An Analysis of Potential Conservation Effort of CRP Participants in the State of Missouri: A Latent Variable Approach

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Abstract

This study investigated the influence of economic, personal, and attitudinal factors on the intended conservation effort of a sample of Conservation Reserve Program (CRP) contract holders after their contracts have expired. Economic factors were found to dominate the decision about future conservation effort. Attitudes towards conservation were found to have no significant influence on the decision. This fact may relate to the recent changes in the regulatory environment brought about by the 1985 Food Security Act which changed conservation from a voluntary to regulated nature.

Key Words: conservation attitudes, conservation effort, CRP, MIMIC, Missouri

Introduction

Conservation compliance provisions of the 1985 Food Security Act require producers to control soil erosion on highly erodible soils in order to maintain eligibility for government farm program benefits. Prior to this act, conservation practices were voluntarily adopted by producers, often motivated by concerns for stewardship or other personal reasons. Conservation compliance provides a much greater economic incentive to adopt some type of soil conservation measures. While attitudes and beliefs may still be important, their relevant role in explaining conservation behavior may be superseded by economic considerations.

Identification of the factors determining conservation behavior is particularly important in considering the fate of land currently enrolled in the Conservation Reserve Program. The Conservation Reserve Program (CRP) was also established by the 1985 Food Security Act in order to take highly erodible land out of production. The primary objectives of the program included the reduction of soil losses from erosion, the reduction of sedimentation and improvement of water quality, the creation of wildlife habitat, and the reduction of production surpluses (Young and Osborn). Land owners who participate in the program provide permanent vegetative cover for the enrolled land and take it out of production for ten years. In return, CRP participants receive an annual payment from the federal government. The 1985 Food Security Act also determined that farmers with highly erodible land not enlisted in CRP must implement conservation practices in order to be eligible for federal programs such as price supports.

By 1990, nearly 34 million acres of highly erodible land had been enrolled in CRP with

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reportedly substantial soil savings. Due to the high erodibility of CRP land and the temporary nature of CRP, substantial interest has already been generated with regard to the fate of the CRP acres when the 10-year contracts begin to expire in 1995. A few recent studies have addressed the issue of the post-CRP land utilization (Dicks, Nowak et al.). These studies have primarily focused on predicting the segment of CRP land that would likely remain in grass under alternative economic scenarios.

In this study, interest concentrates on the future conservation behavior of CRP contract-holders and its causal factors. Specifically, the present study investigates the influences of economic factors and attitudes on the intended conservation effort of a sample of CRP participants in Missouri after their CRP contracts have expired. A random sample of Missouri CRP participants is surveyed with respect to their planned land use and intended conservation practices when CRP land is brought back to production. Subsequently, the potential conservation effort of the surveyed group is formally modeled as a function of their conservation attitudes and other personal and economic factors.

This study builds on the approach employed by Lynne et al., where conservation effort was considered as a latent variable measured with error. This approach is extended here to include multiple indicators for the unobserved potential conservation effort. Within this framework, a multiple-indicator multiple-cause (MIMIC) model is estimated.

Modeling Conservation Effort

In studying conservation behavior, the dichotomous conservation adoption decision has often been investigated (Lee and Stewart, Rahm and Huffman). Because farmers can adopt a number of different conservation practices with differential costs and soil savings, a binary adopt-not adopt distinction fails to capture the extent of the farmers' conservation commitment. For that reason, several studies have employed measures of conservation effort in analyzing conservation behavior (Ervin and Ervin, Lynne et al., Norris and Batie).

While a clear definition of conservation effort has not been offered in the literature, Ervin and Ervin suggested that conservation effort is ".. a function of the effectiveness and extensiveness of individual (conservation) practices over the firm's land" (pp. 281). Along these lines, conservation effort has been empirically measured by the number of conservation practices employed (Lynne et al., Ervin and Ervin), actual conservation expenditures (Norris and Batie), and estimated soil savings from conservation practices exercised (Ervin and Ervin). Total capital expenditures and annual operation and maintenance expenses for conservation practices tend to reflect both the effectiveness and extensiveness of a firm's conservation management and hence appear to be appropriate measures of conservation effort. However, adoption of certain conservation practices, such as minimum tillage and no till, hinge more on changes in familiar farming methods rather than incremental monetary expenses. Hence, appropriate measures of conservation effort should also reflect the extent of the farmers' managerial adjustments in adopting specific conservation practices. Such measures of conservation effort, however, have not been implemented in the literature.

In terms of the determinants of an individual's conservation effort, Ervin and Ervin proposed a behavioral model where physical, economic, institutional, and personal factors combine to influence the individual's conservation decisions.[1] Physical factors, such as slope degree and slope length, define the erodibility of farm land and hence the conservation effort required to decrease potential erosion. The greater the erodibility of land the greater the conservation effort is likely to be (Ervin and Ervin).

Economic factors, such as income and debt levels as well as future discounting rates and risk preferences, are potentially important determinants of a farmer's conservation effort (Ervin and Ervin, Lynne et al.) For example, high debt and low income levels could prevent the farmer from investing in capital-intensive conservation practices. Productivity gains due to soil conservation are usually long-run benefits. Therefore, low discount rates are expected to promote conservation effort. When productivity benefits from soil conservation are considered rather certain, more risk-averse farmers are likely to expend greater conservation effort in order to avoid future losses in soil productivity and revenue. Hence, risk aversion is expected to be positively related to conservation effort. Finally, institutional factors such as technical assistance, cost sharing, and conservation compliance as a condition for federal program eligibility provide economic incentives that increase the likelihood of conservation effort.

A number of personal factors such as age, education, and conservation attitudes have been shown in different contexts to be important influences to a farmer's conservation effort (Ervin and Ervin, Lynne et al., Norris and Batie). Due to the long-run nature of productivity benefits from soil conservation, long planning horizons are expected to positively influence conservation effort. Younger farmers are thus more likely to expend greater conservation effort than older farmers. Similarly, farmers with higher education are expected to devote greater conservation effort to their land. This is so because higher education is associated with greater information on the productivity implications of soil erosion and the benefits of various conservation practices.

In previous research, strong attitudes towards conservation have been found to positively influence conservation effort. One difficulty with isolating the influence of conservation attitudes on conservation effort, however, has been the identification and measurement of such attitudes. Recently, Lynne et al. offered a theoretical framework where fundamental values and beliefs of individuals combine to form attitudes towards soil conservation. Within this framework, attitudes and beliefs towards issues such as farm-related externalities, farming as a way of living, and profits as the primary objective of farming, relate to the same fundamental values that form the individuals' conservation attitudes. Hence, beliefs on such issues can be used to elicit the individuals' conservation attitudes.

Data Collection and Variable Measurement

The issue of the relative influence of economic, physical, attitutidinal, and other personal factors on the potential conservation effort of CRP participants was addressed in this study within a sample of Missouri CRP contract holders. Specifically, a survey of a stratified sample of CRP participants was conducted in the state of Missouri. Procedures outlined by Dillman for conducting a mail survey were followed as closely as possible. The survey provided the necessary economic, demographic, and attitudinal information needed for estimating the relative influences of such factors on the potential conservation effort of the surveyed group. Physical characteristics, such as slope degree, were determined from contract data available from the Soil Conservation Service (SCS).

The surveyed group was initially asked to identify their intentions regarding the potential use of CRP land after their CRP contracts expire. The options available to the respondents included maintaining CRP land in grass or bringing CRP acres into crop production while utilizing terraces, contour farming without terraces, conservation tillage, zero tillage, crop rotations with grasses or legumes, or no conservation practices. The respondents provided the number of CRP acres planned to be under one or more of the above available conservation options.

Measurement of the Dependent Variable

Two different *approximate* measures of potential conservation effort were constructed from the data on intended utilization of CRP acreage; namely, a cost-based and a management-based measure. Through these measures, conservation practices that are more expensive or imply greater managerial adjustments are associated with greater conservation effort.

Ideally, conservation expenditures could serve as an appropriate cost-based measure of conservation effort. However, since potential rather than actual conservation effort is analyzed in this study, no conservation expenditures have yet been incurred by the land owners and hence such a measure is not possible. Average conservation expenditures could be utilized instead. Such expenditures could be constructed as the weighted sum of CRP acres planned to be in each of the aforementioned conservation practices with appropriate weights being the average per acre cost of each conservation practice.

For the state of Missouri, no published research could be found that has estimated the average costs associated with the conservation options listed above. A number of farmers and farm management extension specialists were asked to provide estimates of the average per acre costs of the various conservation practices. While the absolute values of such costs varied widely, their relative rankings were fairly stable. Thus, relative cost rankings rather than average costs per acre were used to weight CRP acres for each conservation practice. Within this framework, a cost-based measure of potential conservation effort for each CRP contract holder in the sample was constructed in this study as

$$CE_j = \frac{\sum_i A_{ij} S_{ij} W_i}{\sum_i A_{ij}}; \tag{1}$$

where CE_j denotes conservation effort of contract holder j, A_{ij} represents the number of acres of land owner j under conservation practice i, S_{ij} is the slope degree of the land parcel under conservation practice i, and W_i is the relative cost ranking of conservation practice i.[2] Normalizing by the total number óf acres A_{ij} in equation (1) insures that the potential conservation effort of contract holders is evaluated relative to the size of their land parcel enlisted in CRP.

The same panel of farmers and extension specialists were also asked to rank the alternative conservation practices with respect to the amount of managerial changes required for their adoption by a "typical" Missouri farm utilizing conventional tillage.[3] The mean relative rankings of the surveyed panel were utilized as weights in constructing a management-based potential conservation effort measure similar to that in (1). Specifically the management-based potential conservation effort measure of each CRP participant in the sample was constructed as

$$CE_j = \frac{\sum_i A_{ij} M_i}{\sum_i A_{ij}}; \tag{2}$$

where M_i represents the management-based relative ranking of conservation practice i.

Within the framework described above, potential conservation effort is clearly measured with error. That is, the measures of potential conservation effort constructed in (1) and (2) can only be considered as approximate measures or indicators of potential conservation effort. There are several sources of error in the measurement of potential conservation effort as described above. First, the relative rankings which were utilized as weights are not scaled. Second, although the relative rankings are expected to hold for the majority of the land owners in the sample, they may be inaccurate for a small number of respondents. For example, for farms currently utilizing minimum or no-till in the non-CRP land, management adjustments for adoption of such practices to their CRP land will be minimal relative to farms unexposed to such production practices.[4] Third,it is possible that some respondents did not have a well-considered conservation plan at the time of the survey, thus incurring bias.

Measurement of the Independent Variables

The explanatory variables of this study were selected to best represent the categories of factors hypothesized to influence potential conservation effort. Specifically, a number of attitudinal, personal, and economic factors that were found to be important in previous studies were elicited through the solicited questionnaire for each CRP participant in the sample.

To elicit attitudes towards conservation and other personal beliefs, the framework of Lynne et al., was employed. In fact, the exact questions solicited by Lynne et al., were utilized in the questionnaire of this study.[5] Risk preferences (RISK) were assessed by asking the survey participants to choose an acceptable mix of risk and returns from a set of risky investments. Similarly, the future discount rates (DISC) of the surveyed group were inferred from their attitudes towards the importance of sustaining the productive capacity of natural resources for future generations and their beliefs about their personal future economic status. CRP contract holders were also surveyed on their attitudes towards conservation (CONS), farm related externalities (EXTER), farming as a way of life (FWL), profits as the primary objective of their farm operation (PROF), and technological capabilities of chemical technologies (TECH). Farmers who have strong attitudes towards conservation, are more willing to bear the cost of farm-related externalities, and view farming as a preferable way of living were expected to expend greater conservation effort. In contrast, farmers who view profitability as the primary objective of their farm operation and believe that chemical technologies, such as improved herbicides and fertilizers, can compensate for soil erosion were expected to expend less conservation effort.

Income levels (INC) were not directly requested in the questionnaires. Instead, the market value of the assets owned by the survey participants was requested. However, the income of the surveyed land owners was assumed to be proportional to the value of the owned assets. Within this framework, income level was measured on a scale of 1 to 6. The debt level (DEBT) of each land owner was directly requested and was measured on a scale of 1 to 5.

In terms of personal characteristics, the level of education (EDUC) and the age (AGE) of the respondents were elicited from the solicited questionnaires and included in the analysis. The level of participation in CRP of each CRP contract holder (PART) was also included in the analysis. PART was measured as the ratio of acreage enrolled in CRP to acreage eligible for enrollment available to each contract holder. As such, it was considered to indicate the individual perceptions of CRP participants with regard to the acuteness of the erodibility problem on their land. Furthermore, PART was taken to summarize economic pressures faced by CRP participants, such as loan obligations or need for livestock feed, which could force land owners to continue production on highly erodible lands rather than enlisting them in CRP. If such perceptions and economic pressures continued in the future they could reduce the likelihood of conservation effort. Hence, a positive relationship was expected between the current level of participation in CRP and potential conservation effort.

Empirical Model and Results

In the previous section it was indicated that the potential conservation effort of survey respondents was measured with error. Such error should be explicitly accounted for when investigating the causal relationship of various economic and personal factors with potential conservation effort. Under these conditions, the relationship between future conservation effort of Missouri CRP participants and its causal factors is investigated within the framework of structural equations with latent variables (Bollen). In standard notation the latent variable model can be specified as

$$\eta = \gamma x + \zeta \quad (3a)$$

$$CE_1 = \lambda_1 \eta + e_1 \quad (3b)$$

$$CE_2 = \lambda_2 \eta + e_2. \quad (3c)$$

The latent equation (3a) specifies the relationship between the unobserved true conservation effort η with the vector of its causal factors x. ζ is a random disturbance term. The measurement equations (3b) and (3c) signify that the cost-based potential conservation effort CE_1 and the management-based potential conservation effort CE_2 are indicators of the unobserved true potential conservation effort. Within this specification, e_1 and e_2 denote systematic or random errors in measurement. The λ_i coefficients, also called factor loadings, denote the magnitude of the expected changes in the observed variables CE_i for a unit change in the latent conservation effort η. A scale must be assigned to the scale-free latent variable η to fully interpret such coefficients. Typically, the scale of a latent variable is set equal to one of its indicators. In this study η has been scaled according to the first indicator CE_1 and hence the factor loading λ_1 in (3b) is set equal to 1. All variables in (3) are defined as deviations from their means and hence no intercepts are specified. The specification in (3) is sometimes referred to as MIMIC model.

Estimation procedures in latent variable models emphasize covariances. Instead of minimizing functions of actual and predicted individual data points, the difference between sample covariances and the covariances predicted by the model are minimized. The underlying principle of these estimation procedures is that the covariance matrix of the observed variables is a function of the parameters in the postulated structural model. Thus, a parameter vector that minimizes the difference between the sample covariances and the ones predicted by the model is pursued.

The proposed latent variable model was estimated with maximum likelihood procedures. Maximum likelihood estimators have several attractive properties. They are unbiased, asymptotically consistent, and efficient. Thus, among consistent estimators none has a smaller asymptotic variance (Bollen). The loss function minimized in this case was

(4) $L = \log |\Sigma(b)| + \mathrm{tr}(S\ \Sigma^{-1}(b)) - \log |S| - \text{const.}$

In specification (4), S is the sample covariance matrix of the observed variables CE_1, CE_2, and x while $\Sigma(b)$ is the covariance matrix of the observed variables when they are expressed as functions of the parameter vector b of the specified model. The estimation in (4) involves the choice of the parameter vector b so that $\Sigma(b)$ is as close as possible to S.

Unique estimation of b requires that the model is identified. For a MIMIC model identification is insured when two or more indicators for the latent variable η and one or more exogenous variables x are included in the model (Bollen). These conditions are satisfied in (3) and hence the specified model is globally identified.

The estimated values of the structural coefficients γ, the factor loadings, the variances of the measurement errors, and the t-values of the estimated parameters are reported in table 1. Several measures of goodness of fit are also provided in table 1. The total coefficient of determination for the indicators CE_1 and CE_2 describes how well these indicators jointly describe, as measurement instruments, the latent variable η. This measure is quite high suggesting a good statistical fit of the measurement equations (3b) and (3c). Similarly, the squared multiple correlations of the indicators are measures of the strength of the linear association between each individual indicator and the unobserved η. Both such measures are fairly high and close to each other suggesting that both indicators, individually, are equally successful measurement instruments for the unobserved conservation effort. The overall fit of the estimated model to the data is measured by the reported chi-square statistic. The hypothesis tested by this statistic is that the covariance matrix of the observed variables $\Sigma(b)$ forecasted by the model is equal to the covariance matrix S estimated from the actual data. The test statistic is 6.12 with 11 degrees of freedom which implies that the hypothesized equivalence cannot be rejected at the 0.05 level. Hence the model appears to fit the data satisfactorily.

Six out of the twelve structural parameters in the estimated model were found statistically significant at the 0.05 level. With the exception of the variable farming as a way of life (FWL), all other attitudinal variables were statistically insignificant. Hence, no positive relationship between attitudes towards conservation and potential conservation effort could be identified for the surveyed group of Missouri CRP contract holders.[6] Most economic factors, however, were found to have theoretically consistent and statistically significant effects on potential conservation effort. Specifically, greater risk aversion and low discount rates were found to have significant and positive effects on potential conservation effort. On the other hand, increasing debt load was found to have a significant negative influence on potential conservation effort.[7] Greater current participation in CRP was found to imply greater probability of future conservation effort. The level of income was the only economic factor included in the model that did not have a statistically significant effect. If income can be considered to be an adequate indicator of farm size, the empirical results of this study imply that no significant differences in the potential conservation effort of large and small farms could be identified. Finally, greater education was found to have a positive and statistically significant effect on potential conservation effort while the age of the land owner was found to have a negative but statistically insignificant influence.

Conclusions

The most significant conclusion of this study is the importance of economic considerations in anticipating future use of CRP lands. Economic factors, such as risk, discount rate, and debt, were found to dominate the decision about future conservation effort on CRP land. Personal attitudes towards conservation were found to have no significant influence on such decisions. This fact may relate to the recent changes in the regulatory environment brought about by the 1985 Food Security Act which changed conservation from a voluntary to regulated nature.

The results further indicate that land owners with greater participation in CRP plan to expend more conservation effort in the future. It appears that CRP attracted participants who are concerned about soil conservation rather than those who view the program as a way to avoid or delay implementing compliance provisions. This finding is relevant in assessing the impact of future land use and the need for an extension of CRP.

Table 1. Estimated Effects of Causal Factors on Potential Conservation Effort of Missouri CRP Participants

Parameter	Estimated Value	t-value
γ_1 (CONS)	-0.085	-0.77
γ_2 (EXTER)	0.021	0.46
γ_3 (TECH)	-0.039	-0.88
γ_4 (PROF)	-0.003	-0.04
γ_5 (DISC)	-0.215	-2.33
γ_6 (RISK)	-0.104	-1.93
γ_7 (FWL)	0.040	1.68
γ_8 (AGE)	-0.001	-0.26
γ_9 (EDUC)	0.057	1.64
γ_{10} (DEBT)	-0.045	-1.78
γ_{11} (INC)	-0.011	-0.36
γ_{12} (PART)	0.638	3.81
λ_1	1.000[a]	---
λ_2	3.051	9.18
var e_1	0.046	1.76
var e_2	0.593	2.20
Number of Observations		126
Total Coefficient of Determination for Indicators		0.91
Squared Multiple Correlation for CE_1		0.85
Squared Multiple Correlation for CE_2		0.82
Chi-Square (χ^2) Test Statistic (11 d.f.)		6.12

[a] Constrained parameter.

Methodologically, the management-based conservation effort measure used was found to be a fairly successful measurement instrument for the unobserved conservation effort. Thus, it would be useful in future studies to further experiment with similar management-based effort measures in order to fully judge their value in assessing potential and actual conservation effort.

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Endnotes

1. In this study the physical, economic, and institutional factors hypothesized to affect conservation effort follow directly from the behavioral model of Ervin and Ervin.

2. The slope of the land parcels are included in the above formula since greater slope is usually associated with larger expenditures for erosion control and greater soil savings. For example, terraces on steeper sloped land will reduce erosion by a larger absolute amount than terraces on lesser-sloped land, but will also cost more due to shorter intervals (Ervin and Ervin).

3. The majority of the firms in the sample indicated that they used only conventional tillage in their non-CRP land. Hence, a crop farm utilizing conventional tillage appeared to best approximate a typical farm in the survey group.

4. While only 6% of the sample indicated that are currently using minimum or no-till in their non-CRP land, note that such differences among the participants are clearly sources of measurement error.

5. The exact questions included in the survey, details on the construction of the attitudinal variables, as well as the theoretical framework underlying the construction of such variables can be found in Lynne et al.

6. The lack of a strong relationship between attitudes and conservation effort should not be surprising as attitudes may be poor indicators of behavior. For example, Festinger proposed that when a person holds inconsistent cognitions he experiences *cognitive dissonance*, an aversive motivational state which he is prompted to reduce by re-establishing consistency. Experimental data have, in some instances, supported the notion of cognitive dissonance as people have been found to change their attitudes to be consistent with behavior (Wicklund and Brehm). Bem, providing experimental data of his own, showed that the dissonance reduction phenomena can be explained without postulating any aversive motivational state. His results support using attitudes to predict behavior as in the cases of Ervin and Ervin, Lynne et al., Norris and Batie, and the present study.

7. Numerically, all the estimated parameters of the latent variable model should be interpreted with care since the variables in (3) have been expressed as deviations from their means. For example, debt is a categorical variable where 1 represents 80-100% ownership position, 2 represents 60-79% ownership etc. The sample mean for DEBT is equal to 2.25. Hence the estimated DEBT coefficient implies that, *ceteris paribus*, an increase in DEBT by one unit *above the mean* would result in a reduction of potential conservation effort by 0.045. Given that the mean value of CE_1 is equal to 0.669, this reduction represents approximately 7 percent of future conservation effort.