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Testing Nonlinear Logit Models of Performance Effectiveness Ratings: Cooperative Extension and Organic Farmers

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Survey evidence from U.S. organic farmers is evaluated to identify the factors influencing effectiveness ratings of cooperative extension advisors by organic farmers. A nonlinear logit model is specified for the ratings provided by organic producers, and critical demographic and management factors that influence the ratings are identified. The impact of the organic farmers' status in transitioning to organic production is highlighted. The results indicate that part-time, newer adopters of organic farming methods are more likely to rate extension service providers as effective providers of information. Scenarios to predict extension effectiveness when interacting with specific groups of organic farmers are developed.

Key Words: cooperative extension, nonlinear logit model, organic farming, performance ratings

JEL Classifications: C25, Q16, Q01

The organic food market, one of the most rapidly expanding food segments, faces significant challenges including new pest management and soil fertility problems, rapid changes in industry structure associated with the entry of large-scale corporate producers and processors in competition with small family farms, and an evolving regulatory environment associated with U.S. certification programs. Kotcon and Thilmany documented emerging support for organic systems with the U.S. Department of Agriculture (USDA), indicating recognition throughout the USDA Cooperative State Research, Education, and Extension Service (CSREES) of the need for, and opportunities in, organic systems research.

Cooperative extension advisors will play a critical role in assisting organic farmers. The National Research Council report on publicly funded agricultural research noted that the extension service's primary role has been to communicate research results to farmers and other citizens through adult education, with an increasing emphasis on broader research including sustainable production systems, environmental issues, and rural development. Agricultural extension program leaders are acutely aware of the difficulties and limitations of the land grant system in adapting to changes in the agricultural and rural economy. Extension leaders face pressure to extend their roles in serving both farm and nonfarm clients while adapting to increasing competitive pressures from private advisors and consultants.

Proponents of organic production and marketing methods have voiced concerns about the performance of cooperative exten-

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sion in promoting this growing market segment. In a nationwide survey of U.S. organic producers by the Organic Farming Research Foundation (OFRF), organic farmers were asked to indicate the degree to which 10 specified constraints inhibited their farm operations, using a scale from 1 to 5 (where 5 represents a "serious constraint or problem"). The percentage of farmers who rated extension advisors as critical constraints on organic production was uniformly high across all geographic regions. Over 41% of farmers nationwide identified "uncooperative or uninformed extension agents" as a significant constraint.

These survey results stand in sharp contrast with previous success stories documenting the efficacy of agricultural extension in promoting innovative programs in sustainable agriculture. Bhattacharyya et al. demonstrated that cooperative extension programs enhanced the rate of adoption of the *Tritrichomonas foetus* vaccine designed to reduce reproductive failure of cows. Postlewait, Parker, and Zilberman noted that extension advisors were the main promoters of integrated pest management and sustainable agriculture programs, and were especially effective in influencing adoption at the early stages before the tangible program benefits in terms of sellable commodities and products were documented.

Performance evaluation is an important component in improving and targeting the timely delivery of extension programs and technical information. Hanson confirmed that an important standard for evaluating excellence in extension programming is meeting the needs of the projected audience. As a result it is critical to understand the systematic factors that are driving producer perceptions of cooperative extension performance. By linking performance to observable characteristics of the farmer evaluators, extension managers and policy makers may clarify interpretations of impact ratings taking into account the exogenous influences on the measurements (Smith and Goddard). Accounting for stakeholder bias helps managers avoid penalizing agents whose ratings reflect the greater challenges of delivering programs to new audiences.

The objective of this article is to evaluate the factors that influence the effectiveness of cooperative extension advisors in assisting organic producers. Survey evidence is initially reviewed to establish the current level of reported effectiveness. Organic farming clients have a diverse set of farming backgrounds and experience in both conventional and organic methods, which may influence their interactions with extension advisors. An econometric model of effectiveness ratings is developed that allows for unobserved heterogeneity in the disturbance variance, leading to the specification of a nonlinear logit model. The model identifies critical factors that influence extension effectiveness as perceived by organic farmers and evaluates their relative impact with the overall aim of improving the performance of cooperative extension advisors. A final section demonstrates how evaluation methods to improve effectiveness ratings can be developed from the model, highlighting where improvements can be made in presentations to specific clientele groups.

Nonlinear Logit Models for Effectiveness Ratings

The comprehensive national survey administered by OFRF solicits farmer evaluations of 12 key information sources used by organic producers. This section describes the performance of cooperative extension advisors as evaluated by organic farmers. We begin with a brief discussion of some preliminary findings as a prelude to a discussion of how the survey results are integrated into an econometric model.

Agricultural producers frequently evaluate the performance and effectiveness of the extension programs that are provided to them. The OFRF survey is consistent with the expectations of extension providers that program participants are able to identify, evaluate, and provide feedback for programs. The producer's effectiveness rating for extension advisors is specified as a dichotomous indicator based on information from the Third Biennial National Organic Farmers' Survey. The probability of a positive effectiveness

rating is determined by whether the producer's satisfaction y is above or below some threshold value, μ. Let EFF = 1 if $y > \mu$ and let EFF = 0 if $y \leq \mu$. The producer's satisfaction level is a latent variable that is generated by a linear function of observable variables

$$(1) \quad y_i = \delta X + \sigma \varepsilon_i$$

where i represents the set of responding farmers with explanatory variables X and the estimated parameters δ. The random disturbance ε has a fixed variance and is independent of the explanatory variables while the σ parameter allows for unobserved producer-specific factors that influence the probability that an effective rating is achieved. If the error term has a standard logistic distribution, the model is

$$(2) \quad g[\Pr(EFF_i = 1)] = \beta X$$

where $g(p)$ represents the logit link function. Greene noted that any proper, continuous probability distribution defined over the real line is appropriate for specifying the model. The estimated β coefficients in (2) are related to the δ coefficients in (1) by $\beta_j = \delta_j/\sigma$, a format which highlights the role of the parameter linked to the disturbance variance. In the logit model, ε is assumed to follow a logistic distribution with variance $\pi^2/3$; in the probit case, ε is normally distributed with variance of 1.

Unobserved variables that influence the ratings will lead to a disturbance variance that differs across producers. In turn, standard tests for differences between types of producers or regional differences in effectiveness ratings based on the estimated coefficients from the discrete choice model will be invalid and provide no information about differences in the δ coefficients across the groups. Note that the unobservable value of σ determines the scale of β. If σ varies between types of producers, then the logit coefficient β will also vary, even when δ is the same between different types of producers.

The farmer's previous and current experience with the extension service is a key unobserved factor that may influence the disturbance variance of the effectiveness ratings. Farmers who have more familiarity with the expertise of extension agents in their geographic region more frequently contact extension providers, seek assistance with more complex problems, and present a greater overall challenge to extension agents. The unmeasured factors that affect the probability of an effective rating for extension agents will be more prevalent or be stronger for farmer–clients with more previous organic farming experience. These factors will decrease the power of the explanatory variables that influence the effectiveness ratings and limit our ability to accurately assess extension effectiveness in assisting organic producers. The econometric model of effectiveness ratings is modified to allow for the impact of unobserved heterogeneity in the disturbance variance, leading to the specification of a nonlinear model.

Two dimensions were combined to control for previous and current experience with the extension service. Under the U.S. regulation, farmers may certify as organic less acreage than they farm, leading to parallel organic and conventional systems being managed by the same operator. Farmers may have also started out originally as conventional producers but transitioned to organic production account. The set of farmers who transitioned to organic farming, but maintained mixed farming operations accounted for 11% of our sample.

The transitioned producers with mixed (organic and conventional) operations were expected to have more familiarity and closer linkages with extension advisors because of their history and continuing use of conventional production techniques. Perceived extension effectiveness is more likely to be higher among this group. This relationship is apparent in the OFRF responses because 67% of the transitional mixed farmers had a positive experience with extension contacts, significantly higher than the effectiveness rating reported by all other farmers at 52%. The transitional mixed farmers had about the same number of contacts with extension advisors (2.96 times per year on average) compared with all other farmers.

Let the variable T_i take on the value 1 for producers who have transitioned to organic farming and continue to farm with both organic and conventional methods and be 0 for all other farmers. Under the null hypothesis that the coefficients of the model are the same for both groups, a single equation for the ratings achieved by extension providers can be specified following Allison:

$$(3) \quad y_i = \gamma_0 + \gamma_1 T_i + \sum_{j>1} \gamma_j x_{ij} + \sigma_i \varepsilon_i$$

where ε_i has a logistic distribution and is independent of the explanatory variables. The disturbance variance differs across the groups as

$$(4) \quad \sigma_i = \frac{1}{1+\delta T_i}$$

and $\delta > -1$. Equation (4) implies that $\sigma = 1$ for producers who have transitioned to organic farming and continue to farm with both organic and conventional methods and $\sigma = 1/(1 + \delta)$ for the remaining farmers. A positive estimate of δ implies that the disturbance variance is smaller for original organic producers. If δ is negative, the disturbance variance is larger for original organic farmers. The logit discrete choice model can be rewritten as

$$(5) \quad \log\left[\frac{p_i}{1-p_i}\right] = \left[\alpha_0^* + \alpha_1^* T_i + \sum_{j>1} \alpha_j x_{ij}\right](1+\delta T_i),$$

where $p_i = \Pr(\mathrm{EFF}_i = 1)$ and $\alpha = \alpha_0 - \mu$. The indicator variable T_i appears in both the disturbance variance and as an explanatory variable to allow the intercept to differ even when the slopes are the same, resulting in a set of nonlinear constraints on the coefficients of the logit model. Estimation of the nonlinear logit model proceeds by the maximum likelihood method, yielding parameters estimates that are asymptotically normal and unbiased.

The econometric issue is to compare estimated coefficients from discrete choice models (probit/logit) across different groups of farmers. We compare the factors that influence extension performance ratings across two groups of organic producers: those who have transitioned to organic farming while continuing to farm with both organic and conventional methods compared with all other organic farmers. Economists often want to know if a covariate has the same effect across different groups and these comparisons are readily made for linear models. However, the standard approach is not applicable for discrete choice models when comparing the effects of coefficients across groups. The nonlinear logit model developed by Allison is the appropriate way to make these comparisons.

A series of hypothesis tests can be performed on the nonlinear logit model of effectiveness ratings to check its validity. The first test examines whether the coefficients are the same for both groups of organic farmers (transitioned organic farmers with mixed systems versus all other organic farmers) while allowing the residual variation (σ) to differ. If the disturbance standard deviation from the nonlinear logit model (incorporating the indicator for unobserved producer-specific factors) differs from zero, a second test examines whether all the coefficients are the same across the farmers. Based on this result, a third test is used to examine coefficients on specific variables in the model using theory or *a priori* reasoning to isolate key variables that differ across the groups of farmers. The sequence of tests is applied and evaluated for the nonlinear logit model of extension effectiveness ratings in Equation (5).

Data Description

The Organic Farming Research Foundation (OFRF) is a private not-for-profit organization that supports and conducts research on organic production systems and public policy. Since 1993, the OFRF has conducted biennial surveys of organic farmers in the United States using grower lists maintained by organic certification organizations and was designed by a committee of nationally recognized organic practitioners, extensionists, researchers, and government specialists. Data on production and marketing practices and prob-

Table 1. Variable Descriptions and Summary Statistics (N = 567 organic farmers)

Variable	Description	Mean[a]	Standard Deviation	Survey Question[b]
EFF	Effectiveness rating for cooperative extension	0.53	0.50	1.2
TrnMix	Farm has transitioned to a mixed, organic system, 1 if yes	0.11	0.31	8.1
PartTime	Operator is part time farmer, 1 if yes	0.37	0.48	8.3
YrsOrg	Years as an organic farmer, from 0 to 45 years	9.65	7.19	8.10
OrgInc	Total gross organic farming income,	4.28	2.10	8.8
	Share of all farmers by income category			
	1 if less than $5,000	0.22		
	2 if $5,000 to $14,999	0.24		
	3 if $15,000 to $99,999	0.36		
	4 if $100,000 to $249,999	0.10		
	5 if at least $250,000	0.08		
OrgAcre	Acreage farmed organically, 1 to 6,000 acres	145.10	414.80	
EffPriv	Effectiveness rating for private sources, rating (0 or 1) multiplied by number used (1 to 4), from 1 to 16	2.02	0.96	1.2
PosRat	Number of private sources rated as effective (rating 0 or 1) over total private sources consulted (1 to 4)	0.75	0.29	1.2
TotSrc	Number of private sources consulted (1 to 4)	2.71	0.87	1.2
ProdConst	Index of organic production problems, rating of 5 problems (1 to 5) multiplied by severity (1 to 5), from 1 to 25	14.16	5.71	7.3
West	Farm is in SARE Region 1, 1 if yes	0.36	0.48	8.12
South	Farm is in SARE Region 3, 1 if yes	0.08	0.27	8.12
Northeast	Farm is in SARE Region 4, 1 if yes	0.28	0.45	8.12
NorthCent	Farm is in SARE Region 2, 1 if yes	0.28	0.45	8.12

[a] For dichotomous variables, the percentage is reported.
[b] The question number in the OFRF report. See text for more information on response categories.

lems of organic farmers were gathered, as well as details on information sources and demographic information (see Walz, 1999, 2001 for details). The data represent all crops grown organically, and all regions in which organic production is conducted.

The Effectiveness Ratings

Table 1 shows the variable descriptions and summary statistics for the dependent and independent variables included in the nonlinear logit model, as well as the question number from the OFRF survey results matching each variable. The dependent variable for the effectiveness ratings was based on the responses to a question about the information sources used by organic producers, coded as a 1 when the source is rated as effective and 0 otherwise. The structure of the survey first asked farmers to recall the frequency with which an information source was used on a yearly basis. Respondents were also encouraged to list favorite sources by name of provider or organization on an additional line, providing an anchor to assist producers in recalling their contacts with each information source. Organic farmers who had contact with cooperative extension advisors and provided a rating for a source were included in the analysis.

The Explanatory Variables

The independent variables were selected to test the importance of structural, demographic, and management factors that influence the perceived effectiveness of cooperative extension advisors. Farmers who have greater knowledge about farm management and ecology may be better prepared to evaluate the suitability of information about organic production methods. Indicators of farm man-

agement expertise include time spent on the farm and experience with organic farming. About 39% of the producers in our sample were engaged in farming on a part time basis (PartTime), compared with 61% of all U.S. farmers. Experience in organic farming averaged over 9 years (YrsOrg), although a few farmers reported no previous experience. With experience ranging up to 45 years, farmers' demand for and ability to evaluate externally provided information that is appropriate to the specific agro-ecosystem should exhibit significant variability in this sample.

A scale effect for farm size is expected to hold, in that larger farms have the most incentive to use the technical information distributed by the extension service, which usually offers at low cost the latest research-based, labor-saving technologies. The mean farm size (OrgAcre) was 144 acres while transitioned organic farmers with mixed systems had slightly larger farms averaging 154 acres. Gross organic income (OrgInc) is included to test for differences across income classes in extension ratings. The mean of the income variable was 4.28, implying that the average farm income from organic sales was between \$100,000 to \$249,999 for this sample while 46% of farmers received less than \$15,000 from organic farming. Farm size is closely linked to organic farming income because the large farms have the highest incomes while small farms have the lowest incomes.

A composite of the effectiveness ratings from four alternative private information sources used by organic farmers was formed (*EffPriv*) to measure how the perceived effectiveness of cooperative extension is influenced by farmers' use of private information providers. We defined U_i to be an indicator variable if the source was used and RE_i is another dichotomous variable indicating if the source was rated as effective or not. There are four private sector sources—field consultants, other farmers, organic certification agencies, and grower associations. The ratings of private sources are consistent with evaluations provided for extension program specialists where a 1 indicated the source is rated as effective and 0 otherwise. The composite index of the effectiveness ratings for private information sources is defined as

$$(6) \qquad EffPriv = \sum_{i=1}^{4} U_i RE_i = U \sum_{i=1}^{4} \frac{U_i RE_i}{U} = URE_p$$

where U is the total number of sources consulted. The term RE_p is the proportion of private sources that achieve an effectiveness rating equal to 1. The private effectiveness rating index reflects both the number of sources consulted and the overall effectiveness of those sources.

The rating index is included in the logit model in loglinear form as

$$(7) \qquad \begin{aligned} EffPriv &= URE_p = TotSrc \cdot PosRat \\ \ln(EffPriv) &= \ln TotSrc + \ln PosRat. \end{aligned}$$

The specification yields separate variables in the logit model that account for how the total number of private sources consulted and the proportion of private sources that were rated as effective providers influence the perceived effectiveness of extension experts in assisting organic farmers.

The OFRF survey also elicits information on the production constraints or problems facing organic farmers. The problems that farmers encounter in organic production influence the need to consult with extension experts and are an indicator of demands on the farmer's management ability. The index of production constraints (ProdConst) facing organic farmers was based on five key problems, including difficulties in achieving desired production levels or yields, sourcing or finding allowable inputs, the costs of allowable inputs, distance or transport problems for inputs, and the effectiveness of organic inputs. Farmers rated the severity of the problem, with the responses defined in the survey as "not a constraint" (value = 1) to a "serious constraint" (value = 5). The production problems index had a mean of 14.16 on a scale ranging from 5 to 25.

Producers who report the highest income from organic operations tend to score lower on the problems index, indicating that the index is related to the economic performance of the farm. In addition, farmers who are

Table 2. Summary of Test Procedures

Step 1:	Define the groups to compare coefficients from the discrete choice models.
Step 2:	Test the hypothesis that the coefficients are equal but the residual variances differ.
Model 1a:	Define the variable T_i, which is 1 for producers who have transitioned to organic farming and continue to farm with both organic and conventional methods and 0 for all other farmers. Estimate the model in Equation (3) and test the δ coefficient on variable T_i.
H_0:	No residual variation between the groups, $\delta = 0$. If H_0 is rejected, continue to Step 3. If H_0 is not rejected, continue with conventional methods for comparing coefficients.
Step 3:	Test the null hypothesis that the coefficients are the same across groups against the alternative that at least one coefficient is different across the groups.
Model 1b:	Estimate separate logit models for each group. This allows the coefficients for all variables to differ across groups and represents the unconstrained model. Add the log likelihoods.
Procedure:	Model 1a represents the constrained model. Model 1b represents the unconstrained model. Develop a χ^2 contrast between the models. The degrees of freedom are equal to the difference in the number of estimated parameters of the constrained and the unconstrained models, or $2n - (n + 2)$, where n is the number of estimated parameters in one of the separate logit models.
H_0:	All coefficients are the same across groups. If H_0 is rejected, continue to Step 4. Develop hypotheses for variables that may differ across the groups.
Step 4:	Test the null hypothesis that the coefficients are the same across groups against the alternative that at least one coefficient is different across the groups.
Model 2:	Add interaction effects to Model 1a and estimate using nonlinear logit. Develop a χ^2 contrast between Model 2 and Model 1a. The degrees of freedom are equal to the number of variables allowed to differ across groups.
H_0:	Variables with interaction effects are the same across groups. If H_0 is rejected, allow the variables to differ across groups.

transitioned to organic production acknowledge higher problem levels compared with farmers who began farming using organic methods. The potential impact of unobserved heterogeneity on evaluation of extension programs across organic farmers motivated application of the nonlinear logit model.

The USDA classifies regional distinctions strictly in terms of production and resource differences, giving rise to nine resource regions. To consistently assess the institutional support and information provided by cooperative extension, we used the four USDA Sustainable Agriculture Research and Education (SARE) regions. These regions reflect the federal government's demarcation for sustainable agriculture extension research support, which we hoped to proxy in the model. A dichotomous variable was created for each region, equal to 1 if the respondent's farm was in that region and 0 otherwise. In our sample, 36% of farmers were in the SARE 1 region (West), 28% in the SARE 2 region (North-Cent), 8% in the SARE 3 region (South), and 28% in the SARE 4 region (Northeast).

Estimation Results and Evaluation Tools

Table 2 shows the steps followed in conducting the analysis. Coefficient estimates and asymptotic t-statistics for the nonlinear logit model evaluating the effectiveness of cooperative extension advisors are presented in Table 3 (Model 1a). The first model is estimated under the null hypothesis that all coefficients are the same for the two groups of farmers (those with transitioned and mixed systems compared with all other organic farmers) but that the residual error term differs across the groups. The value of δ indicates how the disturbance standard deviation varies between the transitioned organic and the original organic producers. The value of -0.998 is significantly different from zero by a Wald χ^2 test based on the squared ratio of the estimate divided by its standard error.

Table 3. Nonlinear Logit Model of Effectiveness Ratings

Variable	Model 1a Coefficient[a]	Model 1a Marginal Effects		Model 2 Coefficient[a]
		TrnMix Farmers	All Others	
Constant	0.360 (0.587)			0.361 (0.588)
TrnMix	380.810 (0.004)	−0.151* (−2.376)		−52.634 (−0.004)
PartTime	0.675* (3.051)	0.003 (0.004)	0.166* (3.136)	0.675* (3.051)
ln(YrsOrg)	−1.128* (−2.648)	−0.004 (−1.600)	−0.005 (−1.620)	−1.128* (−2.649)
ln(YrsOrg^2)	0.239* (2.146)			0.239* (2.147)
OrgInc	0.126* (2.022)	0.028* (1.985)	0.031* (2.023)	0.126* (2.022)
ln(OrgAcre)	−0.019 (−0.327)	−0.004 (−0.327)	−0.004 (−0.327)	−0.019 (−0.327)
ln(PosRat)	0.374 (1.332)	0.083 (1.321)	0.093 (1.332)	0.374 (1.332)
ln(TotSrc)	0.081 (0.313)	0.018 (0.313)	0.020 (0.313)	0.081 (0.313)
ProdConst	−0.023 (−1.222)	−0.005 (−1.214)	−0.006 (−1.222)	−0.023 (−1.223)
West	0.876* (3.278)	0.023 (0.287)	0.216* (3.382)	0.875* (3.277)
South	0.522 (1.339)	0.014 (0.280)	0.139 (1.433)	0.522 (1.338)
Northeast	0.405 (1.537)	0.010 (0.281)	0.100 (1.542)	0.405 (1.537)
Del	−0.998* (2.153)			−0.997 (1.571)
TrnMix * ln(YrsOrg)				711.528 (0.004)
TrnMix * ln(YrsOrg^2)				−228.131 (−0.004)
Estrella R^2	0.12			
χ^2 value	740.006			737.062
Log-likelihood	−370.003			−368.531

[a] Asymptotic t-values in parentheses. Asterisk indicates significance at $\alpha = 0.05$ level. Critical value for $\chi^2_{14,0.95} = 23.69$. Model 1a is the nonlinear logit model. Model 2 is the nonlinear logit model allowing the coefficients on years farming organically to differ across the producer groups.

The evidence strongly suggests that the disturbance standard deviation differs across the two groups. A negative value for δ indicates that the standard deviation is 99% higher for transitioned organic farmers than for all other organic farmers. Effectiveness ratings from organic producers are clearly influenced by unobserved factors related to the farmer's status in transitioning to organic production. A model that neglected this heterogeneity would lead to biased and inefficient coefficient estimates and would not be useful in guiding extension advisors.

Given the finding of unequal residual variation, a second hypothesis is evaluated using a likelihood ratio test following Allison. The null hypothesis is that all the estimated coefficients are the same across the two groups of farmers versus the alternative that at least one of the coefficients is different. The nonlinear logit model constrains the estimated coefficients to be equal across the groups.

The unconstrained model is based on the estimation of separate logit models for each group and the log likelihood values are added from the two models (−34.658 for the transitioned farmers and −329.500 for all other farmers). Twice the difference between this value (−364.158) and the log likelihood from the nonlinear logit model (−370.003) results in a calculated χ^2 value of 11.689. The degrees of freedom are equal to the difference in the number of estimated parameters of the constrained and the unconstrained models, or $2n - (n + 2)$, where n is the number of estimated parameters in one of the separate logit models. The critical χ^2_{10} value is 18.307 so that the null hypothesis that the coefficients are the same across the two groups of organic farmers cannot be rejected. The nonlinear logit model appropriately accounts for the difference in the disturbance variance for these groups of farmers.

A final test of the nonlinear logit model examines whether specific coefficients differ across the two groups of organic farmers. The results for this test are presented in the last column of Table 3 (Model 2). The choice of

variables to examine may be guided by economic theory, knowledge about the agronomic and geographic factors that influence organic production, along with a preliminary analysis of the available survey data. The least experienced farmers (experience of less than 5 years) across the two groups of farmers differ across key economic indicators such as organic farm income and farm size. The transitioned organic farmers have larger farm operations (39% more acreage on average), and earned income is about 13% higher compared with other organic producers.

The constrained model is compared with a model that allows the coefficients on years farming organically to differ across the producer groups. A test for the significance of the interaction terms on years organic and years organic squared (in logarithms) while allowing for a difference in the disturbance variance does not reject the null hypothesis that the coefficients are jointly equal to zero. Organic farming experience does not have a separate effect on the evaluation of extension effectiveness after controlling for residual variation between the two organic farming groups.

A final methodological note also supports the application of the nonlinear logit model. A heteroscedastic logit model (Greene) was estimated that included a variable indicating whether the producer has transitioned to a mixed, organic system in a linear specification of the error term. The coefficient was not significant in the model, incorrectly suggesting that heteroscedasticity was not present. The heteroscedastic logit model did not identify the impact of unobserved heterogeneity that was verified by the nonlinear logit model proposed by Allison. Recent research by Keele and Park demonstrates that estimates from heteroscedastic discrete choice models are biased and can often lead to incorrect inferences.

Model Interpretation and Assessment

The marginal effects from the nonlinear logit model are presented in Table 3. For the dichotomous variables, the marginal effects denote the change in probability that an effective rating is achieved when the condition exists (PartTime = 1) versus when it does not (PartTime = 0). For explanatory variables with multiple integer categories such as income, the marginal effect is evaluated with respect to a change from the mean income category to the next higher category. Standard errors for the marginal effects are calculated using the delta method following Greene.

Part-time farming status has a positive impact on the ratings by organic producers. Farmers who work off the farm and engage in farming on a part time basis have opportunities to diversify their incomes. Previous work by Lohr and Park indicates that part time organic producers tend to adopt and implement a smaller portfolio of farm management techniques than full-time farmers. The model confirms that extension advisors are effective in addressing the needs of these part time producers, who tend to adopt a limited set of management techniques.

The producer's experience with organic farming was measured by a quadratic specification in the logarithm of years engaged in organic farming. Organic farming experience tends to decrease the probability of a positive effectiveness rating, indicating that more experienced organic farmers are comparatively less satisfied with the information provided by extension providers. The marginal effect of an additional year of organic farming experience reduces the probability of a positive effectiveness rating by 0.4% for the transitioned farmers and by 0.5% for all other farmers. The marginal effect is evaluated at the mean values of the explanatory variables with age experience at 9.65 years. Extension providers could use this information when preparing seminars and technical training for a group of highly experienced organic farmers because this group will present a more demanding audience and materials can be adjusted to meet their expertise levels.

A second point to note is that new and entering farmers are a significant share of the organic production community: 36% of farmers in the OFRF survey report 5 or less years of experience in organic farming. For this less experienced group of organic farmers, addi-

tional years of farm experience contribute to a higher probability of an effective rating for extension providers. A clear implication is that extension advisors need to understand the information needs of these entering (and less experienced) organic farmers and adapt materials and programs to the level required by these producers.

The number of four private sector sources consulted has a small positive effect on the performance ratings of extension advisors, suggesting a complementary information provider role for extension. This result aligns with a principal-agent model that casts the farmer as a principal seeking production advice from extension advisors and private information providers, who serve as the agents (Levitt). Frisvold, Fernicola, and Langworthy confirmed a positive role for local community volunteers in the provision of extension services. The model presented here suggests that the evaluation (or perceived quality) of extension is positively linked to the provision of information by private providers. Using multiple information sources and agents provides the farmer-principal the greatest chance of finding the most useful information.

The regional effects were significant for one of the SARE region dummy variables included in the model. The significant positive estimate for West implies that extension advisors in the region have a 21.6% higher probability of obtaining a positive rating relative to the omitted North Central region. Regional differences in resources allocated to the extension service such that practices advocated by extension that could promote sustainable and organic production have been unevenly adopted.

The West SARE region historically has made greater commitments to organic research and education. The West is home to the nation's oldest organic farm and certifying organizations, California Certified Organic Farmers and Oregon Tilth, which have had more than 20 years to develop a research and education agenda, and develop positive relations with state and local extension advisors. California enacted the first state law to define organic foods in 1982. California and Washington were among the first extension services to conduct outreach and applied research on organic agricultural systems using teams of extension providers rather than individuals.

Evaluation Tools for Effectiveness Ratings

Client feedback in the form of program evaluation is used by extension to improve existing services and to suggest new information offerings. McDowell commented on the importance of proactive extension programming that anticipates the research needs of farmers and is a credible source of information. A useful tool from the model calculates the probability of a positive effectiveness rating when extension presentations are targeted to organic farmers with specific demographic or farm characteristics. The probability of an event is calculated using the estimated coefficients from the nonlinear logit model, and a success is predicted (an effectiveness rating equal to 1) when the probability exceeds 50% (Liao).

The information in Table 4 compares the predicted outcomes from the nonlinear logit model with the observed effectiveness of extension reported by organic farmers. The model predicts the proportion of positive effectiveness ratings from organic farmers. A correct prediction of a positive evaluation is termed a hit while a correct prediction of a negative evaluation is a correct rejection. The sum of the hits and correct rejections shows the correct predictions at 64%. In preparation of program materials and *ex ante* assessments of programs to organic farmers, evaluators of extension performance may focus particular attention on identifying situations when unsatisfactory performance is unintentionally overlooked. A missed alarm occurs when the evaluation is negative but the model predicts a positive evaluation and occurs in 21% of the cases. A high rate of missed alarms indicates that additional planning, updated materials and handouts, and new presentation approaches may be needed to effectively target the clientele group and serves as an early warning indicator of the need for an additional allocation of effort. A final category of predictions indicates the failures in predicting

Table 4. Prediction Evaluations of Nonlinear Logit Model for Effectiveness Ratings

	Predicted Effectiveness			
	Hit[a]	Correct Rejection[b]	Missed Success[c]	Missed Alarm[d]
Nonlinear logit (50%)	39	25	15	21
Case 1. Predicted effectiveness, by income of organic farmers				
Income below $15K	37	29	14	20
Income range: $15K–$99K	31	24	22	24
Income range: $100K–$249K	54	21	5	20
Income above $249K	64	14	2	20
Case 2. Predicted effectiveness by farm type				
Transitioned, mixed farmers	67	0	0	33
All other organic farmers	35	28	17	20

[a] Hit: Evaluation is positive and model predicts positive evaluation. All reported values are percentages.
[b] Correct Rejection: Evaluation is negative and model predicts negative evaluation.
[c] Missed Success: Evaluation is positive and model predicts negative evaluation.
[d] Missed Alarm: Evaluation is negative and model predicts positive evaluation.

success when it occurs, and this occurs 15% of the time. Extension evaluators who use a formal model to perform *ex ante* predictions of the success of a program gain information on where improvements can be made in presentations to improve effectiveness for specific clientele groups.

Scenarios to predict extension effectiveness when interacting with specific groups of organic farmers are derived from the model. Table 4 examines breakdowns of effectiveness ratings by income classes of organic farmers. Correct predictions hover above 55% across each income group, reaching 75% or more for farmers with earnings in the highest income classes. The model shows consistent performance across all income levels of organic producers.

A primary motivation for considering the nonlinear logit model was derived from survey information suggesting that organic producers were divided into separate clienteles with potentially different extension needs. The two groups initially identified were transitioned farmers maintaining mixed operations and all other organic farmers. The nonlinear logit model confirmed that effectiveness ratings from organic producers are clearly influenced by unobserved factors related to the farmer's status in transitioning to organic production. Potential problems in assessing performance across the two farm groups are apparent in the predicted effectiveness outcomes. Both the hits (percentage of correct positive effectiveness ratings at 67%) and the missed alarms (incorrect positive predictions at 33%) attain their highest values for these farmers. The model highlights problems in correctly identifying poor ratings for extension advisors who prepare programs or provide advice for transitioned organic farmers with mixed farm operations.

In a practical sense, the model warns that extension experts addressing this group may have difficulty perceiving if they are connecting with these farmers in their presentations. Extension teams should be prepared to modify their communication strategies and allow for expanded in-session questions and interactions with attendees. Information from the OFRF survey could be exploited to understand more fully the production problems that the transitioned farmers identify as significant constraints. For example, three different production constraints were rated as most serious (a value of 4 or 5) by about 50% of the transitioned farmers: difficulties in achieving desired production levels or yields, the costs of allowable inputs, and the effectiveness of organic inputs. Orienting extension materials that specifically addressed these problems would assist in establishing credibility with these farmers.

Summary and Conclusions

This study fills a gap in information about the relationship between extension advisors and organic farmers. A USDA-CSREES white paper on organic agriculture by Kotcon and Thilmany noted that land grant education programs need to better prepare extension agents to design and provide programs for the unique needs and learning styles of organic farmers. Performance evaluation is an important component in improving and fine tuning the delivery of extension programs and technical information. Hanson and Just implicitly addressed the need for methods to evaluate extension programs, noting that without market feedback, extension services may continue to offer educational programs that have become obsolete.

Our model addresses this research agenda by exploring the factors that influence the effectiveness ratings of extension agents based on a nationwide survey of organic farmers. The nonlinear logit model confirms that effectiveness ratings from organic producers are influenced by unobserved factors related to the farmer's status in transitioning to organic production. A model that neglected this heterogeneity would lead to biased and inefficient coefficient estimates without adequately providing guidance on how to improve performance of extension advisors.

The results indicate that part time, newer adopters of organic farming methods are more likely to rate extension service providers as effective providers of information. Not accounting for these demographic components in effectiveness ratings may result in under- or overestimation of results of organic-targeted extension programs. New and entering organic farmers account for a significant share of organic producers, and extension advisors have demonstrated an ability to provide useful information for these farmers.

We demonstrated the validity of the nonlinear logit model as a tool in predicting extension effectiveness when interacting with diverse groups of farmers. The approach and evaluation tools can be extended to other situations. Extension outreach activities are being oriented to serve an expanding set of agricultural producers, including limited-resource producers, direct-marketing producers, and transitional farmers, along with efforts to reach underserved or minority groups. Recognizing the diverse research, extension, and educational needs of these groups suggests the need to account for unobserved factors that may influence the perceptions of these client groups. The continued development and application of models following the approach of the nonlinear logit model could prove useful in developing evaluation tools.

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References

Allison, P.D. "Comparing Logit and Probit Coefficients across Groups." *Sociological Methods and Research* 28(1999):186–208.

Bhattacharyya, A., T.R. Harris, W.G. Kvasnicka, and G.M. Veserat. "Factors Influencing Rates of Adoption of Trichomoniasis Vaccine by Nevada Range Cattle Producers." *Journal of Agricultural and Resource Economics* 22(1997): 174–90.

Estrella, A. "A New Measure of Fit for Equations with Dichotomous Dependent Variables." *Journal of Business and Economics Statistics* 16(1998):198–205.

Frisvold, G.B., K. Fernicola, and M. Langworthy. "Market Returns, Infrastructure and the Supply and Demand for Extension Services." *American Journal of Agricultural Economics* 83(2001): 758–763.

Greene, W.H. *Econometric Analysis,* 5th ed. Upper Saddle River, NJ: Prentice Hall, 2003.

Hanson, J.C. "Opportunities and Challenges in Cooperative Extension for Agricultural Economists." *Agricultural and Resource Economics Review* 26(1997):143–152.

Hanson, J.C., and R.E. Just. "The Potential for Transition to Paid Extension." *American Journal of Agricultural Economics* 83(2001):777–784.

Keele, L.J., and D.K. Park. "Ambivalent about Ambivalence: A Re-examination of Heteroskedastic Probit Models." Working Paper, Department of Political Science. Ohio State University, December 2006.

Kotcon, J., and D. Thilmany. *CSREES Organic Opportunities White Paper*. Washington, DC: U.S. Department of Agriculture, Cooperative State Research, Education, and Extension

Service, Internet site: www.ofrf.org/policy/usda_organic/csrees/organic_opportunities.pdf (Accessed October 10, 2006).

Levitt, S.D. "Optimal Incentive Schemes When Only the Agents' 'Best' Output Matters to the Principal." *RAND Journal of Economics* 26(1995):744–760.

Liao, T.F. *Interpreting Probability Models: Logit, Probit, and Other Generalized Linear Models*. Thousand Oaks, CA: Sage, 1994.

Lohr, L., and T.A. Park. "Choice of Insect Management Portfolios by Organic Farmers: Lessons and Comparative Analysis" *Ecological Economics* 43(2002):87–99.

McDowell, G.R. *Land-Grant Universities and Extension into the Twenty-First Century: Renegotiating or Abandoning a Social Contract*. Ames, IA: Iowa State University Press, 2001.

National Research Council. *Publicly Funded Agricultural Research and the Changing Structure of U.S. Agriculture*. Washington, DC: National Academy Press, 2002.

Postlewait, A., D. Parker, and D. Zilberman. "The Advent of Biotechnology and Technology Transfer in Agriculture." *Technological Forecasting and Social Change* 43(1993):271–87.

Smith, P.C., and M. Goddard. "Performance Management and Operational Research: A Marriage Made in Heaven?" *Journal of Operational Research Society* 53(2002):247–255.

Walz, E. *Final Results of the Third Biennial National Organic Farmers' Survey*. Santa Cruz, CA: Organic Farming Research Foundation, 1999.

———. *Final Results of the Fourth Biennial National Organic Farmers' Survey*. Santa Cruz, CA: Organic Farming Research Foundation, 2001.