BIO-ECONOMIC MODELLING OF CONVERSION FROM CONVENTIONAL TO ORGANIC ARABLE FARMING SYSTEM IN THE NETHERLANDS

S. Acs [a], P.B.M. Berentsen [a] and R.B.M. Huirne [b]

[a] Business Economics Group, Department of Social Sciences, Wageningen University

Hollandseweg 1., 6706KN Wageningen, The Netherlands, Email: szvetlana.acs@wur.nl

[b] Animal Science Group, Wageningen University, Edelhertweg 15, 8200 AB Lelystad, The Netherlands

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. Some governments in Europe have recognized and responded to these potential benefits by encouraging farmers to adopt organic farming practices, either directly through financial incentives or indirectly through support for research, extension and marketing initiatives. Currently policy makers and farmers do not have a clear insight in the effect of certain influential factors which might stimulate or hamper the conversion to organic farming. Different modelling approaches were used in literature to study the conversion but the majority of normative studies do not include the time aspect in the model, which is an important element to study the conversion period. In this paper a model is presented to analyze the conversion process of farms over time.The objective of this paper is to analyse the effect of different influential factors on the conversion process of arable farms in the Netherlands. For this purpose a dynamic linear programming (DLP) model is developed.

2. Method

2.1. Model specification

In order to analyse the conversion from conventional to organic farming system over time a dynamic linear programming (DLP) model was developed for a typical arable farm at the Central Clay Region in the Netherlands. General structure of the DLP model is summarized as follows (Hazell & Norton, 1986):

Maximize $Z = \delta_t \sum_t [(c_t{'}x_t) - f_t]$, where $\delta_t = \left(\frac{1}{1+i}\right)^{t-1}$

Subject to: $A_t x_t \leq b_t$

and $x_t \geq 0$

where:

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. activities for annual crops). The link between the years is provided by the conversion of the land area and the objective function.

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

The constraints of the model are land availability, rotation restrictions, conversion restrictions, supply and demand of family and of seasonal labour, nutrient balance calculation for MINAS (Dutch Mineral Accounting System) regulation, several counting rows for pesticides use and organic matter input to the farm.

There are some technical constrains concerning the dynamic aspect of the model. The first year the model is restricted to produce only in conventional way. 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 before it becomes organic land area. The model decides how much land goes from conventional into conversion.

The objective function of the model is to maximize the sum of discounted labour income over 10 years planning horizon, where the annual labour income is discounted to the 1st year. In the basic situation we assume a 4% discount rate. Labour income includes revenues of produced crops minus variable and fixed costs. 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 fertilizers), hired labour costs and nutrient taxes. Fixed costs include costs of land, machinery and buildings.

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 Central Clay Region in the Netherlands.

The input data for the model concerning conventional, conversion and organic costs, revenues, labour, nutrient and pesticide use per crop on clay soil were collected from the Kwantitatieve Informatie Akkerbouw en Vollegrondsgroenteteelt (KWIN, 2002). For conversion crops organic production yields and costs and conventional crop prices were used.

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 characterizing the region. For conversion and organic production 1:6 crop rotation is used. This more diverse crop rotation is a requirement for organic farming.

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. Apart from family labour there is the option of hiring skilled and unskilled seasonal labour.

The fixed costs are based on the costs of a farm in this region with 48 ha land area. These costs concern basic machinery, buildings and typical cropping plans, and are calculated separately from the DLP model. These costs are connected to the type of farming (conventional, organic).

More detailed information concerning input data for rotation constraints, family labour use, fixed costs, nutrient balance, organic matter input concerning conventional and organic production methods can be found in Acs *et al.* (2005).

2.3. Model output

The solution of the model provides a complete decision strategy for conversion over the planning horizon of 10 years, telling how many hectares of each crop to grow every year. It gives directions about which year and how many hectares to convert (in case of conversion). Next to the optimal production plan, the model provides information on the labour allocation, nutrient and pesticide purchase, nutrient losses, organic matter input to the farm and the economic consequences of the production.

2.4. Setup of the calculations

First, calculations are made for a basic situation of the DLP model in which no external factors influence the conversion. Second, in order to investigate the effect of some limiting factors, in addition to the basic situation, brake-even analysis is made in order to test the effect of these factors on the conversion process. In this analysis different situations are tested and the brake-even points are determined.

In this paper two main influential factors are investigated:

1. Hired seasonal labour availability

In the basic model no limit on hired labour availability was assumed. In conversion from conventional to organic farming there is an increase in the labour demand. In some regions (with a lot of organic farming or other labour intense activities) the availability of labour can be a problem. This is mainly because of the low skill requirements and the usually boring work (mainly by hand) that should be done on organic farms. In order to analyse the effect of seasonal labour availability in the region, the hired labour availability is constrained on 80, 160, 240 etc. hours per fortnight. This new situation is called 'hired labour limit'.

2. Minimum labour income requirement

In the basic situation there is no minimum labour income requirement in the model. However financial difficulty during the conversion to organic farming can be substantial. In this period the farmer can not get higher organic prices for organically produced crops, but he still has the associated lower yields. In conversion years the farmer has to cultivate crops which are good for the soil fertility, nutrient accumulation etc. but economically less attractive. In the case of extra investment in machinery for organic farming and disinvestment of machinery for conventional farming the fixed costs also might rise after the conversion. These effects drastically bring down the income of the farmer. In order to analyse how the conversion would proceed, in the case of minimum labour income requirement per year, a new situation is tested, called 'minimum labour income'. A minimum condition is set for the labour income for each year. This amount is the same over the years. Different limits are tested to find the brake-even point where the farmer switches to organic production.

3. Results of the DLP model

3.1. Basic model

According to the basic model results the optimal plan of the farm would be a one step conversion of the whole land area into organic production in the second year (the first year is fixed as conventional) and then produce organically from year four to ten.

In the first conventional year winter wheat, seed potato, ware potato, seed onion and carrot is produced in three-year crop rotation. In the second year the farm converts at once and the crops are cultivated in an organic way. In these two years of conversion spring wheat, seed potato, seed onion, sugar beet and alfalfa are grown, which gives an optimal plan for the farmer from economic point of view. The difference, compared to the conventional cropping plan, comes from the crop rotation restrictions, which are 1:6 instead of 1:3, the lower yields and the conventional prices, and the costs of organic production of the crops. In the organic year instead of sugar beet carrot and green pea is produced. The fact that sugar beet got into the rotation in conversion years is explained by the higher gross margin compared to carrot or green pea, which were not as profitable due to the lower, conventional, prices.

The output of the model shows that the family labour is fully used every year. In conversion from conventional to organic farming there is an increase in the labour demand. In peak period (summer) in organic farming at least 7-8 additional units of labour (with 80 hours per fortnight) are needed, in addition to the family labour (with 158 h/fortnight). In the conventional situation 1 additional unit of labour is required at a maximum.

Economic results (see Figure 1) show that the organic crop production brings more then two times higher labour income compared to the conventional production. In such a situation, the farmer would prefer to produce organically. But for this he has to get through the two years of conversion with a substantial negative labour income, which is due to lower yields and no premium prices.

3.2. Brake-even analysis

According to different influential factors on the conversion to organic farming two situations were examined:

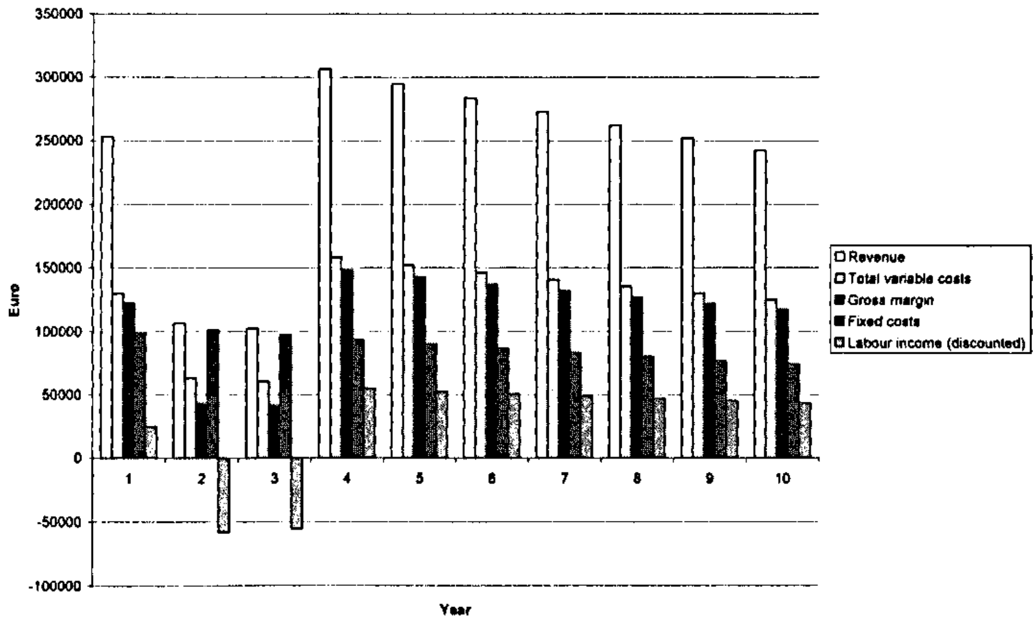
1. Situation 1. Hired labour limit: Restriction on hired labour availability per fortnight in hours. The brake-even analysis provides:
    - If there is 0-1 hired labour per fortnight available then there is no conversion to organic farming.
    - If there are 2 to 5 hired labour per fortnight available then there is partial conversion to organic farming (58-95% of the total cultivated land area).
    - If there are more then 5 hired labour per fortnight available then there is total conversion to organic farming.

   In the case of conversion one-step conversion takes place.
2. Situation 2. Minimum labour income: The brake-even analysis provides:
    - If allow labour income lower then -20000 Euro/year then there is total conversion to organic farming.

- If don't accept labour income lower then -20000 and allow lower then 0 Euro/year then there is partial conversion to organic farming (92% of the total cultivated land area).
- If don't accept labour income lower then 0 Euro/year then there is no conversion to organic farming.

In the case of conversion step-wise conversion takes place.

Figure 1. Discounted economic results form the DLP model (4% discount rate).



4. Conclusion

This study shows that it is important to study the conversion to organic farming with a modeling technique that enables to include the time effect in the model. DLP model is a suitable tool for making such investigations.

As a hypothetical case study based on a typical farm, characterizing the Central Clay region in the Netherlands, this study illustrates by DLP model how a conversion from conventional to organic farming could have occurred. The results of the analysis of the basic situation, without any restriction, show that on a long run conversion to organic farming is more profitable. However, in order to get this higher income the farmer has to get through the two years conversion period, which is economically difficult due to lower yields and no premium prices.

In the case when additional constraints on conversion are included in the basic situation the conversion to organic farming not always economically optimal. Two constraining factors were investigated, such as hired labour limit and minimum labour income requirement. The results of the analysis show that the availability of hired labour has a strong influence on conversion process. A constraint on minimum labour income requirement suggests stepwise conversion for the farmers to overcome the economic difficulties during the conversion period.

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