Credence goods: a labeling problem?

Ashley Wood Renck
Texas A&M-Commerce
Department of Agricultural Sciences
Ashley_Renck@tamu-commerce.edu

Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Mobile, Alabama, February 1-5, 2003

Credence goods: a labeling problem?

The marketing of credence goods has the potential to increase revenue of agricultural producers. However, process attributes must be related to consumers effectively. This paper examines labeling issues of credence goods. Literature related to credence goods and process attributes is reviewed and the potential for labeled agricultural products is explored.

Background

Consumer purchasing decisions can be based not only on the utility derived from consumption of the good, but also on the producing firms' operating practices. Consumer goods are increasingly being differentiated by process attributes. Products of this type are referred to as credence goods. Examples of this include organically produced food, dolphin-safe tuna, and irradiated food. A consumer cannot inspect a good and determine if the process attribute claim is true. This creates an asymmetric information problem that can be alleviated by labeling implemented by a certification agent.

Labeling of this type can take many forms. Labels can be detailed, they can also include information about the process and how it differs from other production practices, and labels can also contain information about the certifying agent. It is the importance of the label in determining purchasing decisions that is the focus of this research.

Data and Methods

The data used in this analysis were collected using a mail survey instrument. Consumers were presented with one of six versions of a labeled poultry product. The respondent was then asked to choose between the labeled product and the regular product. The respondent was further asked to explain why they chose to purchase or not purchase the product.

The study consisted of 2,159 responses. The responses were analyzed using a probit regression model. The explanatory variables used to explain why the consumer chose to purchase the labeled credence good include trust or belief in label, label detail, third party verification, knowledge of the production process, and belief that label was an advertising gimmick.

In order to minimize the effect of nonresponse bias, a selection model was used. A sample selection model consists of a selection mechanism and a regression model that is only observed for survey respondents. The selection model is estimated using the two-step procedure of Heckman (1979). Given a random sample of N individuals, the data available to the investigator is generated by the bivariate model

$$y_i^* = \beta' X_i + \varepsilon \tag{1}$$

$$y_i = 1 \text{ if } y_i^* > 0$$

$$y_i = 0 \text{ if } y_i^* \leq 0$$

$$\text{Prob}(y_i = 1) = \Phi(\beta' X_i) \tag{2}$$

$$\text{Prob}(y_i = 0) = 1 - \Phi(\beta' X_i) \ . \tag{3}$$

Equation 1 represents the selection mechanism. y^* represents an unobservable level of utility the individual receives from filling out and returning the survey. X is a vector of demographic and other variables that explain the probability of an individual participating in the survey. β is a vector of parameters to be estimated and ε is the error term, assumed to follow a standard normal distribution.

The regression on the selected sample is given by equation 4

$$W = \gamma' Z + v \ , \tag{4}$$

which represents the regression equation. W=1 if the respondent was willing to pay a premium for the ecolabeled product and zero otherwise and Z is a vector of variables that explain the response variable W. Equation 4 is only observed if y=1, that is, the survey was returned. The regression equation (4) is only observed in the sample of completed surveys. γ is a vector of parameters to be estimated and v is assumed to follow a standard normal distribution. Correlation between ε in equation 1 and v in equation 4 lead to biased estimation if the regression equation is estimated alone.

Estimation of selection equation

The selection equation

$$y_i^* = \beta' X + \varepsilon \qquad (5)$$

was specified as a probit model in which y=1 for those participating in the survey, and y=0 for those not participating. Results of the t tests previously described suggest that nonresponse is related to certain individual demographic characteristics. Thus, it was hypothesized that nonresponse may be related to demographic characteristics at census block group level such as race, income, and education; here census block group data serves as a proxy for individual household characteristics. The selection equation was then expressed

$$\text{Prob}(y = 1) = f(\text{demographics}) + \varepsilon .$$

The equation was estimated using SAS. The dependent variable, RETURN, was coded 1 if the respondent had sent the survey back and 0 otherwise. Specifically, explanatory variables hypothesized to influence the decision to return the survey were percent black households (BLK1), percent male (MALE), average age category of household head (P1824, P5564, P6574), ages 18 to 24, 55 to 64, and 65 to 74 respectively, percent of persons not citizens of the United

States (CFNO), total number of owner occupied houses (OWN), mean annual income (HINC), and percent college graduates (EDC). The results of the probit estimation are shown in Table 1.

The only variable hypothesized to influence response that was not significant was income. The percentage of the census block that was male was inversely related to the probability of response. This conclusion was supported by the responses. Almost 60 percent of the respondents were female.

Only five percent of the respondents indicated they were African American. This finding also supported the inverse relationship found between the percentage of the neighborhood that is black and the probability of response. The age variables included in the selection model were based on the distribution of the respondents' ages. The age group 18-24 was significantly under represented in the sample. This under representation could be due to active lifestyles of respondents in this age group, which lead to eating more meals away from home. Also, persons in this age group are less likely to head household. The age group 55-64 was over represented in the sample, as was the 65-74 age group. The results of the model indicate that a higher percentage of 18-24 year olds in a census block increased the likelihood of responding, as did a higher percentage between 55 and 64. Interestingly, an increased percentage of the population in the 65-74 age group decreased the likelihood of response.

Respondents were not asked about their citizenship, but this variable was included in the selection model. Not surprisingly, neighborhoods with a high percentage of nonresidents were less likely to respond to the survey. These individuals may be less interested in policy decisions or less aware of agricultural production practices in the U.S.

Individuals who owned their own home were more likely to reply to the survey. Home ownership was possibly correlated with middle age and education, both of which increased the

likelihood of response. A high percentage of college graduates in the census block significantly increased the likelihood of response.

There are two basic tests for goodness of fit for probit models. The likelihood ratio test is an overall global test of significance. This test is based on the ratio of likelihood values of the full and reduced models. The hypothesis tested was expressed as

$$H_o : \beta_i = 0$$

$$H_a : \beta_i \neq 0,$$

where β_i are the parameters estimated from equation 4.

The test statistic was calculated

$$LR_{stat} = -2\log[L(\text{reduced}) - L(\text{full})],$$

where L was the likelihood function and the reduced and full models were expressed

full $$y_i^* = \beta' X + \varepsilon \quad (6)$$

reduced $$y_i^* = \beta_\circ + \varepsilon \quad (7)$$

and

$$LR_{stat} \approx \chi^2.$$

The overall model was significant at the 1 percent significance level. The proportion of correct predictions is also used as an indicator of goodness of fit. The model correctly predicted the observed responses 55 percent of the time.

In order to correct for nonresponse bias in the regression equation 4, the inverse Mills' ratio (lambda) was obtained from the selection model estimates. Lambda (λ) was calculated for each response using the following formula,

$$\lambda = \varphi(\hat{\beta}' X_i) / \Phi(\hat{\beta}' X_i).$$

where ϕ and Φ are the standard normal density and distribution functions respectively. Lambda was then used in the next step to correct for sample selection bias.

Estimation of regression equation

Recall the regression equation

$$W = \gamma' Z_i + v_i \quad (4)$$

where Z is a vector of explanatory variables and W is a yes or no response to the survey question. Each individual i was confronted with an arbitrary threshold premium offer, T_i. W indicates a true valuation either greater than or less than T_i. Acceptance of T_i is denoted W_i=1, and rejection by W_i=0. This equation was rewritten

$$W_i = \alpha + \delta' T_i + \gamma' Z_i + v_i \quad (28)$$

where α is an intercept term, δ and γ are vectors of parameters to be estimated and *v* was independently and identically distributed with mean zero and standard deviation σ.

The regression equation was estimated as both a probit and logit model. However, the probit model was chosen because it provided more conservative WTP estimates. W_i was coded 1 for respondents who chose the ENVIROFRIENDLY product and 0 otherwise. T_i is the premium for the ecolabeled product. Variables included in the Z vector that are hypothesized to influence the decision included: household size (HHSIZE), age of respondent (AGE), education (COED), annual household income (INC), contribution to environmental groups or causes (CONT), weekly consumption of chicken in pounds (CONS), always looks for environmentally friendly products (ENAL), prior knowledge of waste management problems in poultry production (AWNOT), government pays too much attention to environmental issues (GEITM), government pays too little attention to environmental issues (GEITL), believes agricultural practices have a negative impact on drinking water (NEGDW) and food safety (NEGFS), the

premium for the ecolabeled whole chicken in dollars (WHPREMIUM), whether label was detailed (DETAILED), third party verification provided (PROOF), and the lambda values (LAMBDA) from estimation of the selection equation.

The marginal effect of the discrete explanatory variable on the event probability was calculated as the difference in predicted probabilities at the means of the vector of explanatory variables Z. This method was used because partial derivatives of the event probability with respect to a discrete variable are not defined and may overestimate the marginal effect (Maddala). This method was also used to calculate the marginal effect of the premium. The marginal effect of the premium should be interpreted as the change in the likelihood of purchasing the ecolabeled product with a $0.01 change in the premium. The standard errors for the marginal effects were calculated using the delta method (Greene). For the probit model, the variance was calculated using the following formula

$$\text{var}[\hat{\gamma}] = \varphi^2 \left[I - (\hat{\beta}' x)\hat{\beta} x' \right] V \left[I - (\hat{\beta}' x)\hat{\beta} x' \right]' \quad (9),$$

where $\hat{\gamma}$ was the marginal effect, ϕ was the standard normal cdf evaluated at the vector of means x, I was an identity matrix, $\hat{\beta}$ was a vector of estimates and $V = \text{var}[\hat{\beta}]$.

Whole Chicken

The results of the estimation for whole chicken are shown in Table 2. The model was significant at the 1 percent significance level and predicted observed responses correctly 78 percent of the time.

The number of individuals living in the household is inversely related to WTP. Large households are more likely to follow a budget, which means price is a more important component of purchasing decisions. Each additional member of a household decreased the

likelihood of purchase by 2 percent. Twenty eight percent of households with 5 or more members indicated they would not purchase the ecolabeled chicken because it was too expensive, whereas only 13 percent of households with three or fewer members cited too expensive as the reason for not purchasing the ecolabeled product.

Age was inversely related to WTP. One explanation for this finding is that younger respondents were more likely exposed to environmental issues in school than were older respondents. It could also be a function of budget restrictions, as retirees may be more likely to live on a fixed income. Thirty percent of respondents age 55 and above would not purchase the ecolabeled product because it was too expensive. Also, 8 percent who would not purchase the ecolabeled product because they thought it was an advertising gimmick.

Education was not significant, nor was income. Weekly consumption was also not significant in explaining WTP. However, individuals who contributed to environmental organizations were 5 percent more likely to pay a premium for the ecolabeled product, as were those who indicated they always look for environmentally friendly products.

Individuals who had heard little about the waste management problems associated with poultry production were 6 percent less likely to pay a premium. Respondents who felt the government already pays too much attention to environmental issues were also 12 percent less likely to pay a premium. On the contrary, those who felt the government does not pay enough attention to environmental problems were more likely to pay a higher premium.

Respondents' attitudes about agricultural practices also significantly affected WTP. Those who believed current agricultural practices harm drinking water and food safety would pay a premium for an ecolabeled product.

As expected, the magnitude of the premium was inversely related to WTP, with each additional cent added to the premium reducing the likelihood of purchase by 5 percent. Increasing amounts of information provided on the label positively affected WTP, although third party verification did not influence the respondents' choice to buy the ecolabeled product.

Boneless/Skinless Breasts

The results of the estimation for boneless/skinless chicken breasts are shown in Table 3. The model was significant at the 1 percent significance level and predicted observed responses correctly 78 percent of the time.

Similar to the results of the whole chicken model, the number of individuals living in the household was inversely related to WTP. Because the base prices of boneless/skinless breasts were higher than the other two products, it was not surprising that 37 percent of households with 5 or more members indicated the ecolabeled chicken was too expensive. Again, age was inversely related to WTP. Thirty five percent of those 55 and older indicated the ecolabeled chicken was too expensive and nine percent thought it was an advertising gimmick.

The parameter estimate for education level was not significant. However, income was significantly related to WTP for boneless/skinless chicken breasts, which is not surprising because boneless/skinless chicken breasts are considered to be a luxury good. For each $1,000 increase in income, the household was 14 percent more likely to purchase the ecolabeled product. The base prices were significantly higher than those for whole chicken or chicken wings; therefore, one would expect income to play a more significant role in respondents' WTP.

Weekly consumption was again not significant in explaining WTP. Whether or not the respondent contributed to environmental organizations was also not related to WTP for

ecolabeled boneless/skinless chicken breasts. However, those who indicated they always look for environmentally friendly products were willing to pay a higher premium.

Individuals who had heard nothing about the waste management problems associated with poultry production were 10 percent less likely to pay a premium. Respondents who felt the government already pays too much attention to environmental issues were also 9 percent less likely to pay a premium. In contrast, those who felt the government does not pay enough attention to environmental problems were more likely to pay a higher premium.

Respondents' attitudes about agricultural practices also significantly affected WTP for boneless/skinless chicken breasts. Those who believed current agricultural practices harm drinking water and food safety would pay a higher premium for an ecolabeled product.

As expected, the magnitude of the premium was inversely related to WTP. The amount of information provided on the label positively affected WTP. Third party verification did not influence respondents' choices to buy the ecolabeled product.

Chicken Wings

The results of the estimation for chicken wings are shown in Table 4. The model was significant at the 1 percent significance level and predicted observed responses correctly 73 percent of the time.

The model of WTP for ecolabeled chicken wings was estimated with the smallest number of observations, because thirty-three percent of the respondents indicated they would buy neither the regular nor the Envirofriendly chicken wings.

The number of individuals living in the household is inversely related to WTP. Twenty nine percent of households with 5 or more members thought the ecolabeled chicken wings were too expensive. Age is inversely related to WTP. Twenty eight percent of those 55 and older

indicate that ecolabeled chicken wings were too expensive and eight percent perceived the ecolabel as an advertising gimmick.

Education is not significant, nor is income. A contribution to environmental organizations is also not significant in explaining WTP. Those who indicate they always look for environmentally friendly products were 7 percent more likely to pay a premium. The model for chicken wings is the only model where weekly consumption is significant.

Individuals who had heard little about the waste management problems associated with poultry production were 5 percent less likely to pay a premium. Respondents who felt the government already pays too much attention to environmental issues were also less likely to pay a premium. In comparison, those who felt the government does not pay enough attention to environmental problems were more likely to pay a premium.

Respondents who believed current agricultural practices harm drinking water and food safety were 4 percent more likely to pay a premium for an ecolabeled product. As expected, the magnitude of the premium is inversely related to WTP. Each additional cent added to the premium reduced the likelihood of purchase by 6 percent. Neither the amount of information nor third party verification influenced the respondents' choice to buy the ecolabeled chicken wings.

The estimates from the three models were used to estimate expected WTP. The method of estimation and results are described in the next section.

Expected Willingness to Pay

The expected WTP for each respondent is calculated using the formula

$$E(WTP) = -\frac{\alpha + \gamma' Z}{\delta},$$

where α is the intercept term. γ is a vector of parameter estimates of the vector of Z explanatory variables, and δ is the parameter estimate of the premium bid. WTP was estimated for each individual, and then averaged for each product.

The mean willingness to pay for whole chicken was $0.41 per pound. This WTP estimate is a 37 percent mark up on the average base price of $1.10 per pound. The premium ranged from $0.05 to $1.19 per pound, for an average premium offer of $0.42 per pound.

The mean willingness to pay for boneless/skinless chicken breasts was $0.48 per pound. This WTP estimate is a 17 percent mark up on the average base price of $2.90 per pound. The premium on boneless/skinless chicken breasts ranged from $0.14 to $3.19 per pound, for an average premium offer of $1.14.

The mean willingness to pay for chicken wings was $0.26 per pound. The premium ranged from $0.09 to $2.09 per pound. The average premium offer was $0.73 per pound. This WTP estimate is a 36 percent markup on the average base price of $1.89 per pound.

The selection equation was estimated to explain factors contributing to survey response. Males were less likely to complete the survey, as were African Americans. Respondents who live in neighborhoods with high percentages of non-U.S. residents were also less likely to return the survey. College graduates were more likely to return the survey. The selection equation was also used to calculate the nonresponse bias present in the survey data. This measure was then used as a parameter in the second step of the estimation to correct for nonresponse bias. The selection parameter, lambda, was not significant in the three probit models estimated. Therefore, the models were also estimated without lambda, with resulting WTP of $0.43, $0.49, and $0.27 for whole chicken, boneless/skinless breasts, and chicken wings respectively. These estimates

were less conservative than those from the models including lambda. Based on comparison of the WTP estimates, lambda was included in the final models.

The model for chicken wings did not perform as well as the models for the other two products. This performance could be because chicken wings are a specialty product not eaten by most consumers or because of the lower number of observations used in the estimate.

The most interesting result from the survey was the importance of the level of label detail in determining whether a consumer would purchase the ecolabeled product. This finding highlights the importance of identifying the particular environmental good that the premium purchases. It also suggests any ecolabeling program should pay particular attention to the design of the label to be used.

Similar to the results of other studies, the presence or absence of third party verification did not influence purchase of the ecolabeled product. This finding is supported by the reasons given for not purchasing the ecolabeled product. Over half of the respondents who chose the regular product indicated they did so because of expense and lack of information regarding the production practices.

Because consumers indicated that their lack of information regarding production practices resulted in their reluctance to pay a premium indicates that the viability of an ecolabeling program would rely heavily on education about the waste management problem. This conclusion is also supported by the significance of prior information about the waste management problems in poultry production. Respondents who had heard nothing about waste management problems in poultry production were fourteen percent less likely to purchase the ecolabeled product.

Not surprisingly, those who indicated the government spends too little on environmental issues were 20 percent more likely to purchase the ecolabeled chicken. This finding is interpreted to mean that ecolabeling is a viable alternative to government intervention. Individuals who feel the government is not doing enough to address environmental problems are willing to pay a premium voluntarily.

Results

Initial results indicate that consumers are not influenced by third party verification. Trustworthiness of the label also does not significantly influence the decision to purchase a credence good. However, label detail was important in consumers' choice to purchase the labeled product.

Discussion

Credence goods have great potential in agriculture. To differentiate their product, and therefore demand higher prices, producers can use process attribute marketing. However, how the information about the attribute is conveyed to consumers is a potential roadblock to success. This research addresses this issue and examines the issues surrounding credence good labeling.

Table 1
Probit Estimation Results of Selection Equation

Variable	Coefficient	
Intercept	-0.5137	***
	(0.0396)	
MALE	-0.0003	***
	(0.0001)	
BLK1	-0.0002	***
	(0.0001)	
P1824	0.0003	**
	(0.0001)	
P5564	0.0004	*
	(0.0002)	
P6574	-0.0003	**
	(0.0002)	
CFNO	-0.0004	***
	(0.0001)	
OWN	0.0003	**
	(0.0001)	
HINC	-0.0001	
	(0.0001)	
EDC	0.0003	***
	(0.0001)	
Log L	-4255	
χ^2	74.48	***
d.f. χ^2	9	

(standard errors)

* Significant at 0.10 level

** Significant at 0.05 level

*** Significant at 0.01 level

Table 2

Probit Regression Results for the Probability that the Respondent Would be Willing to Pay a Premium for Ecolabeled Whole Chicken

Variable	Coefficient		Marginal Effect	
Intercept	0.0666			
	(0.5075)			
HHSIZE	-0.0931	***	-0.0231	***
	(0.0304)		(0.0014)	
AGE	-0.00673	**	-0.0016	
	(0.0026)		(0.0076)	
COED	0.1278		0.0321	
	(0.0837)		(1.5900)	
INC	0.0199		0.0055	
	(0.0151)		(1.0400)	
CONT	0.1838	**	0.0580	**
	(0.0772)		(0.0099)	
CONS	0.00373		0.0008	
	(0.0142)		(0.0064)	
ENAL	0.6049	***	0.1519	***
	(0.0978)		(0.0134)	
AWNOT	-0.2556	***	-0.0667	**
	(0.0760)		(0.0108)	
GEITM	-0.5169	***	-0.1204	***
	(0.1463)		(0.0128)	
GEITL	0.4849	***	0.1221	***
	(0.0771)		(0.0126)	
NEGDW	0.3913	***	0.1024	***
	(0.0768)		(0.0121)	
NEGFS	0.2201	***	0.0063	
	(0.0739)		(0.0104)	
WHPREMIUM	-0.8833	***	-0.0562	**
	(0.0931)		(0.0146)	
DETAILED	0.2078	***	0.0023	
	(0.0699)		(0.0184)	
PROOF	0.1029		0.0560	
	(0.0736)		(0.0149)	
LAMBDA	-0.0855			
	(0.3802)			
Log L	-874.0000			
χ^2	332.7900	***		
d.f. χ^2	16			

(standard errors)

* Significant at 0.10 level

** Significant at 0.05 level

*** Significant at 0.01 level

Table 3

Probit Regression Results for the Probability that the Respondent Would be Willing to Pay a Premium for Ecolabeled Boneless/Skinless Chicken Breast

Variable	Coefficient		Marginal Effect	
Intercept	-0.2197			
	(0.5061)			
HHSIZE	-0.0574	*	-0.0023	
	(0.0308)		(0.4717)	
AGE	-0.0045	*	-0.0251	
	(0.0026)		(0.2372)	
COED	0.1064		0.0094	
	(0.0842)		(0.5121)	
INC	0.0393	**	0.1461	**
	(0.0154)		(0.0331)	
CONT	0.1047		0.0269	
	(0.0774)		(0.5635)	
CONS	0.0190		0.0044	
	(0.0143)		(0.0647)	
ENAL	0.5786	***	-0.0487	
	(0.0951)		(0.0768)	
AWNOT	-0.2034	***	-0.1086	***
	(0.0780)		(0.0061)	
GEITM	-0.5445	***	-0.0960	***
	(0.1580)		(0.0072)	
GEITL	0.4085	***	0.0541	
	(0.0797)		(0.7155)	
NEGDW	0.3111	***	0.0063	***
	(0.0791)		(0.0007)	
NEGFS	0.2241	***	-0.0011	
	(0.0751)		(0.5863)	
BBPREMIUM	-0.4676	***	-0.0070	

	(0.0373)		(0.8292)
DETAILED	0.1562	**	0.0471
	(0.0709)		(0.0580)
PROOF	0.0168		-0.0129
	(0.0747)		(0.4886)
LAMBDA	-0.1111		
	(0.3766)		
Log L	-848.5000		
χ^2	3.1649	***	
d.f. χ^2	16		

(standard errors)

* Significant at 0.10 level

** Significant at 0.05 level

*** Significant at 0.01 level

Table 4

Probit Regression Results for the Probability that the Respondent Would be Willing to Pay a Premium for Ecolabeled Chicken Wings

Variable	Coefficient		Marginal Effect	
Intercept	-0.4507			
	(0.4980)			
HHSIZE	-0.0519	*	-0.0093	
	(0.0306)		(0.8330)	
AGE	-0.0110	***	-0.0023	**
	(0.0027)		(0.0005)	
COED	0.0039		0.0004	
	(0.0839)		(0.9751)	
INC	0.0119		0.0021	
	(0.0153)		(0.7822)	
CONT	0.0289		0.0042	
	(0.0774)		(0.9969)	
CONS	0.0346	**	0.0075	
	(0.0141)			

			(0.0064)	
ENAL	0.3397	***	0.0763	***
	(0.0927)		(0.0015)	
AWNOT	-0.2555	***	-0.0524	***
	(0.0789)		(0.0012)	
GEITM	-0.5498	***	-0.0914	
	(0.1649)		(0.1498)	
GEITL	0.2861	***	0.0624	
	(0.0804)		(0.1389)	
NEGDW	0.1877	**	0.0400	*
	(0.0796)		(0.0130)	
NEGFS	0.2018	***	0.0419	*
	(0.0752)		(0.0120)	
CWPREMIUM	-0.5664	***	-0.0630	**
	(0.0587)		(0.0145)	
DETAILED	0.0729		0.0012	
	(0.0708)		(0.11100)	
PROOF	0.0732		0.0143	
	(0.0749)		(0.5958)	
LAMBDA	0.3872			
	(0.3711)			
Log L	-851.5000			
χ^2	209.6100	***		
d.f. χ^2	16			

(standard errors)

* Significant at 0.10 level

** Significant at 0.05 level

*** Significant at 0.01 level

References

Bailey, G.W., and T.E. Waddell. 1979. "Best management practices for agriculture and silviculture an integrated overview." *Best Management Practices for Agriculture and Silviculture (R.C. Loehr, D.A. Haith, M.F. Walter, and C.S. Martin, eds)* pp.35-56. Ann Arbor: Ann Arbor Science Publishers Inc.

Boland, M.A., K.A. Foster, P.V. Preckel, D.D. Jones, and B.C. Joern. "Using linear programming to minimize manure storage and application costs in pork production." *Journal of Production Agriculture.* 12,3(1999): 405-408.

Bosch, D.J. M. Zhu, E.T. Kornegay. "Economic returns from reducing poultry litter phosphorus with microbial phytase." *Journal of Agricultural and Applied Economics.* 29(1997): 255-266.

Carson, J.B., and W. Smeltz. "Pennsylvania Farmers' Association Welcomes Passage of Nutrient Management Legislation." *PR Newswire Association.* May 5, 1993.

Chang, C., H.H. Janzen, and C.M. Cho. "Nitrous oxide emission from cattle feedlot manure treated soils." *International Symposium on Soil source and sink of greenhouse gases.* (1995): 9.

Edwards, D.R., T.C. Daniel, H.D. Scott, J.F. Murdoch, M.J.Habiger, and H.M Burks. "Stream quality impacts of best management practices in a Northwest Arkansas basin." *Water Resources Bulletin.* 23(1996):499-509.

Gerstenzang, J. "Potomac River is paying price for nations chicken appetite: proliferation of poultry farms along waterway's banks is reversing a comeback from decades of pollution." *The Los Angeles Times: Home edition.* Thursday, April 17, 1997.

Greene, W.H. "Econometric Analysis." New Jersey: Prentice Hall, 1993.

Maddala, G.S. "Limited Dependent and Qualitative Variables in Econometrics." New York: Cambridge University Press, 1983.

Madison, R.J. and J.O. Brunett. "Overview of the occurrence of nitrate in groundwater in the United States." *Journal of Soil and* Water *Conservation.* 50(1985):321-327.

Martin, J.H., Jr. "The Clean water act and animal agriculture." *Journal of Environmental Quality.* 26(1997): 1198-1203.

McIntosh, C.S., T.A. Park, and C. Karnum. "The potential impact of imposing best management practices for nutrient management on the US broiler industry." *Journal of Environmental Management.* 60(2000): 145-154.

Pigou, Arthur C. "A Study in Public Finance." MacMillan, London, 1928.

Pollak, R.A., and T.J. Wales. "Estimation of Complete Demand Systems From Household Budget Data: The Linear and Quadratic Expenditure Systems." *The American Economic Review.* 68,3(June 1978): 348-359.

Rosen, H. "Public Finance." (New York: Irwin Mcgraw-Hill, 1999) 5th Edition.

Sauer, T.J., T.C. Daniel, P.A. Moore, K.P. Coffey, D.J. Nichols, and C.P. West. "Poultry litter and grazing animal waste effects on runoff water quality." *Journal of Environmental Quality.* 28(1999): 860-865.

Sharpley, A.N. "Availability of residual phosphorus in manured soils." *Soil Science Society of America Journal.* 60(1996): 1459-1466.

Sharpley, A.N., S.C. Chapra, R. Wedepohl, J.T. Sims, T.C. Daniel, and K.R. Reddy. "Managing Agricultural phosphorus for protection of surface waters: Issues and Options." *Journal of Environmental Quality.* 23(1994): 437-451.