

Farm-Specific Factors Affecting the Choice Between Conventional and Organic Dairy Farming

Cornelis Gardebroek

E-mail: koos.gardebroek@alg.aae.wau.nl



**Paper prepared for presentation at the Xth EAAE Congress
'Exploring Diversity in the European Agri-Food System',
Zaragoza (Spain), 28-31 August 2002**

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Cornelis Gardebroek
Department of Social Sciences
Agricultural Economics and Rural Policy group
Wageningen Agricultural University
Hollandseweg 1, 6706 KN Wageningen, The Netherlands
tel. +31 317 482951
fax. +31 317 484736
E-mail: koos.gardebroek@alg.aae.wau.nl

Abstract

Organic dairy farming in the Netherlands is a growing sector. This paper investigates the impact of a number of economic and farm-specific variables on the choice between conventional and organic farming. Based on expected utility maximisation, a theoretical framework is developed that explicitly accounts for the impact of non-economics variables like age and education level and unobserved characteristics. The model is estimated with an unbalanced panel of Dutch dairy farms using a random effects probit specification.

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1. Introduction

In the Netherlands, the number of organic dairy farmers has increased rapidly in recent years. The number of specialised organic dairy farmers has increased from 158 (0.5% of total number of specialised dairy farmers) in 1995 to 434 (1.6% of total) in 2000 (Statistics Netherlands, 2001). A potential explanation for the increased interest of farmers in organic farming is the sequence of crises in agriculture (BSE, foot-and-mouth disease). After these crises some farmers may have come to the conclusion that the conventional way of farming is not sustainable. Other explanations are the high premium price of organic milk, the explicit government support by investment subsidies, tax benefits and income support during the transition period or the increased environmental legislation that reduced the difference between conventional and organic farming systems, making it easier for farmers to switch. The Dutch ministry of agriculture has even set a policy target for the number of organic farmers in 2010. By that time 10% of the Dutch farmers should farm organically (LNV, 2000). However, although some farmers apparently have an interest in organic farming and the Dutch government is stimulating switching from conventional to organic farming, still little is known about the motivation of farmers to switch and the barriers for switching to organic farming. Knowledge about this motivation and potential barriers may help policy makers in formulating effective policies for stimulating organic farming. This paper investigates the role of a number of farm-specific variables in the choice between conventional and organic dairy farming.

A farmer's decision on whether to farm conventionally or organically can be considered as a choice between two available technologies. Given the importance of technology in agriculture, economists have paid considerable attention to the analysis of technology adoption. Sunding and Zilberman (2001) provide an extensive review of the literature on technology adoption. A popular approach to analysing technology adoption is by using binary choice models (see e.g. D'Souza et al., 1993; Burton et al., 1999). Usually, a set of economic and other variables (e.g. age, education) is used to explain the difference between the groups of adopters and non-adopters. What is often lacking in these studies is a theoretical motivation for including a set of variables in the model. For example, the role of age and education in adoption decisions is often not made clear. This paper presents a theoretical framework that explicitly accounts for the role of personal characteristics in adoption decisions.

The paper is built up in the following way. In section 2 a theoretical model for the choice between conventional and organic farming is presented. Section 3 discusses a number of estimation issues. In section 4 information on the data set that is used in this study is given followed by a presentation of the estimation results in section 5. Finally, in section 6 some concluding comments are given.

2. A theoretical framework for the choice of organic farming

In this section a theoretical model explaining the choice between conventional and organic farming is presented. Although the interest in this paper is in dairy farming, the theoretical model presented in this section is more general applicable.

Each time period a farmer decides whether to farm conventionally or organically. Since farmers in the Netherlands can switch and switch back at any time this is a reasonable assumption. Note that when a farmer decides to switch to organic farming he faces a transition period of about two or three years in which he uses organic production techniques but where the produce cannot be sold as organic. This implies that organic premium prices cannot be obtained yet, whereas farmers usually face a decrease in production due to inexperience with organic farming and increased production risk. In order to overcome this decrease in income the Dutch government (partially) reimburses the loss of income during this transition period. Moreover, variable costs are usually lower for organic farming than for conventional farming (Padel and Lampkin, 1994: 304). Therefore, the difference between farmers in transition and certified farmers is not explicitly taken into account.

Assuming that farmers maximise utility, the decision whether to farm conventionally ($y_{it}=0$) or organically ($y_{it}=1$) is based on a comparison of expected utilities of both production practices. Using the difference in expected utilities gives the following decision rule:

$$y_{it} = \begin{cases} 1 & \text{if } E[U_{it}^O - U_{it}^C \mid \Omega_{i,t-1}, z_{it}, \lambda_i] > 0 \\ 0 & \text{if } E[U_{it}^O - U_{it}^C \mid \Omega_{i,t-1}, z_{it}, \lambda_i] \leq 0 \end{cases} \quad (1)$$

where E is the expectation operator which is conditional on the information set $\Omega_{i,t-1}$ of farmer i (the information a farmer has from period $t-1$ to form his expectations for period t), a vector z_{it} containing variables that have an effect on the way expectations are formed (e.g. age) and a farm-specific parameter λ_i reflecting differences among farmers in forming expectations that are not accounted for by the variables in z_{it} . U_{it}^O denotes utility of organic farming and U_{it}^C is utility of conventional farming. The utility level of farm practice j depends upon profits attained with that practice (π^j) and a vector of attributes of the practice (a^j):

$$U_{it}^j = f(\pi_{it}^j, a^j) \quad j = O, C \quad (2)$$

Note that the profits vary per farm and per year. The attributes of the farm practice may directly be related to the production technique (e.g. the use or non-use of fertiliser and herbicides or the way livestock is kept) or may be of a more general nature (e.g. view of society on the production practice). The superscript j only denotes that utility, income and attributes differ for both farm practices.

Utility levels as given in equation (2) are usually not observed. However, assuming a functional form for $f(\cdot)$ makes it possible to substitute for both U_{it}^j 's in equation (1). For convenience a linear relation is assumed:

$$U_{it}^j = \alpha_1 \pi_{it}^j + \sum_{n=1}^N \alpha_{i,1+n} a_{1+n}^j \quad (3)$$

Organic farming and conventional farming may differ in N attributes. Note however, that the weights attached to these attributes differ by farmer. Farmer A may have a higher preference for using fertiliser than farmer B (for reasons of application and effects on plant growth), whereas farmer A's utility level is much less affected by the views of society on farm practices than farmer C's utility level. Furthermore, the parameter for income (α_1) is assumed to be equal for all farmers, implying that income has the same effect on utility for all farmers. Since the N farm practice attributes differ for conventional and organic farming, they can be represented by a set of dummies taking the value 1 if organic and 0 if conventional. This implies that utility of organic farming is given by $U_{it}^O = \alpha_1 \pi_{it}^O + \sum_{n=1}^N \alpha_{i,1+n}$, whereas for conventional farming it is given by $U_{it}^C = \alpha_1 \pi_{it}^C$. For reasons of convenience¹ the sum of individual attribute parameters in the utility of organic farming is aggregated to a single individual constant δ_i reflecting the individual preference for organic farming, so $U_{it}^O = \alpha_1 \pi_{it}^O + \delta_i$. If these expressions are used in equation (1) it follows that the expected utility difference is a function of the difference in profits and a farm-specific parameter. Taken together the conditional expectations in equation (1) can be written as:

$$E[U_{it}^O - U_{it}^C \mid \Omega_{i,t-1}, z_{it}, \lambda_i] = g(x_{it}, \mu_i) \quad (4)$$

where x_{it} denotes variables that explain differences in forming expectations and variables in the information set that are used to determine income. Furthermore, $\mu_i = \delta_i + \lambda_i$ is a composite farm-specific effect reflecting differences in utility and expectations formation.

3. Empirical model and estimation

In this section the empirical specification is given for the model developed in the previous section. First, the choice of the explanatory variables that are used in the model is motivated. Next, an approach for estimating the empirical model is discussed. This is closely related to the third issue of this section, i.e. how to deal with the farm-specific effects.

As specified in equation (4), x_{it} represents variables that have an effect on how expectations are formed and variables in the information set that are used to determine income. In the analysis the following variables are included:

- *Age*. It is often stated that organic farmers are younger on average than conventional farmers (Padel and Lampkin, 1994: 296; Burton et al., 1999). The hypothesis for this observed difference in age is that organic farms practices are often implemented with a change of farm ownership (e.g. farmer's child taking over farm control from parents). An additional hypothesis is that older farmers are more conservative than younger farmers are and therefore more resistant to organic farming.
- *Education*. Another often stated difference between organic and conventional farmers is the education level (Padel and Lampkin, 1994: 296). Explanations that are given are that

¹ Note that in estimation we also cannot estimate the N individual parameters due to singularity (the dummy variable is the same for each parameter).

part of the organic farmers are new entrants to farmers that usually high-educated and idealistic. However, it could also be that higher educated farmers expect to cope with difficulties in organic farmer better than conventional farmers.

- *Father and child.* If a farm is owned and operated by a father and (one of his) children, there may be a potential conflict about the future strategy of the farm (Freyer et al., 1994: 248-249). Older farmers (parents) may be more conservative and reluctant towards organic farming compared to their children. A farm with a single (young) operator may not be hindered by such conflicts to go organic.
- *Rent.* If the major part of the farm is rented, deciding to farm organically may raise objections from the landlord. This conflict may also have an impact on the decision process.
- *Size of milk quota.* Dairy farmers that want to expand their production need to buy additional milk quota. Instead of expanding and buying expensive additional quota in order to maintain farm income at an acceptable level, farmers may decide to choose organic farming as an alternative strategy. The extensive nature of organic farming implies less production capacity. So, a small milk quota may induce conventional farmers to start organic farming. Moreover, organic farms may expect conventional farming to be not profitable enough given their small milk quota.
- *Size of farm in hectares.* The relation between organic farming and farm size in hectares differs by country (Padel and Lampkin, 1994: 296). However, the hypothesis is that there exists a positive relation between organic farming and number of hectares. Organic farms are more extensive than conventional farms requiring more land for pasture. Moreover, organic farms use more roughage than concentrated feed and this roughage may be produced on the farm, requiring more land.
- *Animal feed produced on-farm.* Above it was explained that organic farmers may produce more roughage than conventional farms. For conventional farms that already produce a large amount of roughage, it may be easier to start farming organically.
- *On-farm selling of milk (products).* Organic dairy farms may be more involved in off-farm selling of milk and milk products produced on the farm. Although the on-farm processing implies additional costs, organic farmers may expect to generate additional income in this way. The on-farm selling of milk and milk products also refers to the 'natural' way of farming of organic farming.
- *Profits in the previous period.* The profits obtained in the previous period may be used as to determine the expected profit for this year. If a farmer had low profits in the recent past using a particular production technology, he may be inclined to switch to the alternative production technology.
- *Premium milk price.* The premium organic milk price is hypothesised to be important in determining the expected difference in income under conventional and organic farming. If the price difference is large enough this may keep existing organic farmers to their practice and induce conventional farmers to switch to organic farming.

Besides these variables the farm-specific effect accounts for remaining differences in attitudes, farmer's philosophy of life and expectation formation.

For the estimation of the specified discrete choice model there are three often used methods available: the linear probability model, the logit and the probit model (see e.g. Verbeek, 2000: 177-189). However, the linear probability model suffers from a number of drawbacks. The distribution of error terms is highly non-normal and errors are heteroskedastic. However, the biggest problem is that predicted probabilities are not guaranteed to lie between zero and one. The logit and probit models overcome this problem by transforming the underlying latent process, as given in equation (1), by a logistic or normal

distribution function. Therefore, a logit or probit model is usually preferred in empirical analysis.

However, the presence of farm-specific effects in the model also has implications for the binary choice model to be used. Farm-specific effects can be specified as fixed parameters (fixed effects) or as random error components, independently and identically distributed over individuals (random effects). The latter assumption is more appropriate for a large sample with many individual having few observations over time (Verbeek, 2000: 319). A drawback of the random effects assumption is that the random error components have to be independent from the explanatory variables (which of course also holds for the regular error terms). A standard linear fixed effects model is usually estimated by differencing the fixed effects out, either by using deviations from individual means (within estimator) or by taking first differences. However, in non-linear models like the logit or probit this is not possible. This is referred to as the incidental parameters problem (Lancaster, 2000). For a random effects probit model a somewhat related problem arises, making maximum likelihood estimation infeasible (for details see Maddala, 1987). Therefore, alternative approaches are necessary to estimate binary choice models with panel data. It appears that estimation of a fixed effects logit model and a random effects probit model, both under some special conditions, is possible (Maddala, 1987; Verbeek, 2000: 336-340). Major drawbacks of the fixed effects logit model are that only observations that have a change in the value of y can be used and that explanatory variables that are constant for individuals (dummies) cannot be used. Given the choice of variables for the model made above (education, renting, father and son), the fixed effects logit model is not feasible here² and therefore a random effects probit model is used. The restriction for the random effects probit model is that the correlation of the combined residuals over time (via the random effects) is the same for all individuals.

Using a latent variable y^* for the difference in expected utility, the model is written in the standard binary choice formulation:

$$y_{it}^* = x_{it}'\beta + v_i$$

$$y_{it} = 1 \quad \text{if } y_{it}^* > 0$$

$$y_{it} = 0 \quad \text{if } y_{it}^* \leq 0$$
(5)

where $v_i = \mu_i + \varepsilon_i$. Assuming that the joint distribution of v_{i1}, \dots, v_{iT} is normal with zero mean, variance equal to 1 and $\text{cov}\{v_{it}, v_{is}\} = \sigma_\mu^2, s \neq t$. This implies that μ_i is normally distributed with zero mean and variance σ_μ^2 , whereas ε_i is normally distributed with zero mean and variance $1 - \sigma_\mu^2$. The specification of the error distributions makes estimation of the random effects model by maximum likelihood feasible (for details see Verbeek, 2000: 338-340). Estimation was performed using Stata 7.0.

² Note that a fixed effects linear probability model is also no solution. Although the fixed effects can be removed by deviations from the means (within estimator) or first-differences, this implies that a major part of the variance in the data is not taken into account. The within estimator only uses variance within the observations for a given individual and ignores variance between individuals. Since a number of dummy variables are included in the model (denoting differences *between* individuals but not for an individual over time) this will result in very poor estimates. First-differences transforms all dummy variables, including the dummy dependent variable into columns of zero's, which makes estimation impossible. See Verbeek (2000: 313-318) for a discussion on within and between variance.

4. Data

Data on specialised dairy farms covering the period 1994-1999 are obtained from a stratified sample of Dutch farms keeping accounts on behalf of the farm accounting system of the Dutch Agricultural Economics Research Institute (LEI). Specialised dairy farms are defined as farms having a share of dairy output in total output exceeding 50%. In the sample there are 41 organic farms of which 5 have switched to organic farming in the sample period. In total there are 121 observations on organic farming. The majority of the farms in the sample are conventional. In total there are 795 conventional farms, having 2841 observations. The sample is representative for the (specialised) dairy sector in the Netherlands.

Sample averages standard deviations for the variables used in the empirical analysis are given in table 1 for organic farms and conventional farms separately.

Table 1. Sample means for model variables of conventional and organic dairy farms (standard deviations in parentheses)

Variable	Unit	Conventional ($y = 0$)		Organic ($y = 1$)	
age	years	49.306	(11.09)	46.421	(9.109)
educ	dummy	0.471	(0.499)	0.835	(0.373)
faso	dummy	0.283	(0.450)	0.215	(0.412)
rent	dummy	0.179	(0.383)	0.281	(0.451)
sizequo	100000 kg	4.284	(2.652)	3.318	(1.379)
sizeha	hectares	37.822	(22.18)	44.403	(18.09)
feedrt	ratio	0.054	(0.053)	0.097	(0.102)
locmilk	ratio	0.003	(0.021)	0.046	(0.112)
prof _{t-1}	100000 Dutch guilders	4.436	(2.651)	3.880	(2.568)
premium _{t-1}	guilders	0.150	(0.005)	0.150	(0.005)
N		2841		121	

Age is the age of the (main) farm operator and is given in years. Education is represented by a dummy variable denoting whether the farm operator has had higher education ($educ=1$) or not ($educ=0$). The dummy variable *faso* is 1 for farms that are operated by father and a child and *rent* is 1 for farms that are rented for the major part. The size of the milk quota (*sizequo*) is given in 100000 kg. milk, whereas the farm size in hectares is given by *sizeha*. Furthermore, *feedrt* is defined as the ratio of animal feed produced on the farm to the amount of feed purchased and *locmilk* is the ratio of revenues from on-farm selling of milk(products) to total revenues. *Prof_{t-1}* and *premium_{t-1}* give one period lagged profits and organic milk premium price respectively.

Table 1 shows that organic farmers are on average younger and higher educated. Furthermore, organic farms have a slightly lower percentage of farms run by father and son together, are more often rented, have more selling of milk (products) on the farm and use more feed produced on the farm. With respect to size, it should be noted that organic farms have on average more land but less quota than conventional farms, reflecting the more extensive way of organic farming. Surprisingly, average profits are lower for organic farms. The premium is the same for each farm in a given year.

5. Results

Using the variables described in the previous section, the model given by equation (5) was estimated using a random effects probit specification. Estimation results are given in table 2.

Table 2. Estimation results for random effects probit model

Parameter	Estimate	Standard error	P-value
constant	-20.837	8.333	0.012
age	0.038	0.050	0.451
educ	6.677	1.856	0.000
faso	-4.825	1.982	0.015
rent	0.905	1.033	0.381
sizequo	-3.709	1.006	0.000
sizeha	0.380	0.103	0.000
feedrt	4.822	5.688	0.397
locmilk	115.346	31.994	0.000
prof _{t-1}	-2.238	0.796	0.005
premium _{t-1}	-22.387	41.961	0.594
<i>N</i>	2131	Wald $\chi^2(10)$	16.59
McFadden's R ²	0.35	P-value Wald test	0.084
ρ (st.error ρ)	0.994 (0.003)	LR-test $\rho=0$	310.77

From the 11 estimated parameters, 7 are significantly different from zero at the 5% critical level. Education, the size of the farm in hectares and the ratio of revenues of on-farm selling of milk (products) to total revenues (*locmilk*) have a positive impact on the choice between conventional and organic farming. Stated in other words, farms with these characteristics have a higher probability of being or transforming to organic. These results are in accordance with what was expected. Higher educated farmers may choose more consciously for organic farming or expect more often to be able to solve potential problems. The large land base accords with the extensive nature of organic farming. On-farm selling of milk refers to the desire of organic farmers to show their natural way of farming to the public. Conventional farms with on-farm selling have a higher probability of switching in order to obtain premium prices. The evidence of these positive effects obtained by comparing the variable means for both groups as given in table 1, is confirmed by the significance of these variables.

Farms operated by a father and a child, farms with a large milk quota and with high profits in the previous period have a lower chance of being or becoming organic. These findings are also in accordance with the hypotheses stated in section 3. Farms operated by a father and a child may have conflicts about switching to organic farming, providing an extra barrier for switching. However, it could also be that organic farms are new entrants in agriculture with a single operator only. What can be concluded is that a potential positive effect of having a father with a child running the farm, viz. the additional availability of labour that is often required for organic farming, is not present. Farms with a large milk quota consider enlargement of production scale as a better strategy for the development of their farm, than switching to organic farming. The effect of profits in the previous period is also not surprising. Table 1 already showed that conventional farms had higher profits than organic farms, which is in accordance with this result. So, profits in the previous period can be used to discern between both groups. However, low profits in the previous period may also induce conventional farms to switch to organic farming.

It appears that age, whether a farm is rented or not, the amount of animal feed that is produced on the farm and the size of the premium do not have a significant effect on choice between conventional and organic farming. Especially the finding for age is surprising. Although it is often mentioned that organic farmers are young than conventional farmers, age does not seem to have an effect on the choice of production technology. Or in terms of the theory, age does not have an effect on how expectations are formed about the utility of a particular production technology. It also appears that the price differential between conventional milk and organic milk does not have an impact on the choice of production technology.

A Wald test was performed to test whether the parameters are all equal to zero. At the 10% critical level, this hypothesis was rejected. A likelihood ratio (LR) test was performed to test for absence of correlation of residuals over time. Absence of such correlation implies that there is no persistence of individual (random) effects over time. However, this hypothesis is firmly rejected with a LR statistic of 310.77 exceeding any critical value. In other words, random effects, accounting for unobserved differences among farmers in expectation formation and utility perception, are not rejected by this test.

The estimated model was used to predict the probability of being organic for the sample used in estimation. Note that these predictions are not completely reliable, since the random effects could not be calculated for each farms. Therefore, predictions were made assuming the random effects to be zero for all farms. Since the number of conventional farms is much larger than the number of organic farms and the average probability is therefore close to zero, a weighted cut-off point of 0.011 was used to classify the predictions (Hair et al., 1990:86). From the 2131 observations used in estimation³, 2032 were correctly predicted as conventional, 19 correctly as organic and 80 predictions were wrong. From the 80 wrong predictions, 9 observations on conventional farming were predicted to be organic, whereas 71 'organic' observations were classified as conventional. Therefore, the predictive power of organic farming of the model is only $19/90=0.21$. However, this low percentage of correct predictions may be due to setting all the random effects to zero. Taking random effects into account should increase the total number of correct predictions.

A final remark is on the difference in sample sizes for conventional and organic farming. In estimation 90 out of 2131 (4.2%) observations were organic. Does this small size of organic farms have an impact on organic farming? It appeared to be not. From the total sample of conventional farms a number of small random samples were drawn and used in estimation together with the sample of organic farms so that the distribution of observations was one-third organic and two-thirds conventional. It appeared that the signs and effects of the variables remained largely the same, whereas the standard errors of the parameter estimates increased. The outcomes were of course dependent on the sample drawn. In order to have as much precision in estimation (small standard errors) and because the total sample is representative for the Dutch dairy sector, estimation is based on the total sample available.

6. Conclusions and Discussion

This paper investigates the choice between conventional and organic production technologies for individual farmers. A theoretical framework is developed that explicitly accounts for the effects of farm-specific variables like age and education on the expectations farmers have on the utility of both production technologies. Furthermore, farmers may also differ in their utility levels for both production technologies. Unobserved farm-specific effects account for differences not represented by the variables included in the model.

The model was estimated on a panel data set of Dutch dairy farmers for the period 1994-1999 using a random effects probit specification. It appears that education, the size of the farm in hectares and on-farm selling of milk (products) have a positive impact on the choice between conventional and organic farming, whereas joint operation of the farm by father and child, the size of the milk quota and profits in the previous period have a negative effect on this choice. Age, renting a farm, the amount of animal feed produced on the farm and the size of the premium do not have a significant effect on choice between conventional and organic farming.

³ Note that only 2131 out of the total 2962 observations were used in estimation because of taking lagged values for profits and the premium on the milk price. Only 90 from 121 observations on organic farming were used.

So, it can be concluded that a number of farm-specific variables (e.g. education) have an impact on the decision to farm organic or conventional. The effect of these variables is via the expectations farmers have on the utility of these production technologies. Furthermore, unobserved farm-specific effects also impact on these decisions. Policy implications of these findings are that besides economic variables, farm-specific characteristics are also important in decisions on switching to organic farming. In developing policy measures that stimulate switching to organic farming, these characteristics should be taken into account. In other words, policy measures should be aimed at the group of farmers having the characteristics found to be important in this study.

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