of the thesis. In section 6.2 methodological issues with respect to farm level approach, the use of empirical and normative modelling, with emphasis on static and dynamic linear programming and dynamic utility-efficient programming models, and the problems concerning data availability for modelling purposes are discussed. Section 6.3 discusses the model results. Section 6.4 focuses on policy implications. Finally, section 6.5 presents the main conclusions on methodology and results achieved within this study.

6.2 Methodological issues

6.2.1. Farm level approach

Analysing conversion from conventional to organic production system different levels of analysis can be distinguished: field, farm and aggregated (sector, regional, national) level. In this research farm level approach is preferred to field or aggregated level, since the purpose of this research is on clarifying the influential factors on the decision making of farmers concerning conversion. This requires investigation at farm level rather than an aggregated level. Lampkin (1994) and Offerman and Nieberg (2000) argue that it is only a systems-level comparison that is meaningful: in the context of comparing organic and conventional farming systems the key issue is the difference in systems, not simply modifications in existing practices. The philosophy behind organic farming considers a farming system as one coherent whole rather then the sum of different components (soil, organic matter, plants, animals, humane etc) (Lampkin & Padel, 1994). The diversity of farms with respect to their types (i.e. arable, dairy) and specificity (i.e. soil type, size, intensity) and the difference in farmers' attitude towards conversion also suggests analysis at farm level. This makes it possible to show the effect of policies and other influential factors on the conversion, which are important, especially, for farmers who are interested firstly in consequences of their own type of farm. The main drawback for modelling at farm level is that market prices are exogenous in the model. Compared to the aggregated level there is lack of mechanism that controls demand and supply of inputs and outputs. Especially a large-scale conversion can have significant effect on market prices of inputs and outputs. This would lead to drop of prices of organic products, which would make the situation of already converted farmers worse of (see Lampkin & Padel, 2004). This can effect the conversion decision of farmers and lead to 'backward' conversion due to lower relative prices compared to conventional ones.

6.2.2. Empirical vs. normative approach

When the relationship between agricultural production methods and economic and environmental sustainability at the farm level is examined we can distinguish two main categories of models: empirical and normative models. Empirical models are understood here as econometric models, and normative models are mathematical optimization and simulation models. The main difference lies in the purpose and the use of these models. Econometric models are used for statistical testing of economic and/or technical relationships (Pindick & Rubinfeld, 1998). Normative models are based on systems of equations and/or inequalities to replicate farm-level activities related to production, marketing and finance and to explore the effect of future changes (Hazell & Norton, 1986; Weersink *et al*., 2002). The advantage of econometric models is its ability to aggregate from individual units to a large scale in a statistically consistent manner; however, the disadvantage of these types of models is its intensive data demand (Weersink *et al*., 2002). Moreover, these models are based on historical data and cannot deal easily with new technologies or new types of policy. In principle the conclusions based on such analyses are valid only for the period for which data was collected (Falconer & Hodge, 2000). In contrast, *normative* models are able to capture more detailed technical information and analyse the effects of new or even hypothetical technologies and policies that makes them suitable for what-if analyses (Van Ittersum *et al*., 1998). Beside this, in empirical models the behavioural relations are determined from the data, while in normative models the behaviour is assumed by the modeller. Since the purpose of this research is to investigate the conversion process from economic and environmental point of view and analyse the possible policy incentives on conversion based on limited availability of historical data a mathematical modelling approach was used. Several constraints, variables and activities can be added to the model and the effect of these on the conversion process can be analysed. In this study we focused on one specific farm type within a certain region, but the model can be easily adapted also to other regions and farm specificity (i.e. size, soil type).

6.2.3. The use of LP-, DLP- and DUEP -models

This research was focusing on the use of three mathematical modelling techniques: linear programming (LP), dynamic linear programming (DLP) and discrete stochastic dynamic utility-efficient programming (DUEP). All these models are mathematical optimization models. Optimization is an important feature since the farmers usually want to maximize their income, utility or minimize costs subject to several constraining factors (i.e. land, labour).

The LP modelling approach was chosen to compare established conventional and organic farming systems in a steady state. These models capture detailed economic, environmental and technical information about these two farming systems. In the developed two LP models the labour income of the farmer was maximized subject to farm specific constraints and the results of these two models were compared from economic, environmental and technical point of view. The steady state comparison, however, does not give a clear picture on whether farmers would convert to organic production, since an important phase, the transition period, is missing. The transition to organic farming is a long-term strategic decision which usually implies a planning horizon of a decade or more (Dabbert *et al.*, 2004). This means that the time aspect plays an important role while analysing the conversion of farms. The conversion period takes two years during which a farmer has to learn the new production method and adopt his farm according to the new production requirements. There is a possibility for partial or stepwise conversion, which give the farmers more time for adoption and learning the new production method. This also allows farmers to produce conventional products next to in-conversion products on part of their land to secure income to some extent during the conversion years. By modelling over time it is possible to see in which year what area of certain corps would be the best to produce from economic or/and environmental point of view and how it would develop over the years. Another reason to include the time aspect is that it gives the possibility to include different policy incentives, such as taxes and subsidies, before, during and after the conversion period. In a dynamic model the effect of these instruments on the conversion of farms can be analysed. For these reasons a DLP modelling approach was used to investigate the process of conversion and the effect of several constraining factors on the conversion of farms. The model maximized the discounted labour income of the farmer over a ten-year planning horizon.

From several studies it appears that farmers also include risk considerations in the decision whether or not to convert to organic production (Lampkin and Padel, 1994). To include risk a DUEP approach was used. This model incorporates the risk attitude of farmers towards the stochastic nature of yields and prices for conventional, transitional and organic production. The DUEP model maximizes the expected utility of the farmer over the entire planning horizon with respect to the farmers' risk attitude. This last stage could be possibly solved by using quadratic risk programming method. However, given the assumptions underlying this method it generally considered as less flexible approach then DUEP model (Hardaker *et al.*, 2004).

6.2.4. Data issues on farm modelling

Besides the applied modelling techniques data used is also critical for the model output results. In general data can be collected from case studies, experiments and survey data. The first two can be criticized on the basis of representativeness and generalizability (Lampkin and Padel, 1994). In this research survey data was used for modelling conversion. There are insufficient reliable survey data available for modelling, especially concerning new production methods. This can be a critique on the reliability of the model results. The survey data availability is improving by collection and publication of data from organic farming (FADN data collected by LEI, data from BIOM projects collected by PPO), especially for established organic systems. However, more observations are needed from in-conversion and organic farms in order to get more realistic model results.

The survey data used in this thesis concerning yield risk and also other evidence (Van (Bueren *et al*., 2002) showed that in organic farming the variance of crop yields is higher compared to conventional farming. However, the conclusion that organic yields fluctuate more than in conventional systems is not certainly a 'fact', there is also evidence in the opposite direction (Lamkin & Padel, 1994). This means that in the case organic farming would have more stable yield compared to conventional farming risk averse farmer would convert 'easier' to organic production.

Several studies show that during conversion years the yields tend to be lower than after the conversion period, and that pre-cropping have significant effect on the yields of subsequent crops (Lampkin & Padel, 1994). Since in the conversion period the main aim is to build up soil fertility, in order to get higher yields in subsequent organic crops, it is important to know the effects of pre-cropping for different crop sequences. However, the magnitude of these effects is per possible crop sequence is unknown due to the fact that survey data does not include this information separately. However, these effects are implicitly included in the data. Since the knowledge of crop sequence effects on yields could decrease the risk associated with organic farming, more efforts should be made to improve data availability in the future. Experiments could be set up to determine these effects. However, this is more costly and time consuming.

6.3 Results

6.3.1 Economic results

Economic performance is widely seen as an important factor determining the acceptance of organic systems within the farming community (Morris *et al.*, 2001). In Chapter 3 model results for arable farm showed better economic results for organic farming, due lower production costs and access to premium prices. The significant better results resulted partly from the fact that the costs of conversion were not included in the calculations. Overall profitability through longer planning horizon including the conversion period was investigated in Chapter 4. The results show that using a ten years planning horizon organic farming is still more attractive from economic point of view. However, in the case when additional constraints are included (such as extra depreciation costs, hired labour availability, lower organic market price, minimum labour income requirement) the conversion to organic farming is not always economically optimal.

Several literature studies showed that economic performance of organic farms is similar to comparable conventional farms (Mahoney *et al*, 2004; Stockdale *et al*, 2001; Offerman and Nieberg, 2000). However, significant differences in economic performance occur between different studies, countries and between farm types. Organic arable farms show remarkably high profits relative to comparable conventional farms (Morris *et al.*, 2001), mainly due to lower input costs that compensated for reduced outputs (Offerman and Nieberg, 2000). Relative profitability of conventional and organic farming system depends on the economic performance of the conventional farms used for comparison and the differences in access to premium prices for different products (Morris *et al*, 2001).

6.3.2 Price and yield risk

Swinton and Roberts (1996) (as cited in Morris *et al.*, 2001) highlight that although profitability is the main criterion used in economic comparisons, average profitability is an inadequate criterion in itself, since it ignores risk. In Chapter 5 special attention was given to the effect of future yield and price uncertainty on the conversion concerning conventional, conversion and organic crops, including farmers' risk attitude towards this uncertain outcome. The results showed that taking risk into account for a risk-averse farmer it is optimal not to convert, unless policy incentives are applied such as taxes or subsidies, or the market prices for the organic products get more stable.

In Chapter 5 the data of organic farms showed more variance in yields and prices thus higher risk than that of conventional farms. Considerable variation over time was also observed in other studies, with the organic consistently outperforming the conventional system (Morris *et al*., 2001). However, there is also evidence that risk is not unambiguously higher in organic farming (Lampkin and Padel, 1994). This fluctuation follows the same pattern in both systems, and demonstrates that external factors such as climate, prices and policies are important determinants of revenues (Offerman and Nieberg, 2000).

There are two types of considerations about risk in organic farming: higher risk, due to higher variability in organic yields and prices; and lower risk, due to more extensive farming with more diverse crop rotation (Morris at al., 2001). Even if the variance is not higher than in conventional farming many farmers perceive organic farming more risky. To adopt a new farming system, such as organic farming, means that the farmer has to make a decision surrounded by uncertainty, in which farmers' perceptions and attitudes are influential (Buck, 2001). The perceived risk may be higher because the farmer has no firsthand experience with the new method, and because the adoption of the new technology requires a substantial investment, such as the compulsory conversion process (Hardaker *et al*., 2004). The uncertainties concerning market prices for organic products are also perceived higher due to organic market conditions such as the smaller scale and immature nature of organic market. Farmers base their decisions on perceived rather then on real risk (Hardaker *et al*., 2004), which suggests to pay attention on both risk perception and real risk. One possible method to reduce the degree of risk perceived by the farmers can be by supplying relevant technical and economic information about the new production method. This would help the farmer to decide more easily which choices best suit his/her particular circumstances and risk-bearing capacity (e.g. how to cope with real risk associated with organic farming). Agricultural policy makers also need to account for risk and farmers' responses to it. Models that include risk can provide better predictions of farmers' behaviour than those that do not (Hardaker *et al* 2004).

6.3.3 Environmental results

In the last decade negative environmental impacts of agricultural production have gained importance in European agricultural policy (Dabbert *et al.*, 2004). In terms of some environmental effects, there is unequivocal evidence that organic systems perform better than conventional systems (Stolze *et al.*, 2000). In Chapter 2 the model results showed better environmental results for organic farming than for conventional concerning nutrient surpluses, pesticide use and organic matter input to the farm. In our study nutrient surpluses were calculated instead of losses, because it is easier to measure and because it was also controlled by the Dutch policy regulation called MINAS (Dutch Mineral Accounting System). Overall evidence from the literature indicates that organic farms have lower total nutrient emissions to the environment (Morris *et al.,* 2001; Anon. 1997; Cobb *et al.*, 1999). This can be explained by the fact that organic farmers, unlike conventional farmers, have an interest in minimising loss of nutrients to the environment due to limited opportunities to replace them (Morris *et al.*, 2001). However, since the relative environmental performance of organic farming differs substantially according to farming system, farm type and region (Dabbert *et al.*, 2004); and in many cases research evidence is lacking and/or produces variable results (Morris *et al.*, 2001) it is difficult to draw a general conclusion that organic farming in all cases performs environmentally better than conventional farming.

6.3.4 Policy implications

The dual societal role of organic farming should be recognized while designing policy concept for organic farming (COM, 2004). First, organic farming produces food products which consumers are willing to buy for higher prices. From this perspective the development of organic farming is governed by market rules. Second, organic farming delivers public goods such as environmental benefits, social and rural development, public health and animal welfare. From this perspective the development of organic farming can be stimulated with public means based on policy choice, (mainly on environmental policy grounds.) Both roles of organic farming contribute to the income of farmers. This means consumers give a ‘pulling effect’ and policy incentives a ‘pushing effect’ on the conversion from conventional to organic farming (Dabbert *et al.*, 2004). In this discussion the focus is made on the effect of policy incentives.

According to Lampkin and Padel (1994) financial payments during the conversion period can have a significant impact on the rate of adoption of organic farming. Within agri-environmental program (European Council Regulation 2078/92) as part of the 1992 Common Agricultural Policy reform and rural development program (Rural Development Regulation 1257/1999) of EC, organic farming can be supported in accordance with its potential to achieve a broad range of environmental and other objectives (Dabbert *et al*., 2004). Member States decide themselves about the form of implementation of this support through direct payments or provision of public services such as marketing activities, dissemination of information, supporting market integration and research. Offerman and Nieberg (2000) determined the significance of financial payments for the economic performance of organic farms throughout the EU. The absolute level of payments appeared to vary significantly between farm types and countries. Despite the importance of financial payments some countries do not provide subsidy or the amount provided is not high enough to cover conversion-induced costs (Dabbert *et al.* 2004). In the Netherlands the planned conversion subsidy during 2001-2004 under Dutch Regulation to Stimulate Organic Production Methods (Regeling Stimulering Biologische Productiemethode – RSBP) was abolished in 2003. However, due to stagnation of growth in the number of organic farms in 2003 it was open again in 2004. The reason behind the abolishment in 2003 was its lack of stimulation of farmers to convert to organic production, as was expressed by farmers in interviews (Taen *et al*., 2004). This can be explained by two main reasons: i) the subsidy was not high enough to secure the income of the farmers; or ii) other than financial motives drive the farmers to convert. In Chapter 5 the amount of financial support needed for the conversion was calculated. This appeared to be considerably higher than that provided by financial payments during the last years.

In order to reach the goal of ten percent for 2010 of organic land area of the total UAA in the Netherlands a 30% yearly growth would be required instead of the average 6.5% which was observed during the last few years (2001-2003), with a stagnation in 2004 (Taen *et al*., 2004). Based on current situation the target does not seem realistic anymore. However, policy makers still want to keep the target for stimulating reasons, e.g. ‘show’ that they care about organic farming (Taen *et al*., 2004). Due to shortage of supply in the past the direct support to farmers has been relatively overrated in organic farming policy in the EU, as also in the Netherlands (Dabbert *et al*., 2004). Currently there is a new action plan for Dutch organic farming for the period of 2005-2007 (MINLNV, 2005). This action plan aims to integrate both the demand and supply side focusing on market expansion and providing direct payments for farmers. This integrated, more balanced action plan is prioritized at the moment in the EU as a whole (Dabbert *et al.*, 2004).

The decision to convert is a long-term strategic decision for the farmer. This means that attractive support measures are necessary for a long time horizon. Differentiation of payments between farm types and regions might be justified (Dabbert *et al.*, 2004). However, a more stable institutional environment is necessary in order to reduce the institutional risk associated with changing short- and medium-term policy design. The current uncertain, in-transparent subsidizing leads to a source of risk which might hinder the conversion of farms. This means that without a proper long-term policy uncertainty is high for farmers. This has a negative effect on the decision to convert.

Other instruments, such as taxes on conventional production (i.e on fertilizers, pesticides) could be more effective than subsidies, since they are giving continuous motivation for farmers to change his management to more environmentally friendly production method (Folmer *et al.*, 2000). It does not necessarily motivate them to convert to other production, such as organic, rather than just to have more effective management practice and switch the input use to more environmentally friendly one. This suggest that policy measures stimulating conversion should take into account the already existing policies, which drives conventional farming closer to organic farming. This can be even more efficient in tackling certain environmental goals than organic farming.

6.4 Main conclusions

The following general conclusions can be drawn from the methodologies used in this thesis:

- Mathematical modelling, including LP, DLP and DUEP, is a suitable tool for analysing the interactions between management measures and production intensity on one hand, and farm income and environmental aspects on the other hand. Moreover, it is a useful tool for determining the implications of different policy options at farm level on economic and environmental aspects of farming.
- Linear programming is a good tool to compare different farming practices in a steady state situation from an economic and environmental point of view.
- For modelling conversion of farms from conventional to organic farming the inclusion of time is important for two main reasons: (i) conversion is a strategic decision including an investment in the form of the compulsory two years conversion period, and (ii)

government intervention can play a role before, during and after the conversion. For these reasons a dynamic linear programming appears to be a suitable tool for analysing the conversion period of farms.

- Risk and uncertainty in yield and price of future conventional and organic crops play an important role in the decision to convert to organic farming. The dynamic utility-efficient programming model is a suitable tool to incorporate dynamic and stochastic risk aspects in the model and to analyse the conversion and the effect of different policy incentives on the conversion.

The following general conclusions can be drawn from the results of this thesis:

- In a steady situation organic farming appears to be more profitable than conventional farming. Besides, organic farming shows less intensive land use and better environmental results.
- The conversion period shows a considerable income drop due to lower yields and no premium prices. This needs more attention from policy makers to help the farmers through this period.
- Price and yield risk play an important role while deciding about conversion. These aspects should be taken into account while analysing conversion.
- The more risk averse the farmer is the stronger the incentives need to be to make the farmer convert to organic production.
- The policy environment concerning organic farming is not stable over the years. This contributes to uncertainty and it makes the decision to convert more difficult for the farmers.

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Summary

Background and problem definition

Society and governments in many countries show an increasing concern about food production due to environmental problems, animal welfare and human health problems. These problems have induced many governments in the world to promote more sustainable farming systems, such as organic farming. Organic farming in European Union (EU) showed rapid growth in the last few decades due to policy incentives and consumer demand. However, the overall significance of organic farming in the EU context is still quite small in terms of land area used. In some EU member states, such as in the Netherlands, the last few years the conversion from conventional to organic farming was progressing more slowly than the government expected. In order to stimulate the conversion, policy makers need more information about the process of conversion. Factors that motivate and hamper the conversion of farms have to be investigated in more detail.

This study aims to gain more insight in the economics of conversion. The research attempts to answer the following three sub-questions:

1. Why do the farmers not convert?
2. What are the important influential factors of conversion? What is the magnitude of them?
3. What types of incentives can be useful to stimulate conversion?

The main objective of this research was to answer the above questions by means of (1) developing a modelling approach that can be used for analyzing the conversion from conventional to organic arable farming systems from economic and environmental point of view and (2) determining the effects of influential factors and policies (incentives) on the choice of farmers to convert from conventional to organic farming systems. The models were developed for a typical arable farm in the central clay region in the Netherlands.

Four phases were identified in the research project (see Figure 6.1 for phase 2 to 4):

1. A thorough review of scientific literature on economics of conversion in order to identify the most suitable method to analyse the conversion process.
2. The development of a static bio-economic linear programming model at farm level in order to compare conventional and organic arable farming systems from economic and environmental point of view.

3. The development of a dynamic linear programming model in order to analyse the conversion process from conventional to organic farming system taking into account the factors influencing conversion.
4. The inclusion of production and price uncertainty of crops and analysis of the effects of these uncertainties taking into account farmers risk attitude on the willingness to convert.

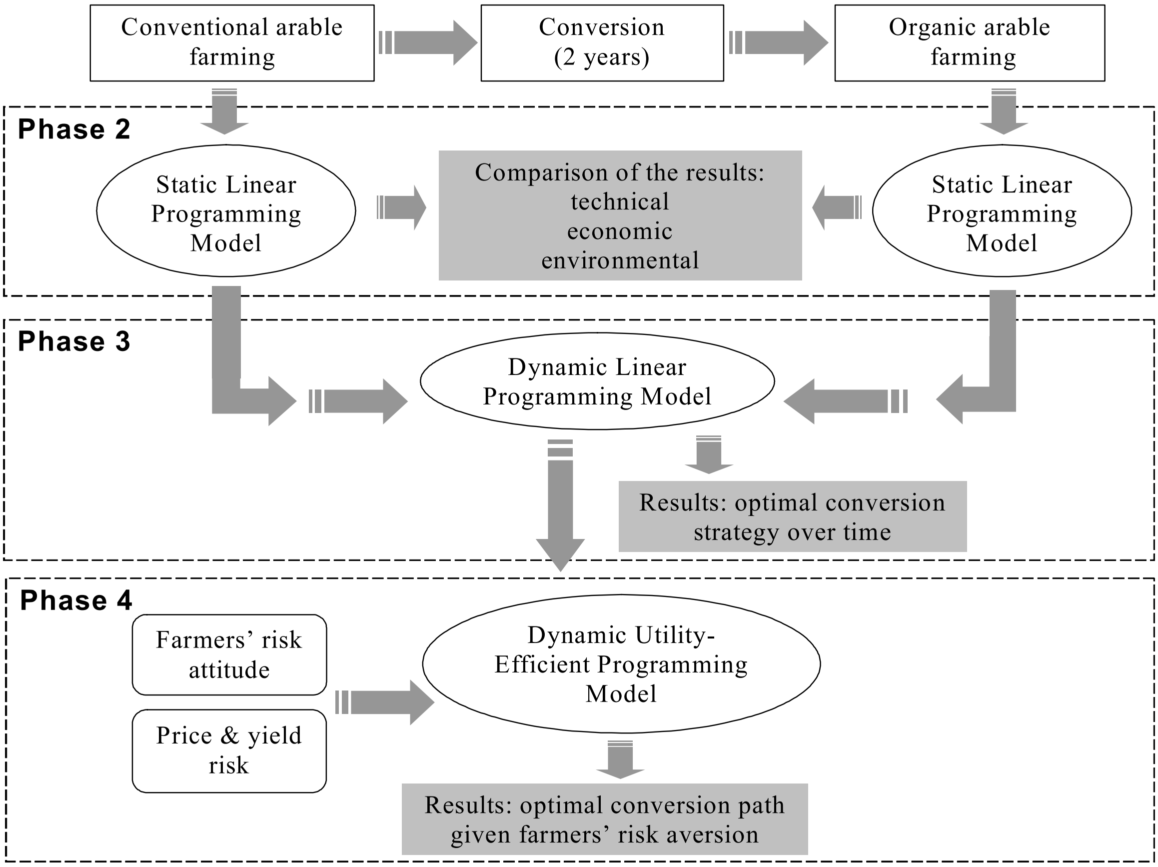

Figure 6.1 Research outline

Literature review

Chapter 2 reviews scientific literature on the evaluation of the technical, economic and environmental aspects of conversion from conventional towards more sustainable production, such as organic farming. Methods and results of empirical and normative modelling studies at the farm level, with special regard to farm management and policy, are analysed. Empirical studies show the importance of incentives via agricultural policy, and the usefulness of integrated modelling for determining the effects of different policies on farm management.

Normative modelling shows the effects of new policy instruments and technology, and allows the high level of detail needed for what-if analysis. Normative models of conversion to organic farming confirm the importance of incentives and the agricultural policy context. Since the purpose of this research is to investigate the conversion process from economic and environmental point of view and to analyse possible policy incentives on conversion and since there is limited availability of historical data a mathematical modelling approach suits best for this research.

Comparison of conventional and organic farming

In Chapter 3 a comparison of the conventional and organic arable farming system is made by using a normalised situation (same area, soil type, climate, etc.). In this phase a linear programming model (LP) of a conventional arable farm and of an organic arable farm in the central clay region of the Netherlands is developed. The models include environmental externalities such as losses of nutrients and pesticide use, the levels of which can be influenced by using different production structures (cropping plans). With the conventional model two different crop rotations (3-year and 4-year), and with the organic model one rotation (6-year) are analysed and the technical, economic and environmental results of these three situations are compared. The results show that organic farming leads to less intensive land use, better environmental results and better economic results. Expenditure on hired labour is much higher in organic farming which also leads to higher variable costs. Prices for organic products are higher than for similar conventional products, but lower yields and the less intensive cropping plan mitigates the effects on total revenues.

Conversion process from conventional to organic farming

The results of Chapter 3 and several other studies show that organic farming is more profitable than conventional farming. However, in reality not many farmers convert to organic farming. The objective of Chapter 4 is to develop a dynamic linear programming (DLP) model in which the conversion period between conventional and organic farming is included. This model is based on the LP-models from Chapter 3. By the use of this model the effects of different limiting factors on the conversion process of farms are analysed. The DLP describes the conversion process of a farm over time by maximizing the net present value over a ten-year planning horizon. There a three phases in the model, the conventional, the conversion and the organic farming phase. The solution of the model provides a complete decision strategy for the farmer for the whole panning horizon for each year. Next to the optimal cropping plan it provides information on the labour allocation, nutrient and pesticide purchase, nutrient losses, organic matter input to the farm and the costs and revenues of the production. It shows whether partial or complete conversion, one-step or stepwise conversion is more profitable.

The results of the analysis of the basic scenario show that conversion to organic farming is more profitable than staying conventional. However, the income difference is much smaller than that in Chapter 3. In order to get to the really profitable phase of organic farming the farmer has to get through the two years conversion period, which is economically difficult due to lower yields and no premium prices. Sensitivity analysis show that if extra depreciation costs would occur due to superfluous machinery because of conversion, which would be higher than 25% of conventional fixed cost conversion is less profitable then staying conventional. Also the availability of hired labour, which can be constrained in peak periods, has a strong effect on the cropping plan and on the area converted. Further analysis show that slight drop (2%) of organic prices lower the labour income of the farmer and make the conversion less profitable than conventional farming. For the farmers a minimum labour income can be a requirement to ‘survive’. The analyses show that a constraint on minimum labour income suggests stepwise conversion for the farmers to overcome the economic difficulties during the conversion period.

Effect of yield and price risk and farmers’ risk attitude on the conversion of farms

Studies suggest that the main sources of risk for both conventional and organic farmers are the output price and production risk. In arable farming in the Netherlands there is a large variation between the years in crops’ gross margin of conventional, conversion and organic crops. This is mainly caused by large revenue (yield and output price) variation across the years. Differences in variation between conventional, conversion and organic crops are caused mainly by different management practices (i.e. restrictions on pesticide use and fertilizer) and by different market opportunities and prices for the products. This suggests that it is important to take into account the variation of revenue while analysing the conversion to organic farming. There is quite some literature on inclusion of risk in agricultural farm models, however, very few studies have tackled the issue of risk and uncertainty in organic farming.

In Chapter 5 a discrete stochastic dynamic utility-efficient programming (DUEP) model is developed which includes yield and price uncertainty before, during and after the conversion years. The DUEP model is based on the developed DLP model of Chapter 4. The model maximizes the expected utility of the farmer over a ten-year planning horizon depending on the farmers' risk attitude. Sensitivity analysis for different factors such as policy incentives, market stabilization for organic products or learning effect of farmers were carried out. The results show, that for a risk-neutral farmer it is optimal to convert to organic farming, however for a risk-averse farmer it is only optimal to convert if policy incentives are applied such as taxes on pesticides or subsidies on conversion, or if the market for the organic products gets more stable. The more risk averse the farmer is, the more incentive is needed to make the farmers convert to organic farming. Although this seems obvious, the risk aversion of the farmers is neglected easily. This model provides the basis to determine such incentives.

Main conclusions

The following general conclusions can be drawn from the methodologies used in this thesis:

- Mathematical modelling, including LP, DLP and DUEP, is a suitable tool for analysing the interactions between management measures and production intensity on one hand, and farm income and environmental aspects on the other hand. Moreover, it is a useful tool for determining the implications of different policy options at farm level on economic and environmental aspects of farming.
- Linear programming is a good tool to compare different farming practices in a steady state situation from an economic and environmental point of view.
- For modelling conversion of farms from conventional to organic farming the inclusion of time is important for two main reasons: (i) conversion is a strategic decision including an investment in the form of the compulsory two years conversion period, and (ii) government intervention can play a role before, during and after the conversion. For these reasons a dynamic linear programming appears to be a suitable tool for analysing the conversion period of farms.

- Risk and uncertainty in yield and price of future conventional and organic crops play an important role in the decision to convert to organic farming. The dynamic utility-efficient programming model is a suitable tool to incorporate dynamic and stochastic risk aspects in the model and to analyse the conversion and the effect of different policy incentives on the conversion.

The following general conclusions can be drawn from the results of this thesis:

- In a steady situation organic farming appears to be more profitable than conventional farming. Besides, organic farming shows less intensive land use and better environmental results.
- The conversion period shows a considerable income drop due to lower yields and no premium prices. This needs more attention from policy makers to help the farmers through this period.
- Price and yield risk play an important role while deciding about conversion. These aspects should be taken into account while analysing conversion.
- The more risk averse the farmer is the stronger the incentives need to be to make the farmer convert to organic production.
- The policy environment concerning organic farming is not stable over the years. This contributes to uncertainty and it makes the decision to convert more difficult for the farmers.

Samenvatting

De voedselproductie ondervindt in veel westerse landen toenemende mate van kritiek vanwege problemen op het vlak van het milieu, dierwelzijn en volksgezondheid. De biologische landbouw wordt als een mogelijke oplossingsrichting gezien. Deze wordt sinds midden jaren negentig van de vorige eeuw door veel nationale overheden gestimuleerd. Dit heeft geleid tot een forse groei van het areaal biologische landbouw. In Nederland is deze groei de laatste jaren vertraagd. In het licht van mogelijke vormen van overheidsbeleid om biologische landbouw te stimuleren komen de volgende vragen op:

1. Waarom stappen boeren niet over naar biologische landbouw?
2. Wat zijn belangrijke factoren in de besluitvorming om wel of niet over te stappen en wat is de de bandbreedte van deze factoren?
3. Welke soorten overheidsbeleid zijn bruikbaar voor het stimuleren van conversie naar biologische landbouw?

Het hoofddoel van dit onderzoek was het beantwoorden van bovenstaande vragen voor Nederlandse akkerbouw door middel van (1) het ontwikkelen van een model van een akkerbouwbedrijf dat gebruikt kan worden om de conversie naar biologische landbouw vanuit economisch en milieutechnisch perspectief te analyseren en (2) het vaststellen van mogelijke effecten van belangrijke factoren en beleidsmaatregelen op de beslissing al dan niet tot conversie over te gaan aan de hand van berekeningen met het ontwikkelde model. Het ontwikkelde model is een afspiegeling van het typische akkerbouwbedrijf in het centrale zeekleigebied in Nederland, dat wil zeggen een bedrijf van 48 ha met een gemiddeld bouwplan.

De eerste stap in het onderzoek was een literatuuronderzoek naar technische, economische en milieutechnische analyses van conversie naar biologische landbouw, teneinde zicht te krijgen op bruikbare methoden om bovenstaande vragen te onderzoeken (H2). Het beschikbare modelonderzoek viel uiteen in empirisch, econometrisch onderzoek en normatief modelonderzoek. De conclusie van het literatuuronderzoek was dat, gezien de wens verschillende deels nieuwe vormen van overheidsstimulering te onderzoeken en gezien de relatief geringe beschikbaarheid van data, normatief modelonderzoek het meest geschikt is voor het onderhavige onderzoek.

De volgende stap was een statische vergelijking van een conventionele en een biologische geoptimaliseerde bedrijfssituatie onder de veronderstelling van dezelfde bedrijfsgrootte, grondsoort en weersomstandigheden (H3). Voor beide bedrijfssituaties is een lineair programmeringsmodel (LP) opgesteld met als doelstelling maximalisering van de arbeidsopbrengst van het gezin (1,1 VAK). Naast de verschillende mogelijke gewassen die verbouwd kunnen worden bevatten de modellen telrijen voor het bepalen van de nutrientenverliezen en het pesticidegebruik. Met het conventionele bedrijfsmodel is een 3- en een 4-jarige rotatie geoptimaliseerd en met het biologische model een 6-jarige rotatie.

Vergelijking van de resultaten liet zien dat de biologische bedrijfsvoering leidt tot een minder intensief grondgebruik en tot substantieel betere economische en milieutechnische resultaten.

De statische vergelijking in H3 gaat voorbij aan het feit dat een beslissing om te converteren betekent dat het bedrijf een periode van twee jaar door moet waarin al wel volgens biologische voorschriften geproduceerd dient te worden terwijl de gerealiseerde lagere productie nog niet als biologisch aangemerkt mag worden. Dit betekent hogere kosten en lagere opbrengsten en dus een lagere abeidsopbrengst. Om dit aspect mee te nemen in de analyse is in H4 een dynamisch lineair programmeringsmodel (DLP) ontwikkeld, gebaseerd op de twee LP-modellen van H3. Het DLP-model maximaliseert de gedisconteerde arbeidsopbrengst van het gezin over een periode van 10 jaar. Het model bevat drie mogelijke fasen. Er wordt altijd gestart met een conventionele productie als eerste fase. Na het eerste jaar kan het bedrijf conventioneel blijven of in conversie gaan. Conversie kan ineens voor het bedrijf als geheel plaatsvinden, maar ook stapsgewijs. Op de conversiefase van twee jaar volgt de biologische fase voor de rest van de 10 jaar. De resultaten geven aan dat conversie naar biologische bedrijfsvoering economisch aantrekkelijker is dan conventioneel blijven. Het verschil in arbeidsopbrengst is echter aanzienlijk lager dan het verschil dat volgde uit de statische vergelijking (H3). Dit komt met name door de twee conversiejaren met een negatieve arbeidsopbrengst. Gevoeligheidsanalyse laat zien dat 2% lagere prijzen voor biologische producten het voordeel doet omslaan naar conventionele landbouw, dat een minimumeis voor de arbeidsopbrengst in de conversiejaren leidt tot stapsgewijze conversie en dat beperking van beschikbare losse arbeid leidt tot een omschakeling voor slechts een deel van de bedrijfsoppervlakte.

In de berekeningen in H3 en H4 is steeds uitgegaan van de arbeidsopbrengst als criterium. Deze is ondermeer gebaseerd op de gemiddelde productie en de gemiddelde opbrengstprijs per ha gewas. Een eventueel risicoverschil wat het gevolg kan zijn van een verschil in variatie in producties en prijzen blijft hiermee buiten beschouwing. Omdat uit beschikbare LEI-data blijkt dat de variatie in opbrengsten groter is in de biologische landbouw en omdat uit onderzoek bekend is dat boeren in het algemeen risicomijdend zijn is in H5 het DLP-model uitgebreid met de opname van risico tot een DUEP (Dynamic Utility Efficiënt Programming) model. Arbeidsopbrengst wordt daarbij in nut (utility) omgezet volgens een relatie die afhankelijk is van de risicohouding. Voor een risico-averse houding is deze relatie kromlijnig wat betekent dit het marginaal nut van extra arbeidsopbrengst afneemt bij een stijgende arbeidsopbrengst. Door voor een plan meerdere berekeningen van het resulterende nut te maken, gebaseerd op verschillende opbrengsten met elk een waarschijnlijkheid, kan het gewogen gemiddelde nut van een plan bepaald worden. Dit gewogen gemiddelde nut is in het DUEP-model het criterium op basis waarvan het optimale plan bepaald wordt. De resultaten op basis van de LEI-data voor wat betreft de variatie in opbrengsten laten zien een geringe mate van risico-aversie al leidt tot de beslissing om conventioneel te blijven. Subsidies op conversie (minimaal € 2737 per ha ineens) of een heffing op pesticidegebruik (€ 23 per kg actieve stof) zijn vormen van overheidsbeleid om het voordeel weer te laten omslaan naar conversie. Hetzelfde wordt bereikt door een stabielere markt voor biologische producten en door een hogere gemiddelde productie voor biologische productie.

Uit deze studie zijn een aantal conclusies te trekken voor wat betreft de gebruikte methode en de verkregen resultaten. De belangrijkste conclusies zijn:

- Optimaliseringsmodellen (LP, DLP en DUEP) zijn bruikbare modellen om de interactie tussen management en productie-intensiteit enerzijds en arbeidsopbrengst en milieuresultaat anderzijds te analyseren. Bovendien zijn het bruikbare instrumenten om de implicaties van overheidsbeleid voor bedrijven te kwantificeren;
- De sterke daling van de arbeidsopbrengst in de conversiejaren en het grotere opbrengstrisico (bestaande uit productie- en prijsrisico) in de biologische productie zijn belangrijke factoren die conversie naar biologische akkerbouw negatief beïnvloeden.

Publications

List of Publications

Peer-reviewed scientific papers

Acs, S., P.B.M. Berentsen, M. de Wolf, R.B.M. Huirne 2006. Comparison of conventional and organic arable farming systems in the Netherlands by means of bio-economic modelling. Accepted for publication in *Biological Agriculture and Horticulture*

Acs, S., P.B.M. Berentsen, R.B.M. Huirne 2006. Conversion to organic arable farming in the Netherlands: a dynamic linear programming analysis. Submitted to *Agricultural Systems*

Acs, S., P.B.M. Berentsen, R.B.M. Huirne 2006. Effect of yield and price uncertainty on conversion from conventional to organic farming. Submitted to *American Journal of Agricultural Economics*

Acs, S., P.B.M. Berentsen, R.B.M. Huirne 2005. Modelling conventional and organic farming, a literature review. *Wageningen Journal of Life Sciences,* NJAS 53-1

Conference papers

Acs, S., P. Berentsen, R. Huirne 2005. Bio-economic modelling of conversion from conventional to organic arable farming system in the Netherlands. 15th IFOAM Organic World Congress, 21-23 September 2005, Adelaide, Australia

Acs, S., P. Berentsen, M. de Wolf, R. Huirne 2004. Bio-economic modelling of arable farming system, comparison of conventional and organic farming systems in the Netherlands. The Agricultural Economics Society 78th Annual Conference, 2-4 April 2004, Imperial College London, UK

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Kovacs, A., Acs S., 2000. Economic analysis of nitrogen circulation by LP model. VII. International Agricultural Economic Conference, Gyöngyös, Hungary

About the Author

Szvetlána Ács was born on 26 February, 1977 in Budapest, Hungary. In 1995 she finished her secondary education in Körösi Csoma Sándor Bilingual (Russian-Hungarian) Grammar School in Budapest. In the same year she began her study at Szent István University at the Faculty of Economical and Social Sciences, Gödöllő, Hungary. In 2000 she graduated and got her MSc diploma in Agricultural Economics and Management. After her graduation she was working at the Department of Farm Management and Economics on the research project entitled "Planning of agricultural enterprises with special emphasis on nutrient economy". During this period she visited and carried out research at Business Economics Group, Wageningen Unversity, first, as an Erasmus student for a period of 3 month, and later as a researcher for a year financed by Dutch Ministry of Agriculture and Fisheries (IAC grant) and Mansholt Graduate School. From January 2002 till February 2006 she has been employed as PhD researcher in the Business Economics Group. The focus of her PhD project was on "Bio-economic Modelling of Conversion from Conventional to Organic Arable Farming." During this period she followed her PhD education program in the Mansholt Graduate School of Wageningen University and in the Netherlands Network of Economics (NAKE - Graduate program in Economics and Econometrics). She completed the full NAKE program and received her NAKE diploma in 2006.

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