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FACTORS AFFECTING MANAGEMENT PRACTICES USED BY SOUTHERN DAIRY FARMERS: A MULTIVARIATE PROBIT ANALYSIS

by

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ABSTRACT

This paper presents an empirical analysis of southern dairy farmers' use of recommended management practices to enhance their economic efficiency. Survey data and a multivariate probit analysis are used to draw inferences concerning their choices. Production and human capital characteristics were identified that indicate who used certain practices.

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Many management practices have been recommended to improve production and economic efficiency on southern dairy farms. The effectiveness of research and education programs may be measured to some extent by the number of dairy farmers that use these recommended practices. The identification of key variables explaining the use of certain practices may aid in the development of more effective education programs.

The following management practices have been identified as important to the improvement of economic efficiency on southern dairy farms. The Dairy Herd Improvement (DHI) program is recommended to dairy farmers in every state. An economic evaluation of the DHI program in the western U.S. showed that DHI herds realized an estimated $42.55 more annual net return per cow than non-DHI herds resulting in an internal rate of return of 26 percent (Araji and Gardner).

Artificial insemination (AI) of dairy cattle is a recommended management practice. AI is one of the greatest single tools available to dairymen, other than DHI, for herd improvement (Maddux). In using AI, genetically superior sires are available to every dairyman with improvement in reproductive efficiency possible as well.

Another group of management recommendations involve using balanced feed rations, least-cost rations, and testing for forage quality. Since about 50 percent of the cost of producing milk is feed cost, a balanced ration is important in order to obtain efficient use of protein and energy. Therefore, dairy farmers are urged to test their forage regularly for protein and dry matter content. This forage analysis is then used to formulate a balanced forage-concentrate ration using those ingredients that make it a least cost ration (Guthrie; Ely and Guthrie).

In this paper maximum likelihood multivariate probit analysis is used to determine human capital and production characteristics that correlate with farmers decisions to use specific management practices. The objectives of the paper are (a) to present a model of management practice utilization, and (b) to explain the differences in dairy farmers decisions to use a specific management practice.

Analytical Model

The application of binary qualitative dependent variable models to agricultural decision making and acceptance of marketing changes has become quite common (see Hill and Kau; Rahm and Huffman; Epperson, Turner and Fletcher; Thompson and Eiler; Turner, Epperson and Fletcher). Multivariate probit analysis extends the basic probit model to situations involving multiple binary decisions.

Dairy farmers face the problem of choosing management practices that will result in improving production and economic efficiency. This model assumes that farmers select specific practices based on utility maximization. In determining which recommended practices he will use, the dairy farmer makes J distinct but possibly related decisions with regard to the various alternatives (Fletcher and Terza). The likelihood that the t^{th} farmer will include a given combination of management practice alternatives in his selection is based on a vector of "utility indexes," $U_t = [u_{1t}. \ldots, u_{Jt}]$. These indexes are assumed to be linearly related to a vector of observed farmer-specific characteristics (e.g., human capital and production characteristics). In explicit form we have

(1) $u_{jt} = X_{jt}\beta_j + e_{jt}$, $\quad (j = 1, \ldots, J)\ (t = 1, \ldots, T)$

X_{jt} is a row vector of farmer-specific variables, β_j denotes a column vector of parameters to be estimated and $e_t \sim MVN(0,\Sigma)$. The random error term e_{jt} is included in (1) to capture the effects of all unmeasured variables that influence the likelihood of the t^{th} farmer including the j^{th} practice in his management decision.

The higher is u_{jt} the more likely it is that the j^{th} alternative will be included. One can characterize this selection of a particular management choice in the following way:

(2) the j^{th} alternative is chosen iff $u_{jt} > m_j$

where m_j is a constant threshold specific to the j^{th} alternative.

Now (2) holds iff

(3) $e^*_{jt} < X_t\beta^*_j$

where $e^*_{jt} = -e_{jt}/\sqrt{\sigma_j}$ and $\beta^*_j = [(\beta_{j1} - m_j)/\sqrt{\sigma_j}, \beta_{j2}/\sqrt{\sigma_j}, \ldots, \beta_{jK}/\sqrt{\sigma_j}]'$. The coefficient β_{jk} is the k^{th} element of β_j with β_{j1} a constant term, and σ_j denotes the j^{th} diagonal element of Σ. Assuming that the elements of e_t are independent implies that $e^*_t \sim MVN(0,I_J)$, where I_J denotes the J^{th} order identity matrix.

A vector of binary variables indicating the particular combination of management alternatives chosen by the t^{th} farmer is denoted

$$D_t = [d_{1t}, \ldots, d_{Jt}]$$

where

$$d_{jt} = \begin{cases} 1 = \text{iff the } t^{\text{th}} \text{ farmer uses the } j^{\text{th}} \text{ alternative} \\ 0 \text{ otherwise.} \end{cases}$$

Therefore, given that N denotes the standard normal distribution function and $P_{jt} = N(X_t\beta_j^*)$, the likelihood of the t^{th} farmer's observed management strategy is

$$P_t = \prod_{j=1}^{J} \{d_{jt}P_{jt} - (1-d_{jt})(1-P_{jt})\}.$$

Thus, that the likelihood function for the full sample is

$$(4)\ L(\beta_1^*, \ldots, \beta_J^*) = \prod_{t=1}^{T} P_t$$

Clearly, the particular values of $\beta_1^*, \ldots, \beta_J^*$ that maximize the J individual functions of the form

$$(5)\ L_j(\beta_j^*) = \prod_{t-1}^{T} \{d_{jt}P_{jt} + (1-d_{jt})(1-P_{jt})\}$$

also maximize (4). The task of estimating the J parameter vectors is thus simplified since (5) is a binary probit likelihood function. The β_j^* vectors are obtained as the result of J individual probit analyses applied to the entire sample, one for each of the J alternatives.

Empirical Specification and Data

The choice of using recommended management practices depends on a farmers ability to grasp the economic consequences of his action. The management practices used by dairy farmers that were analyzed included participation in DHI (DHI), using artificial insemination (AI) in more than 75% of the matings, test forage for quality (FORT), formulate feed rations (FORM), and keep individual records on all cows (INDR). Farmer-specific variables expected to influence the farmer's utility, and thus his probability of using a specific management practice, were number of cows in the herd (COWS), production of milk per cow (PROD), the number of years the dairy farm has been operated by principal operator (YREX), ownership arrangement of the dairy farm (OWN), and formal education level of the principal operator (EDUC).

Size of the herd is expected to have a positive effect on a dairy farmer in utilizing management practices. A positive sign is expected for production per cow. One may argue that using given management practices will lead to higher production per cow, which cannot be denied. However, the approach in this analysis is to determine if there is a higher probability of using a specific practice in a high per cow production herd than in a low per cow production herd.

Experience in dairy farming is expected to be captured by the human capital variable, years of experience. Years of experience is expected to be positively related to a dairy farmer's ability to recognize the gains from using a specific management practice. However, a newer dairy farmer may seek out the latest management recommendations to enhance his income level, but the farmer with longer experience may be associated with the idea that he has survived without using certain practices and has a shortened planning horizon. Thus, the sign of the variable YREX is indeterminate.

The ownership arrangement may influence whether certain management practices are used. An individual owner of a dairy herd may have a different utility and threshold towards an alternative than a partnership or corporation. Thus, the sign of the relationship is a priori indeterminate. Four ownership arrangements, individual ownership (INDO), father-son partnership (FSPR), family-relative partnership (FRPR) and family corporation (CORP) were each treated as a dichotomous variable, 1 if a given ownership and 0 otherwise.

The human capital variable, education, is expected to have a positive influence. As the number of years of education increase, the efficiency of a farmer in making economically correct decisions should increase. To capture this relationship six levels, no high school (NHSC), some high school (SHSC), high school graduate (HSCG), technical training beyond high school (HSTT), some college (SCOL) and college graduate (COLG), were each treated as a dichotomous variable, 1 if level obtained and 0 otherwise.

The data base used in this study was obtained from a 1983 mail survey of a randomly selected sample of dairy farmers located in 11 southern states. Data were obtained from 3,647 dairy farmers. Since some questions were not answered by some dairy farmers, observations with missing data were excluded.

The Empirical Results

The coefficients obtained from the maximum likelihood multivariate probit model are shown for each management practice in table 1. Since differences were expected among the eleven states in the probabilities of using a given management practice, states were entered as a discrete variable with the resulting coefficient being a shift coefficient. The state of Georgia was used as the base.

Table 1. Maximum likelihood coefficients of the multivariate probit analysis of management practices used by dairy farmers, 11 southern states, 1983

Item	Coefficients from probit models[a]				
	DHI	AI	FORT	FORM	INDR
Intercept	-3.248	-2.588	-2.501	-1.717	-1.166
COWS (100)	.167*	.012	.294*	.341*	.149*
PROD (1000 lbs)	.209*	.162*	.136*	.073*	.091*
YREX	-.005**	.004***	-.011*	-.012*	-.015*
State					
AL	.168	.705*	-.090	-.072	.081
AR	-.276**	.139	-.324**	-.256**	.110
KY	-.577*	-.146	-.017	.158	-.156
LA	-.013	.392*	-.815*	-.228***	-.081
MS	-.053	.209***	-.218***	-.175	-.135
NC	.077	.237**	-.151	-.133	-.185
SC	.734*	.427*	.208	.255***	-.161
TN	-.290**	.067	-.099	-.184	-.133
TX	-.624*	-.144	-.430*	-.299*	-.225**
VA	.223***	.658*	.436*	.267**	-.091
Ownership					
FSPR	.093	.203*	.196*	.049	.106***
FRPR	.080	.077	-.051	-.032	-.011
CORP	.158	.285*	.241**	.247*	.138
Education					
SHSC	.122	-.022	.162	.124	-.065
HSCG	.314*	.081	.215**	.071	.157***
HSTT	.383*	.236***	.453*	.315**	.288**
SCOL	.680*	.296*	.604*	.253**	.328*
COLG	1.002*	.678*	.667*	.283*	.525*
χ^2 value	864.000*	577.510*	611.960*	326.490*	273.210*
Pseudo-R^2	.350	.246	.262	.151	.123
% Choices correct pred	72.19	69.12	70.11	70.78	62.68

a There were 2,834 observations in each equation.

Superscripts *, **, and *** on the coefficients represent statistical significance at the 1%, 5%, and 10% levels, respectively.

The coefficients for the number of cows and production per cow have the expected positive signs and are statistically significantly different from zero. The exception was the coefficient for herd size in the AI management equation. The coefficients for years of experience were negative for four management practices and positive for the use of AI. The relationships were significantly different from zero in all cases. Implications are that as dairy farmers gain years of experience they are more likely to use AI and less likely to use the other practices. This relationship may be explained as a result of AI being recommended for many years while the other practices have been recommended more recently.

The type of ownership, with individual ownership the base, showed a mixed pattern with the coefficients generally not significant. Most of the coefficients were positive indicating a higher level of probability of father-son and family corporation using a given practice than individual owners. Group decision making may have a more positive influence on using recommended management practices than individual decision making.

Education levels were compared against no high school education, the base. Some high school was not significantly different from no high school education in explaining the use of management practices. The coefficients increased in value for each higher level of education and indicated that each education level was significantly different from no high school education. There was an especially large increase in the coefficients between high school graduate and college education. Education level was found to be an important human capital variable in explaining whether a dairy farmer would or would not use specific management practices.

The coefficients from the probit model do not have any economic interpretation except for qualitative effects and for statistical testing the significance of a particular independent variable. Thus, one usually investigates the derivative of the probability with respect to a particular independent variable in order to predict the effect of changes in that variable on the probability of belonging to a group. In the case of a continuous variable, this derivative is calculated by multiplying the coefficient by the probability distribution function of the probit model. However, this procedure can not be used for discrete variables. Since several discrete variables are used to represent a certain factor like state and education, the actual probability associated with a given discrete variable (holding all other variables at the sample mean except for the other discrete variables in that particular group which are set equal to zero) are computed. The results are shown in table 2.

The probability is higher for using forage testing and feed formulation as herd size increases than it is for using DHI *ceteris paribus*. Using DHI and AI have a higher probability as production per cow increases than using forage testing or feed formulation. For each additional year of experience of the operator, the probabilities decrease .002 to .006 of a probability point.

Generally, individual owned herds showed lower probabilities of using the five practices than other types of ownership. The family corporation showed the highest probabilities for using all five practices.

Table 2. Probability of dairy farmers using a management practice, 11 southern states, 1983

Variable	DHI	AI	FORT	FORM	INDR
Continuous			Probability Derivative		
COWS (100)	.067	.005	.113	.122	.059
PROD (1000 lbs)	.083	.064	.052	.026	.036
YREX	-.002	.002	-.004	-.004	-.006
Discrete			Probability Level		
State					
GA	.556	.475	.454	.343	.580
AL	.612	.706	.419	.317	.611
AR	.437	.530	.330	.255	.622
KY	.323	.410	.447	.403	.518
LA	.540	.629	.176	.263	.548
MS	.524	.558	.370	.281	.526
NC	.577	.569	.395	.296	.507
SC	.773	.642	.537	.441	.516
TN	.431	.502	.415	.278	.527
TX	.265	.419	.293	.241	.491
VA	.633	.724	.626	.445	.576
Ownership					
INDO	.488	.485	.387	.312	.527
FSPR	.525	.565	.463	.330	.570
FRPR	.520	.515	.367	.301	.523
CORP	.551	.597	.481	.404	.582
Education					
NHSC	.331	.475	.263	.269	.454
SHSC	.380	.466	.315	.312	.429
HSCG	.451	.507	.337	.293	.516
HSTT	.478	.568	.428	.382	.568
SCOL	.596	.592	.487	.359	.584
COLG	.714	.730	.513	.370	.659

A dairy farmer with no high school education shows a .33 probability of using DHI in contrast with a college graduate showing a .71 probability of using DHI. For most of the management practices examined, there was a difference of at least .20 probability points between no or some high school and college graduate.

The likelihood ratio test indicates that the models were statistically significant at the .001 level. The ability of the models to classify dairy farmers in the respective management practice used was quite good. In four of the models 69 to 72% of the farmers were correctly classified and in the other model 63% were classified correctly.

Conclusion

This paper presented an empirical analysis of dairy farmers use of five recommended management practices. Data obtained from a survey of dairy farmers in 11 southern states and a multivariate probit model are used to make inferences concerning the use of such practices.

At the means of the variables for the total group, there was considerable differences among the 11 states of dairy farmers using a given management practice. The practice of using DHI and AI had generally higher probabilities of use than did practices having to do with feeding programs.

Generally, as herd size increases or production per cow increases dairy farmers are more likely to use each of the five management practices. Feed programs had higher probabilities of being used in larger herds than did DHI and AI. Individual owners had the lowest probabilities of all types of ownership in using the various practices. Group decision making may have some influence on adoption of recommended management practices.

The level of education had a significant positive influence on the use of each of the practices. There were three levels of education in which there were large differences; less than high school graduate, high school graduate, and some college or college graduate.

Some inferences may be drawn regarding extension educational program direction. More emphasis should possibly be given to the use of forage testing and optimum feed formulation. The two practices go together but require some extra effort on the part of dairy farmers. Programs may need to be directed toward the individual owner who appears to be less likely to use the various practices. Reaching dairy farmers that are not at least high school graduates may require a different approach with more emphasis on individual help.

The methodology used in this analysis provides the means of identifying differences among dairy farmers in the use of certain recommended management practices without having to take a census. Specific characteristics, both production and human capital, were identified that indicate who is or is not using the practices as well as a measure of the probability of using.

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