THE ADOPTION OF SUSTAINABLE AGRICULTURAL TECHNOLOGIES IN PARANÁ, BRAZIL

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ABSTRACT - Logit/probit analysis and a dynamic econometric framework (duration analysis) is used to analyze the determinants conditioning farmers' decisions on whether or not to adopt organic and/or biodynamic production methods in the State of Paraná. A wide range of potential determinants (both economic and non-economic) are considered. Our results suggest that the probability of a farmer's adoption of these production practices increases if the farmer has undertaken further education, if he has tried to maximize consumption of his own farm's produce, and if he has obtained information from a producer association or organic advisory service. On the other hand, the probability of adoption was reduced if the farmer is a member of a farmers' union, has obtained information from the radio or the extension service, and has a greater reliance on agriculture as an income source. In addition, duration analysis permitted the exploration of systematic effects that influence the adoption decision. It was found that the number of years working in farm management is significant. The conditional probability of adoption increases over time, but the probability of adoption is markedly higher in the first four years of farm management. This suggests that if the use of sustainable farm production techniques is to be promoted, farmers should be targeted at an early stage in their careers.

Key words: Technology, logit, probit, sustainable agriculture, State of Paraná.

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INTRODUCTION

The analysis reported here is part of a larger project[1] which examines the adoption of sustainable agricultural technologies in three countries: Brazil, Spain, and the UK. The principal aim of this project is to investigate a wide range of potential determinants which lead to the adoption of sustainable agricultural technology, including farm and farmer characteristics, sources of information, attitudes, and membership in various organizations. Our research is focused on the State of Paraná, particularly in an area where the agricultural sector is characterized by relatively production intensive, medium and small farms in which a number of environmental problems associated with intensive production have been observed.

The debate about how to achieve sustainability in agriculture is confused by disputes and disagreements over which production technologies are applicable and which are not.[2] There are several different agricultural technologies which are classified in the literature as sustainable, although the sustainability of farms where they are employed may be questioned by advocates of one or another line of thought. As pointed out by Ikerd (1993:31), "some contend that sustainability must be achieved by fine tuning conventional systems of farming. They do not believe that lower-input or organic systems of farming will ever be capable of feeding the growing world population. Others argue that sustainability will require a different model or paradigm for farming that relies less on commercial inputs and more on farm resource management. They see the input-dependent industrial model of agriculture as being fundamentally incompatible with maintaining a healthy ecological and social environment. Advocates of organic farming believe that sustainability will require the total elimination of manufactured chemical inputs. Others propose still different models of farming as a means of achieving long run agricultural sustainability."

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[1] The project, 'Adoption of Sustainable Agricultural Technologies: Economic and Non Economic Determinants', is funded by the ESRC in its research programme, 'Global Environmental Change'.

[2] For a discussion of the definition of sustainable agriculture, see Rigby and Caceres (1997).

OECD (1994) stressed the difficulty of imposing a rigid definition of sustainable agriculture in the face of the enormous variety of social, economic, and environmental contexts that characterize countries and even regions in the same country. However, it is possible to obtain a consensus that "sustainable forms of agriculture are characterized by the adoption of practices and technologies that: use integrated management techniques which maintain ecological integrity both on and off the farm; are necessarily site-specific and flexible; preserve biodiversity, landscape amenity and other public goods not valued by existing markets; are profitable to producers in the long-term; and are economically efficient from a societal perspective" (OECD, 1994:8).

This analysis is confined to a sample of horticultural producers in the State of Paraná and, for present purposes, the use of organic and biodynamic practices is taken to be indicative of agricultural sustainability. Biodynamic farming is a holistic system of agriculture devised by Rudolph Steiner that seeks to connect nature with cosmic creative forces. An attempt is made to create a whole-farm organism in harmony with its habitat. Compost and special preparations (e.g. plant derived sprays) are used. Synthetic fertilizers and pesticides are avoided. Organic farming is a system of agriculture that encourages healthy soils and crops through practices such as nutrient recycling of organic matter (compost and crop residue), crop rotations, proper tillage, and the avoidance of synthetic fertilizers and herbicides (Reijntjes, 1992).

The empirical work is based on probit/logit analysis, which is a conventional approach in this type of research, and duration analysis, which, being relatively new, is less well established but which offers some particular analytical advantages in this context.

THE SAMPLE

The sample is comprised of data on 200 horticultural producers from 24 municipalities in the State of Paraná. Of these farmers, 147 were classified as 'conventional' producers and 53 as 'sustainable' producers (i.e. using organic or biodynamic methods of production). It had been expected that within the latter group there would be some farmers who had never used modern farming methods, but this proved not to be the case. All the sustainable farms in the sample had been converted from conventional to sustainable techniques of production.

The survey questionnaire covers: (a) the physical characteristics of the farm (e.g. area, number of sites, soil type); (b) the characteristics of the farmer (e.g. age, gender, experience, education); (c) cropping patterns (e.g. areas of each crop, irrigation, tillage methods, soil analysis); (d) input use (e.g. pest control, fertilisers, weed control); (e) economics of the farm enterprise (e.g. farm sales, other income sources, capital assets); (f) sources of information (e.g. advisory bodies, buyers/merchants) and contact with others (e.g. membership of producer groups, co-operatives); and (g) attitudes to environmental issues such as the sustainability of conventional agriculture, and awareness of aid to organic producers, market opportunities, etc. Definitions of the variables used in the quantitative analysis are presented in Table 1; Table 2 and Figures 1 to 3 provide some descriptive statistics of the sample farms.

Other studies (Dalecki and Bealer, 1984, Harris et al., 1980, Lockeretz, 1995, Murphy, 1992) have suggested that farmers using organic/sustainable techniques are younger, better educated, and have smaller farms than conventional producers. This is in part borne out by our study. In this sample, the conventional farmers are on average older but only marginally so (Table 2), and although there are more of them in the over 45 category (37% of conventional farmers fall into this age group, compared to 21% in the organic sub-sample), there are also more conventional farmers in the youngest group (Figure 1). There is a more marked distinction in terms of educational background: conventional farmers have had less formal education (only 11% of them reached secondary school or above; whereas, 40% of organic farmers attained that level). In terms of farm size, a more complex picture emerges. Conventional farmers have somewhat larger farms on average (17 ha compared to 14 ha in organic holdings), but the smallest as well as the largest farms are found in the conventional sector.

In terms of other farmer/farm characteristics, conventional farmers rely more on agriculture as a source of income (obtaining over 90% of their income from farming; whereas, organic farms have 78% of their income from that source on average). There were relatively few female farmers (8% of the sample), and these were evenly distributed between the 2 sub-samples (Table 2).

In both groups of farmers there is a high proportion of farmers who are aware of environmental issues (81% of organic farmers; 75% of conventional farmers) and who seek to maximize consumption of their own products (94% and 88% respectively). A similar proportion of farmers in each group (45%) view the growth of large farms as detrimental. Unsurprisingly, relatively more conventional farmers believe that productivity growth in conventional agriculture can continue indefinitely and relatively more organic producers feel that agricultural policy is biased in favor of conventional agriculture.

The distribution of farmers by membership in farm oriented organizations (Fig. 2) is broadly similar across the two sub-samples. The obvious exception is membership in an organic producer organization, which is almost exclusively to be found in the organic farmer group. About half of the organic farmers in our sample belong to such organizations. Other notable features in this Figure are that farmer union membership attracts a higher proportion of farmers in the conventional group and only 6% of organic farmers are members of an environmental organization, although this is still twice the proportion of conventional farmers.

Figure 3 lists the primary information sources cited by farmers in each sub-sample. A similar proportion in each group use other farmers, TV, and buyers and merchants as principal sources of information. Relatively more conventional farmers used agricultural advisory services (61% of them cited this source compared to 51% of organic farmers) and radio (12% compared to 6%) as information sources. On the other hand, organic farmers make relatively more use of producer associations (55% compared to 27%) and the press (15% compared to 8%). Rather surprisingly, several conventional farmers (16% of the sub-sample) cite organic advisory services as a primary source of information (38% of organic farmers make use of this source).

EMPIRICAL ANALYSIS [3]

As with the analyses of adoption in the other two study areas, the empirical analysis of the survey data begins with the estimation of probit and logit models. In probit/logit analysis the variable to be "explained" is the dichotomous choice: adopt/do not adopt.

In making the decision whether or not to adopt a given technology, it may be assumed that the producer weighs the marginal advantages and disadvantages of adoption. As the parameters of this decision are not usually observable, for each farm i we can define a latent variable, y*, as

$$y_i^* = \beta' X_i + u_i \quad i = 1,\ldots,N \tag{1}$$

where X denotes a set of explanatory variables. The observed pattern of adoption can be described by a dummy variable, y, such that $y_i=1$ if firm i has adopted, $y_i=0$ if it has not adopted. These observed values of y are related to y* as follows:

$$\begin{aligned} y_i &= 1 \text{ if } y_i^* > 0 \\ y_i &= 0 \text{ otherwise} \end{aligned} \tag{2}$$

$$\begin{aligned} Pr(y_i = 1) &= Pr(y_i^* > 0) = Pr(u_i > -\beta' X_i) = 1 - F(-\beta' X_i) \\ &= F(\beta' X_i) \end{aligned} \tag{3}$$

where F is the cumulative distribution function for *u* and a symmetric distribution is assumed. Using maximum likelihood procedures, estimates of the βparameters can be obtained.

For the probit model, a normal distribution is chosen for $F(\beta' X)$; for the logit model, a logistic cumulative distribution function is assumed. In fact only the logit results will be presented here as both forms of the discrete choice model yield very similar results. In the logit model,

[3] All empirical analysis has been undertaken using STATA 5.0. See Statacorp (1997).

$$\Pr(y_i = 1) = \frac{e^{\beta X}}{1+e^{\beta X}} \qquad (4)$$

$$= \Lambda(\beta' X)$$

where Λ denotes the logistic cumulative distribution function.

The results of estimating a general specification of the logit model are summarised in Table 3. The determinants of the adoption decision considered in this version comprise 5 farmer/farm characteristics, 3 attitudinal variables, 5 membership variables and 8 variables denoting information sources. Here we present the 'odds ratios' (or e^{β}) rather than the β coefficients themselves. The interpretation is that as the explanatory variables change, the probability of adoption changes by that factor, i.e. variables with an odds ratio of greater than unity would increase the probability of adoption, while those with a value of less than unity would have a negative impact on adoption.

It is evident that many of the explanatory variables are statistically insignificant and so we pass on to a more parsimonious version of the model (Table 4). In Table 4, thirteen of the original variables have been dropped (we fail to reject these restrictions on a Likelihood Ratio (LR) test; LR=4.55 with χ^2_{13} = 22.36). The probability of adoption is seen to increase if the farmer undertakes further education, tries to maximize the proportion of own-consumption of farm produce, and obtains information from a producer association or organic advisory service. For example, further education increases the probability more than fourfold; and the use of an organic farming advisory service almost doubles the probability of adoption. The probability of adoption is reduced, however, if the farmer is a member of a farmers' union, obtains information primarily from the radio or the farm extension service, or has a greater reliance on agriculture as an income source. The overall fit is less than satisfactory, and this is demonstrated by the predictive ability of the estimated model. Although eighty percent of the sample is correctly allocated to the adopters/non adopters classes, only 40 percent of the adopters (21 of the total adopters) are correctly predicted by the model.

The results highlight the importance of education and information sources in the decision to adopt organic and/or biodynamic methods of production in the State of Paraná. Only one of the attitudinal variables has been retained in the preferred version of the model, and this is insignificant on the usual statistical criteria. These results are quite different from those of the UK and Spainish studies (Burton et al., 1997a, Albisu and Laajimi, 1997), in which the attitudinal variables and information sources were found to be statistically important, whereas education was not. Nevertheless, with respect to education, the findings are in keeping with other published research (e.g., for the USA, Dalecki and Bealer, 1984, and Lockeretz, 1995).

To illustrate the influence of these variables on decision making, the probabilities of adoption organic farming techniques under various conditions can be computed (Table 5). So, for example, a farmer who undertakes further education has a .63 probability of adoption if a producer association is used as a principal source of information, but only .15 if the extension service provides the farming practices information.

MODELLING THE PROCESS OF ADOPTION

In the second phase of the empirical analysis, duration analysis is used to investigate the process of adoption. This research method has been widely used as a biometrics analytical technique where the focus of analysis is often the survival time of a patient following a medical intervention. This has led to the use of the term 'hazard' to describe the probability of the process ending, i.e. of moving from one state to another. Although this technique has obvious advantages in the analysis of technology adoption, only a few examples have been cited in technology literature (Hannan and MacDowell, 1984 and 1987, Levin et al., 1987) and, it would seem, even fewer in the particular context of agricultural technology adoption (Souza Filho, 1996 and 1997, Caletto et al., 1996, Burton et al., 1997a).

In our case study the process to be modeled is the time it takes a farmer to adopt organic technology starting from the time he first manages the property, and the 'hazard' is the conditional probability of adopting sustainable techniques. The explanatory variables may be the same as used in the logit analysis but can also include variables which vary over time (e.g. the prices of production inputs, such as labour and agrichemicals, or the introduction of organic conversion incentives) that affect the timing of the adoption decision. Unlike logit analysis, duration analysis attempts to capture adoption as a *dynamic* process. As output, we can compute the *conditional* probability that a farmer with particular attributes will adopt at a particular time, given that adoption has not occurred previously. We can also trace the evolution of the probability of adoption over time.

Let f(t) be a continuous probability density of a random variable T, where t, a realization of T, is the length of a spell. The corresponding cumulative distribution is given by

$$F(t) = \int_0^t f(s)ds = \Pr(T \leq t). \tag{5}$$

Equivalently, the distribution of T can be expressed by

$$S(t) = 1 - F(t) = Pr\,(T > t) \tag{6}$$

which is the *survival function*. S(t) gives the probability that a spell is of length at least t, that is, the probability that the random variable T exceeds t. The *hazard function*, defined as the probability of a spell being completed at duration t, given that it has lasted until t, can be expressed as

$$h(t) = \frac{f(t)}{S(t)}. \tag{7}$$

The hazard function specifies the instantaneous rate of completion of a spell at T=t, conditional upon survival to time t. Once a parametric distribution of T has been chosen, estimation of parameters follows maximum likelihood procedures.

The hazard function can be reformulated to allow for the influence of explanatory variables. Let X be a vector of covariates associated with a vector of unknown parameters β. The hazard may then be expressed as

$$h(t, X, \theta, \beta) = h_0(t, \theta) q(X, \beta) \qquad (8)$$

where $h_0(t,\theta)$, is the baseline hazard, associated with the baseline survivor function which is independent of X. Models with this specification are called proportional hazards, and are used in this study. The covariates enter via $q(X,\beta)$ and act multiplicatively on the baseline hazard. Since $h>0$, the most widely used specification is

$$q(X, \beta) = \exp(\beta' X) \qquad (9)$$

This form guarantees the necessary non-negativity condition, without restricting β.

Thus far we have assumed that the durations have been drawn from a continuous time distribution (i.e. t can take any, possibly non-integer, value). But this is not considered appropriate for our application, since in our survey data duration times are recorded in *years*. We therefore follow the approach used in Burton et al. (1997b) and specify a discrete form of the duration model. This specification is based on the work of Prentice and Gloeckler (1978). Assuming that the hazard rate is a complementary log-log:

$$h(t, X, \theta, \beta) = 1 - \exp(-\exp(h_0(t, \theta) + \beta' X)) \Leftrightarrow \log(-\log(1 - h(t, x, \theta, \beta)) = h_0(t, \theta) + \beta' X \qquad (10)$$

(where $h_0(t,\theta)$ is the baseline hazard) leads to a model that is the discrete-time counterpart of an underlying continuous-time proportional hazards model. Following Meyer (1990) the associated log-likelihood function is given by:

$$L = \sum_{i=1}^{N} \left[d_i \log(1 - \exp\{-\exp(h_o(t_i, \theta) + \beta' X)\}) - \sum_{j=1}^{t_i - 1} \exp(h_o(j) + \beta' X) \right] \qquad (11)$$

where $d_i = 0$ if the farm has not adopted by the time of the survey (i.e. the observation is censored). An appropriate parameterisation for the baseline hazard then yields 'Weibull', 'exponential' or 'piece-wise constant' discrete-time models. In fact, the baseline hazard can be estimated as any general function.

We specify a flexible functional form for the baseline hazard which nests a number of alternatives:

$$h_0(t) = \lambda p t^{p-1} * \exp(\sum_{t=1}^{4} \alpha_t) \tag{12}$$

where the a parameters are introduced to permit the baseline hazard to shift from period to period over the duration. If $a_t=0$ ($t=1,\ldots,4$) then we have a standard Weibull. If $p=1$ then it is a piece-wise constant specification, with variation in the hazard over the first 4 periods[4]. If $p=1$ and $a_t=0$ ($t=1,\ldots,4$) then it is an exponential.

In order to analyze the adoption decision using duration analysis, it was necessary to first reduce the sample, for a number of reasons. To conduct the analysis one needs a start and end point for each duration, which is to be explained. For the adopters the start point is the year they began managing the property, the end point is the year of adoption. For the non-adopters the start point is also the year when management began and the duration is censored at the survey end date. Of the 53 adopters, 9 did not record an adoption year, and another 9 identified an adoption year which pre-dated their management period. These 18 cases were therefore excluded from the duration modeling. Three of the 147 non-adopters did not identify a year when they began managing the property, and their duration start point could not be identified. The sample for the duration analysis was therefore reduced to 179, of which 35 were adopters and 144 were non-adopters.

Figure 4 depicts the time path of adoption observed in the sample. Table 6 presents the results of a general specification of the model. Two new variables are included here: *cumage* which denotes the age of the farmer in each period and *cumyr* which denotes time in calendar years. The estimated coefficients presented in this table are the b parameters of the hazard function. A positive sign on these coefficients indicates that the respective variable increases the conditional probability of adoption; a negative sign implies that the variable reduces the conditional probability. However, some of these coefficients are

[4] Experiments that included dummy variables for a duration greater than 4 did not lead to the identification of any significant impacts.

statistically insignificant and can be omitted without loss of explanatory power.

Table 7 presents the preferred specification. This table makes it apparent that the conditional probability of adoption is higher if the farmer has further education and obtains information from producer associations or from buyers/merchants; the probability of adoption is lower if the principal source of farming information is the farm extension service, if the farmer is a member of a farmers' union, or if the farmer believes that conventional farming can sustain yields indefinitely. These results broadly confirm the results of the static logit analysis. However, duration analysis also allows us to investigate changes in the probability of adoption over time. The coefficient on the time variable, *cumyr*, indicates that the probability of adoption increases over time (in fact, the probability rises by a factor of 1.3 each year). The first four years of management are also found to be a critical period during which, *ceteris paribus*, the probability of adoption is significantly higher.

An implicit assumption being made in estimating the model is that the functional form selected is correct and that, conditional on the explanatory variables, individuals in the sample are homogenous. It is possible to test for homogeneity using an analysis of residuals. Central to this is the integrated hazard, which is defined as:

$$\Lambda = \int_0^t h(s)ds, \tag{13}$$

and the generalized errors, defined as

$$\varepsilon = 1 - \Lambda \tag{14}$$

These errors will, under the null hypothesis of homogeneity, be independent realizations of a unit exponential variate, which will, by definition, have a survivor function $e^{-\Lambda}$ (Lancaster, 1990, p.307). This leads to a natural test of homogeneity: if one estimates the empirical survivor function for the integrated hazard, then minus log of the survivor function evaluated at $L(t_i;\beta'X)$ should equal $L(t_i;\beta'X)$. This can be examined graphically by plotting the minus log survivor function, estimated for the integrated hazard, against the integrated hazard for the uncensored individuals (Fig. 5). On the basis of this evidence it may be concluded that the assumption of homogeneity is tenable.

CONCLUDING REMARKS

Using a sample of 200 horticultural producers in the State of Paraná, this paper has explored a wide range of potential determinants for the producer's decision whether or not to adopt organic/biodynamic technology. An attempt is made to go beyond a descriptive narrative and provide a quite rigorous empirical analysis based on both logit and duration adoption models. However, the quantitative analysis has identified only a few factors which are statistically significant; nevertheless, these may offer some useful pointers for appropriate policy design.

The farmer's level of education has been cited elsewhere as an important factor in the adoption decision. In both our static logit model and our duration analysis, education is indeed found to be a significant determinant. Another key element in the adoption decision is the farmer's principal source of farming information. In particular, the use of producer associations or to a lesser extent buyers/merchants as a primary source of farming information increases the probability of adoption, but using farm extension information services reduces adoption probability. Membership in farming organizations is generally found to be unimportant, though farmers' union membership reduces the chances that a farmer will adopt organic practices.

An attractive feature of duration analysis is that it permits a study of the adoption process dynamics through an exploration of the systematic effects that influence the adoption decision during the farmer's lifetime and over the survey period. Use of duration analysis in this study has produced the interesting finding that, contrary to conclusions reached in other similar studies, the farmer's age is not a significant factor while the number of years spent in farm management is. Specifically, the conditional probability of adoption increases over time; but the probability of adoption is markedly higher in the first four years of management. This suggests that the use of more sustainable farming techniques can be promoted if the farmers are targeted at an early stage in their farming careers.

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Table 1 - Definition of farmer and farm characteristics

Totha	The size of the farm (ha)
Age	The age of the farmer at the date of the survey (years)
Gen	The gender of the farmer (=1 for female; =0 for male)
Hefe	If the farmer has had further or higher education =1, =0 otherwise
Yagric	If income from agriculture is the main source of household income =1, =0 otherwise
Maxcon	If the farmer tries to maximise the proportion of own consumption which is supplied from
Conindef	If the farmer believes that 'current practices in conventional farming will sustain farm
Enviss	If the farmer is concerned about local, national or global environmental issues =1, =0
Inftv	If main information source is television = 1, =0 otherwise
Infrdo	If main information source is the radio = 1, =0 otherwise
Infbuy	If a farmer's primary information source is buyers/merchants =1, =0 otherwise
Infpss	If main information source is the press =1, =0 otherwise
Inffmrs	If main information source is other farmers = 1, =0 otherwise
Infadas	If main information source is the extension service =1,=0 otherwise
Infoth	If main information source is other than those cited above =1,=0 otherwise
Infoas	If main information source is organic advisory bodies =1, =0 otherwise
Infpa	If main information source is producer association =1, =0 otherwise
Memcoop	If the farmer is a member of a co-operative =1, =0 otherwise
Mempga	If the farmer is a member of a producers' group =1, =0 otherwise
Memtu	If the farmer is a member of a farmers' union =1, =0 otherwise,
Memenv	If a member of environmental organisation =1, =0 otherwise
Memoth	If the farmer is a member of another organisation not cited above=1, =0 otherwise

Table 2 - Characteristics of the sample farms and farmers

	Conventional (147)		Organic (53)	
	mean	s.d.	mean	s.d
Gen	0.082	0.275	0.075	0.267
Age	40.483	13.252	38.528	10.622
Hefe	0.109	0.313	0.396	0.494
Totha	16.755	33.130	13.928	19.991
Yagric	0.905	0.295	0.774	0.423

Table 3 - A general specification of the logit model

Number of obs = 200 chi2(21) = 42.040 rob > chi2 = 0.004	Log Likelihood = -90.602 Pseudo R2 = 0.216			
f2type	**Odds Ratio**	**Robust Std. Err.**	**z**	**P>|z|**
gen	0.523	0.323	-1.048	0.295
age	0.991	0.016	-0.551	0.582
hefe	3.409	1.736	2.409	0.016
yagric	0.460	0.278	-1.286	0.198
totha	0.992	0.011	-0.720	0.472
enviss	0.818	0.420	-0.390	0.696
conindef	0.711	0.403	-0.601	0.548
maxcon	2.325	1.943	1.010	0.312
memcoop	0.837	0.729	-0.204	0.838
memenv	0.527	0.406	-0.830	0.406
mempga	0.964	0.471	-0.076	0.940
memtu	0.428	0.257	-1.414	0.157
memoth	0.529	0.435	-0.774	0.439
inftv	0.893	0.400	-0.252	0.801
infrdo	0.359	0.320	-1.151	0.250
infpa	4.173	2.010	2.966	0.003
infoas	2.572	1.246	1.951	0.051
inffmrs	0.851	0.391	-0.351	0.725
infadas	0.373	0.160	-2.291	0.022
infbuy	1.243	0.612	0.441	0.659
infoth	1.645	1.166	0.702	0.482

	Prediction			
	0	1	Total	
0	136	11	147	
1	31	22	53	
Total	167	33	200	

Table 4 - A parsimonious specification of the logit model

Number of obs = 200 chi2(8) = 33.400 Prob > chi2 = 0.000	Log Likelihood = -92.877 Pseudo R2 = 0.197			
Variables	**Odds Ratio**	**Robust Std. Err.**	**z**	**P>|z|**
hefe	4.231	1.921	3.177	0.001
yagric	0.521	0.276	-1.232	0.218
maxcon	2.733	2.177	1.262	0.207
memtu	0.429	0.222	-1.633	0.102
infrdo	0.348	0.291	-1.261	0.207
infpa	3.584	1.601	2.858	0.004
infoas	1.937	0.938	1.365	0.172
infadas	0.371	0.149	-2.463	0.014

	Prediction			
	0	1	Total	
0	139	8	147	
1	32	21	53	
Total	171	29	200	

Table 5- Probabilities of adoption*

	Principal information source			
	Producers association	**Organic advisory service**	**Radio**	**Extension service**
Not a Member of Farmers' Union				
Further education	0.63	0.48	0.14	0.15
No further education	0.29	0.18	0.04	0.04
Member of Farmers' Union				
Further education	0.42	0.28	0.07	0.07
No further education	0.15	0.09	0.02	0.02

*These are calculated for the mean level of *yagric* (0.87) and *maxcon* = 0.

Table 6 - A general specification of a discrete duration model

Residual df = 3275	No. of obs = 3303
Pearson X2 = 2986.531	Deviance = 260.646
Dispersion = 0.912	Dispersion = 0.080

Bernoulli distribution

Variables	Coef.	Std. Err	z	P>lzl
hefe	1.131	0.480	2.359	0.018
yagric	-0.295	0.585	-0.503	0.615
gen	-0.549	0.664	-0.827	0.408
cumage	-0.008	0.021	-0.371	0.711
totha	-0.001	0.008	-0.116	0.908
conindef	-0.351	0.308	-1.139	0.255
enviss	-0.215	0.507	-0.424	0.672
memcoop	-1.094	0.850	-1.287	0.198
memenv	-0.276	0.852	-0.324	0.746
mempga	0.068	0.480	0.142	0.887
memoth	-0.086	0.734	-0.117	0.907
maxcon	0.412	0.824	0.500	0.617
memtu	-1.486	0.665	-2.233	0.026
infrdo	-0.529	0.761	-0.695	0.487
infpa	1.640	0.469	3.496	0.000
infoas	0.561	0.471	1.191	0.234
infadas	-0.933	0.425	-2.193	0.028
inftv	-0.079	0.451	-0.176	0.860
inffmrs	-0.068	0.408	-0.168	0.867
infbuy	0.870	0.447	1.949	0.051
infoth	0.376	0.715	0.526	0.599
cumyr	0.260	0.055	4.718	0.000
cons	-521.244	109.653	-4.754	0.000
$\alpha 1$	0.305	1.242	0.245	0.806
$\alpha 2$	-0.007	1.061	-0.006	0.995
$\alpha 3$	0.516	0.893	0.578	0.563
$\alpha 4$	0.723	0.800	0.903	0.367
p	-0.323	0.471	-0.685	0.493

Table 7 - A parsimonious specification of the discrete duration model

Residual df = 3291	No. of obs = 3303			
Pearson X2 = 2632.085	Deviance = 265.9434			
Dispersion = 0.800	Dispersion = 0.081			
Bernoulli distribution				
indic	**Coef.**	**Std. Err**	**z**	**P>|z|**
hefe	1.204	0.380	3.164	0.002
conindef	-0.402	0.276	-1.456	0.145
memtu	-1.416	0.569	-2.486	0.013
infpa	1.696	0.419	4.046	0.000
infadas	-0.940	0.351	-2.679	0.007
infbuy	0.702	0.381	1.842	0.065
cumyr	0.260	0.053	4.904	0.000
cons	-522.248	105.627	-4.944	0.000
$\alpha 1$	1.479	0.488	3.033	0.002
$\alpha 2$	0.826	0.621	1.331	0.183
$\alpha 3$	1.106	0.622	1.779	0.075
$\alpha 4$	1.163	0.618	1.882	0.060

Figure 1 - Age of farmer by farm type

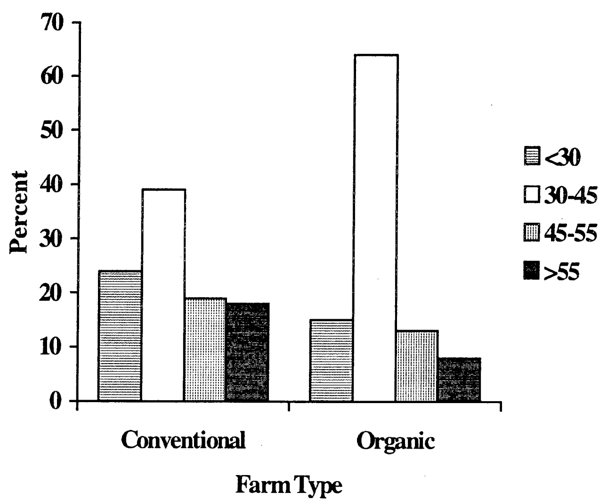

Figure 2 - Membership by farm type

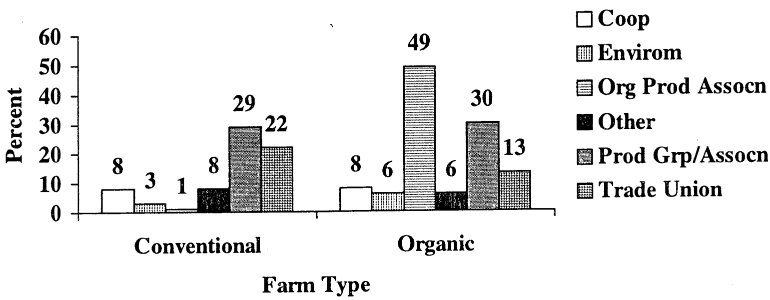

Figure 3 - Primary information sources by farm type

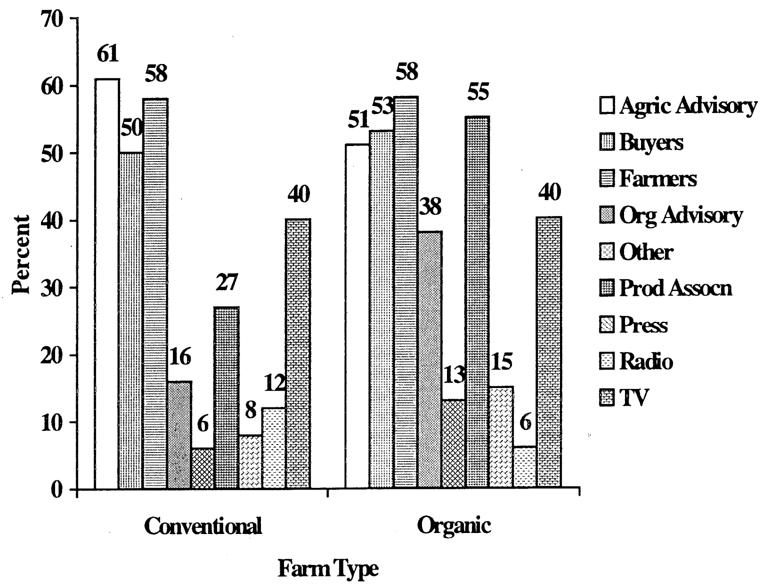

Figure 4 - Time path of adoption

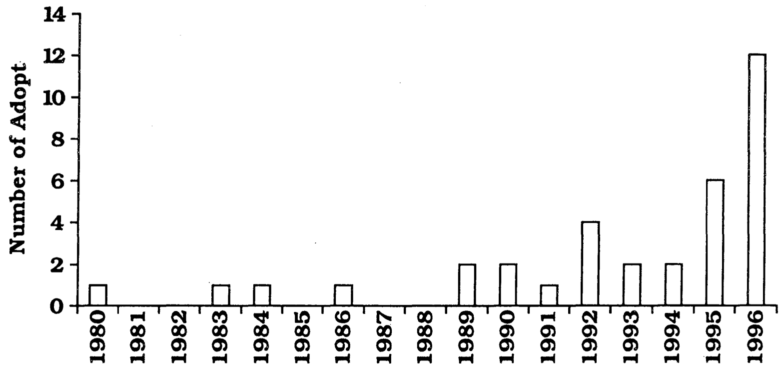

Figure 5 - Plot of minus log survivor plot of minus log survivor