MANAGEMENT STRATEGIES AND HUMAN CAPITAL INVESTMENTS BY ORGANIC PRODUCERS

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Abstract:

Survey evidence from U.S. organic farmers is evaluated to identify the factors influencing adoption of farm management strategies to mitigate the impact of key production constraints. A multilevel count data model is specified for the number of frequently used management strategies adopted by organic farmers facing pest control problems.

Key words: organic farming, pest management, count data model

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INTRODUCTION

With the advent of increasingly sophisticated agricultural production technologies economists have examined the role of learning in the adoption and diffusion of innovations by producers. McWilliams and Zilberman (1994) identified three forms of learning. The first is learning by doing which describes how producers learn to manage and control the cost effectiveness of a technology and to identify quality improvements in the technology. Learning by doing explains the supply of the technology to early adopters but does not identify the demand for new technology or management methods by producers.

A second driving force in the adoption and diffusion of innovation is “learning by using.” Rosenberg (1982) noted that users of a technology may increase their productivity over time as they learn how to more effectively manage and control a technology. McWilliams and Zilberman measures how learning by using (LBU) affects the intensity with which agricultural producers use new computer technology. The intensity measure was based on the number of computer applications used by the producer. This approach provides support for the adoption of management strategies by organic producers that is examined here.

A third type of learning allows potential adopters to evaluate the performance of the new technology or managerial structure. Producers are able to assess the potential costs and benefits by exchanging ideas with early and current adopters, reviewing information from input suppliers and distributors, and to experiment with the new technology on a limited scale.

The overall objective of this paper is to identify characteristics of organic producers which influence the adoption and use of sustainable agricultural production techniques. The primary motivation for the analysis follows Comer *et al.* (1999) who note that “despite economic and non-economic disadvantages of conventional agriculture, farm have been slow to adopt [sustainable agricultural] practices, and adoption appears to vary widely by region and crops.

Data from the Third Biennial National Organic Farmers' Survey (1997) conducted by the Organic Farming Research Foundation (OFRF) is used in model development and specification. The OFRF survey was based on grower lists maintained by organic grower certification groups and was designed by a committee of nationally recognized organic farmers, organic farming/marketing advocates, agricultural researchers and representatives of state and federal agricultural agencies.

The survey examines production practices use by organic farmers in dealing with five common problems that constrain farm output. The five categories of production problems include pest control, crop diseases and nematodes, weed control, fertilization and fertility management, and livestock management. The survey lists a portfolio of strategies or technique for managing each problem and the surveyed farmers indicate both whether they are familiar with the strategy and how frequently the strategy is used.

In the econometric specification, the number of frequent-use practices for dealing with each production problem depends on farm level and geographic effects unique to organic production region. The model separately identifies the impact of factors such as the operator characteristics, enterprise scale and diversity, on-farm agronomic and production conditions, along with economic constraints facing individual growers.

Regional effects account for larger scale agronomic and climactic conditions, along with preferences for quality features and marketing outlets that vary across distinct geographic areas. Farmers learn about the productive performance of organic crops and marketing advantages by observing and exchanging information with extension agents and other farmers in neighboring counties. To separately estimate the impact of farm level and regional characteristics on adoption decisions, we use a two-stage estimator for the random effects Poisson model. The composed error term contains the regional components and is correlated for any farmers located in the same region. Estimation procedures that ignore this correlation will result in biased standard errors, with a magnified bias associated with the coefficients of the regional variables.

ECONOMIC DECISION MODEL OF MANAGEMENT STRATEGIES

Following Sah (1998) who noted the importance of accounting for the integer and discrete nature of economic decisions, the adoption of management techniques by farmers is defined as a nonnegative integer variable, denoted as N. Quality control and consistency with organic growing requirements is a primary factor in the adoption decision by growers. The performance and input requirements of new management techniques are assessed prior to adoption in field trials and discussions with farmers, extension agents and industry representatives but profitability is not directly observed by farmers until after adoption, cultivation, and marketing.

The grower chooses a portfolio of N techniques over time where the random variable n represents the number of techniques which are profitable and meet grower quality expectations, and $N \geq n \geq 0$. The probability that the technique is profitable is an independent event with probability, p, which is bounded by zero and one. The probability that n out of N chosen management strategies will be profitable is represented by the binomial density

$$\mathrm{B}(n,\ N,\ \ p)\ =\binom{N}{n}p^{n}(1\ -\ p)^{N\ -\ n} \qquad \textbf{(1)}$$

The grower’s utility from the n profitable adopted strategies, U**[**n (ð)**]**, depends on the expected profits ð, where the utility function is increasing and concave in n. For farmer i located in region j, expected gross profits are specified as ð(F_{ij}, R_j). Here F_{ij} is a vector of farm level and management variables which are exogenous and R_j is a vector of regional agronomic variables that influence production decisions. Reinganum’s model of innovation demonstrates that the probability of adoption is positively related to expected profits, the number of previously successful projects that were adopted, and prior expectations about the quality or performance of the innovation.

The grower’s expected utility of profits from choice of technique N for a given level of quality p is denoted by U(N, p) or:

$$U(N,\ p)\ \equiv\ \sum_{n}B(n,\ N,\ p)\,\boldsymbol{U}(n) \qquad \textbf{(2)}$$

where the dependence on expected gross profit is implicit in the notation. Based on the farmer’s assessment, the largest optimal number of adopted management strategies is denoted as n(p) and the grower’s indirect utility for this decision is V(p):

$$V(p) \equiv \max_n U[n, p] \equiv U[n(p), p] \quad \textbf{(3)}$$

For an increase in the quality of organic production methods from p to p′ the indirect utility of organic producers is at least as high as under the previous quality level

$$U[n(p), p'] \geq U[n(p), p] \quad \textbf{(4)}$$

The indirect utility function is useful in developing welfare measures for the gains to organic growers associated with improvements in organic management strategies. Let M represent a grower’s current income level. If organic growers adapt management techniques which result in a higher probability p of meeting production and quality goals for organic production, then ÄM represents that maximum increase in income that growers would pay for this increase in quality. Given a specification of the indirect utility function along with characteristics of growers and farm level variables, the value of M can be calculated from the equality:

$$V(p, M + \Delta M) \equiv V(p', M) \quad \textbf{(5)}$$

Here we focus on the factors that influence the adoption decision. Forming the discrete equivalent of the first-derivative, a management practice is adopted if the grower’s expected marginal utility $U_N(N,p)$ is positive, or

$$U_N(N, p) \equiv U(N + 1, p) - U(N, p) > 0. \quad \textbf{(6)}$$

Equation (6) generates the grower's decisions on the observed number of management strategies which forms the basis of the econometric model.

Survey information is provided on the number of management strategies adopted by each farmer and a count data model is specified for the observed decisions. The adoption decision depends on individual farm level variables and regional variables which influence the expected profitability of organic production. The estimation procedure for the count data model adapts a two-stage technique for estimation and inference in nonlinear models with structural group effects.

SAMPLE AND VARIABLE DESCRIPTION

Information from the 1997 National Organic Farmers Survey which was sponsored by the Organic Farming Research Foundation (Walz, 1999) was used in the model specification. Complete data for model development was obtained from 1,028 organic farmers throughout the United States.

Definitions of the variables and summary statistics are presented in Table 1 and are described here. Organic farming management strategies used by farmers were grouped in five main categories. The categories consist of insect pest control, crop disease and nematode control, weed control, fertilization and fertility management, and livestock management strategies. Producers were provided a listing of common materials and techniques that were available to deal with each production problem. Each farmer indicated how frequently they used the listed management strategy. Frequency of use could be checked as “never” (coded at the lowest value of one) through “frequent or regular” use (coded at the highest value of four).

The set of management strategies and materials in the insect pest control category consists of eleven techniques. A sampling of the available techniques includes bacillus thuringiensis treatments, use of beneficial insects, trap crops, crop rotations and applications of viral pathogens. Organic farmers who use a given technique on an occasional or regular basis were coded as “adopters” while farmers who rarely or never consider that specific pest control strategy are coded as “non-adopters.” Within the insect pest control category the number of management strategies adopted by each organic farmer was recorded. With eleven available techniques in the insect pest control category, organic farmers adopted on average about 3 different techniques. Over 62 percent of farmers adopted 4 or fewer techniques while 14 percent utilized 7 or more management strategies.

Explanatory variables are organized into broad categories related to farm organization and finances, demographic background, and information sources used by farmers. Indicators related to managerial characteristics of organic farmers include the type of business structure and a measure indicating full time or part time farming status. Sole proprietorships is the dominant form of business structure consisting of 72 percent of the sample. Corporations account for about 6 percent of the organic farms. The organic producers are primarily part time farmers as only 36 percent of the producers farm on a full time basis. The average number of acres farmed was about 209 acres with the largest farm made up of 7000 acres. Acreage farmed organically averaged about 137 acres with a maximum value of 6000 acres.

The survey asked producers to indicate the percentage of net family income which originated from organic production with categories arranged in quartiles. Over 66 percent of respondents obtain less than half of net family income from organic production, a slight decline from the 70 percent value for organic farmers recorded in the 1993 OFRF survey. Organic production accounted for over three-quarters of family income for about 20 percent of the farmers which was essentially unchanged from the 1993 level of 18 percent. The figures demonstrate stability over time in the family income distribution for organic farmers.

Survey information on total gross organic farming income was recorded in twelve categories, ranging from a category of no income or a loss through a category of over $20 million in total income. Producers who reported no income or losses in organic farming accounted for 5 percent of respondents while 79 percent of organic farmers reported income below $100,000 in 1997, a slight decline from the 87 percent figure from the 1993 OFRF survey. Demographic information on age and education levels were also recorded.

A numerical measure of the sources used in acquiring and evaluating information about organic production practices was formed. The OFRF survey identified thirteen primary sources and asked respondents about the frequency of use (on an annual basis) and an overall rating of the appropriateness and value of the information. A representative listing of the sources includes extension advisors, university researchers, growers associations along with state agricultural and USDA regional or national offices.

An alternative measure of information about organic production techniques was measured by the resource outlets used by farmers. Following the same format as the information personnel question, the resource question listed nine primary outlets including farm and gardening periodicals, books, on-farm demonstrations, along with radio, television, and internet websites. The OFRF survey results tabulated the farmer ratings on the usefulness of the information sources, with the highest ratings accruing to other farmers, field consultants, and suppliers (seed, equipments or other materials). The ratings for resource outlets indicated that organic farmers rely most intensively on farming and gardening books, conferences and seminars. About 42 percent of organic farmers seek information from 2 or fewer information sources and delivery outlets.

MODEL ESTIMATION AND RESULTS

The model is estimated using a Poisson regression recognizing that the number of adopted management strategies is recorded as count data (Greene, 1995). Adoption by each farmer occurs at the rate ë, which depends on a set of explanatory variables. The conditional expectation of the count random variable is $E(Y_i | X_i) = \exp(X_i\beta)$ where Y_i is the count variable for farmer i and X_i contains the variables which influence the adoption decision. A quasi-maximum likelihood (QML) method for estimating the parameter vector â specifies Y_i as Poisson where the elements of the conditional mean are developed below. If the conditional mean is correctly specified, the QML estimator provides a consistent estimator for â regardless of the distributional assumption (Winkelmann).

In the econometric specification, the number of adopted management techniques depends on farm level, demographic, and information effects unique to production region. Let $PestAdopt_{ij}$ measure the number of pest management techniques by farmer i in region j. The statistical model separately identifies the impact of farm characteristics such as the farm size, business structure, and demographic factors, along with information sources used in organic production practices.

Regional effects account for larger scale agronomic and climactic conditions, along with preferences for organic production methods that vary across distinct geographically growing areas. Farmers learn about the productive performance and marketing advantages of organic production by observing and exchanging information with extension agents and other farmers in neighboring counties. The econometric specification in general form is:

$$\ln(PestAdopt_{ij}) = \beta_0 + \beta_1 F_{ij} + \beta_2 R_j + \epsilon_{ij} \quad \textbf{(7)}$$

where F_{ij} is a vector of relevant farm level variables and R_j represents the regional characteristics.

To separately estimate the impact of farm level and regional characteristics on adoption decisions, we use a two-stage estimator for the random effects Poisson model. Following Borjas and Sueyoshi, an alternative derivation of equation (7) is used to clarify the stochastic structure of the model. Adoption depends on farm characteristics and a vector of regional fixed effects:

$$\ln(PestAdopt_{ij}) = \beta_0 + \beta_1 F_{ij} + D_j + u_{ij} \quad \textbf{(8)}$$

where D_j is the regional fixed effect and u_{ij} is assumed to be *iid* normal. The Poisson model in equation (8) can be estimated by maximum likelihood.

The variable D_j is given a structural specification:

$$D_j = \gamma_0 + \gamma_1 R_j + \nu_j \qquad \textbf{(9)}$$

Substituting (9) into (8) yields equation (7) where the disturbance term is given as $å_{ij} = í_j + u_{ij}$. The composed error term contains the regional components and is correlated for any farmers located in the same region. Estimation procedures that ignore this correlation will result in biased standard errors, with a magnified bias associated with the coefficients of the regional variables.

Borjas and Sueyoshi propose a computationally simpler two-stage estimator for latent variable models that is superior both in ease of implementation and in inference than the estimation of random effects components in nonlinear models. The Poisson model in equation (8) can be estimated by maximum likelihood methods to obtain the coefficients of the farm-level variables and regional fixed effects. In the second stage, the parameters in (9) are estimated by regressing the fixed effects on the regional variables using generalized least squares to correct the estimated variance. The two-stage procedure for structural group effects in nonlinear models is asymptotically unbiased as group sizes grow, and consistent when both group sizes and number of groups increases.

Model Evaluation and Interpretation

Parameter estimates and asymptotic standard errors for the basic adoption model for pest control management strategies are presented in table 2. The initial discussion focuses on the farm level and information variables which influence adoption decisions.

Both information measures are positive and statistically significant. Organic farmers who use a more diverse set of information sources both in personal contacts and publication and media outlets tend to adopt a larger set of management techniques. We test whether the two information components have an equal impact on adoption decisions. A Wald test is unable to reject the restriction that the coefficients on the information sources components is equal as the calculated $\div^2$ statistic of 2.83 does not exceeds the critical value for a $\div^2_1$ variable of 3.84 at the 95 percent confidence level.

Kalirajan and Shand (2001) suggest that the main constraint on technical efficiency in agricultural production is the lack of information about the best practice techniques. With limited information farmers benefit from gradual “learning by doing.” in adopting new production and management methods. But they suggest that in the long run improvements in technical efficiency are needed to sustain improvements in economic performance. The organic farmers sampled here have an active and diverse set of resource channels and providers which can deliver information about new technologies and management methods.

Elasticity estimates proposed by Brannas and Greene (2000) for important variables in the adoption decision along with indicators of statistical significance for the elasticities are presented in Table 2. Consider the change in any exogenous variable from its mean value to x_p + ä$_p$. The elasticity measure evaluating the change from the base level ë$_0$ (where ä$_p$ = 0) and the new level ë$_1$ is

$$\eta_p = 100 * \frac{\hat{\lambda}_1 - \hat{\lambda}_0}{\hat{\lambda}_0} = 100 * \left[e^{\delta_p \hat{\beta}_p} - 1\right] . \qquad \textbf{(10)}$$

The elasticity measure allows for discrete changes in a given variable so that the impact of specific unit increases in age and use of additional or expanded information sources by growers can be evaluated. For continuous variables the elasticity can be evaluated by computing the impact of a 1 percent change in any explanatory variable, when ä$_p$ = $0.01x_p$.

Snow and Warren (1990) note the importance of obtaining empirical evidence on how changes in income impact the demand for human capital investment. The income elasticity is measured by by the responsiveness of pest management strategies to shifts in organic farming income. The types and varieties of management expertise used in pest management strategies confirms that human capital is critical in adopting organic production methods. The income effect is critical in determining how risk-averse agricultural producers respond to increased uncertainty associated with human capital investments.

An alternative method to evaluate the Poisson model measures the predicted probability that the event count takes on any specific value. The predicted probability is conditional on a given a set of values for the explanatory variables. The probability that farmers adopt a set of n pest management strategies can be calculated as

$$P(Y = n) = \frac{e^{-\lambda_i}\lambda_i^n}{n!} \quad . \qquad \textbf{(11)}$$

We consider the probability that organic farmers will adopt four different pest management techniques. Extension agents and input supply representatives may be interested in knowing how many practices a farmer will typically prefer to use and whether a farmer will consider learning about additional pest management tools.

The model is used to evaluate the probability that organic farmers will adopt a set of four pest management practices even as organic acreage expands by 10, 20, and 30 percent. The probabilities of adoption are stable at about 45 percent for each expansion in organic acreage, suggesting that acreage is not a primary factor driving adoption of pest management practices.

CONCLUDING REMARKS

In this paper the adoption decision for a portfolio of organic production practices is modeled in a discrete, integer choice framework leading to the econometric specification based on a count model for adopted practices. The model incorporates producer evaluations of information sources and assesses the relative impact of farm size and allocation of acreage to organic production on the diversity and intensity of pest management practices.

Additional analysis is required to assess comparative management patterns for dealing with common production problems that confront organic producers. An extended empirical model will examine the factors that influence managerial options chosen by farmers who operate completely organic farms from choices by producers who operate mixed organic enterprises.

A richer model to address the expertise and human capital investment required by organic production methods should incorporate a wider range of adopted practices used by organic farmers. The OFRF survey identifies five common production problems that constrain farm output, including pest control, crop diseases and nematodes, weed control, fertilization and fertility management, and livestock management. The survey lists a portfolio of strategies or technique for managing each problem and the surveyed farmers indicate both whether they are familiar with the strategy and how frequently the strategy is used. The number of regularly used management practices can be recorded for the five groups of production problems leading to a set of count data models estimated using a panel framework.

The results of the model will be useful in identifying and targeting extension and information requirements of organic producers. Practices that are used by farmers across different farm sizes and by farm income grouping can be assessed and used to assist in highlighting the expertise levels of organic farmers.

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Table 1. Variable Description and Summary Statistics[a]

Variable	Description	Sample
PESTADOPT	Number of adopted pest management strategies	3.29 (2.33)
	2 or fewer techniques[b]	30
	3 to 4 techniques	33
	5 to 6 techniques	23
	7 or more techniques	14
SOLEPROP	Farm is operated as a sole[b] proprietorship	0.72 (0.45)
CORPORAT	Farm is operated as a corporation[b]	0.06 (0.24)
FULLPART	Operator is full time farmer[b]	0.37 (0.48)
ACREFRM	Total acreage farmed (acres)	209.38 (574.38)
FRMORGN	Acreage farmed organically (acres)	137.02 (382.41)
PCTFIOR	Income from organic production[b] (50% or less)	66.7
AGE	Age of farmer	47.22 (10.94)
FIORG	Total gross organic farming income[b]	
	No income or loss	5.3
	$30,000 or less	57.6
	$30,000 to $100,000	21.0
	Over $100,000	16.1
EDUC	Education[b] – finished high school	34.5
	- finished college	18.3
SUMWHOM	Number of information resources used	5.4 (2.9)
SUMWHERE	Number of information outlets used	3.5 (2.2)

[a] Mean values with standard deviations in parentheses.
[a] Percentage of respondents in each category.

Table 2. Adoption Model for Pest Management Strategies

Explanatory Variable	Coefficient Value	Elasticities
Constant	0.940* (7.634)	
SOLEPROP	-0.018 (-0.425)	
CORPORAT	-0.114 (-1.406)	
FULLPART	-0.064 (-1.529)	
ACREFRM	-0.628 (-1.225)	
FRMORGN	-0.340* (-3.599)	-0.112* (-3.434)
PCTFIOR	-0.034* (-1.813)	-0.111* (-1.760)
AGE	-0.006* (-3.542)	-0.019* (-3.379)
FIORG	0.032* (2.992)	0.104* (2.873)
EDUC	0.056* (4.327)	0.184* (4.081)
SUMWHOM	0.021* (2.720)	0.068* 2.620)
SUMWHERE	0.047* (4.676)	0.063* (2.489)
N	1028	

[a] Asymptotic t-values in parentheses with significance at 0.05 level noted by the asterisk.