NÚMERO 402

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Testing for Information Asymmetries in Voluntary Conservation Contracts

DICIEMBRE 2007

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Abstract

We use data from a Maryland farm survey and a multivariate switching regression model with endogenous switching to investigate the effects of information asymmetries on conservation cost sharing contracts. Our estimations indicate that the role that asymmetries of information play in the impact that cost-sharing programs have on conservation effort depends on the type of practice under analysis. After controlling for observables (including history of cost-share awarding), we found no evidence of detrimental effects from information asymmetries neither on the acreage under permanent vegetative cover nor on the level of use of conservation cropping practices. As a matter of fact, information asymmetries have no statistically significant impact on permanent vegetative cover, while their impact on conservation cropping is both positive and significant.

Resumen

Es creencia común que los agricultores aprovechan las asimetrías de información que tienen a su favor para no cumplir cabalmente con compromisos adquiridos en contratos de conservación. Este artículo usa datos de granjas en Maryland y un modelo multivariado con “switching” endógeno para examinar empíricamente los efectos que las asimetrías de información tienen sobre el nivel de implementación de prácticas conservacionistas. Nuestros resultados muestran que, al menos para la población estudiada, el rol de las asimetrías de información cambia con el tipo de práctica bajo análisis. Después de controlar por las características observadas por los administradores de los programas y contrario a la creencia habitual, no se encontró evidencia de efecto sobre la proporción de tierra destinada a cubierta vegetal permanente, pero sí se observó un efecto positivo sobre el uso de prácticas conservacionistas de cultivo. Paralelamente, no se encontró evidencia que indicara que los administradores de los programas de conservación en Maryland asignaran sus fondos de acuerdo a criterios ambientales. La distribución de los fondos parece más bien estar determinada por los costos de transacción de los agricultores, lo cual sugiere que los efectos de información observados son más bien el resultado de autoselección de los agricultores que de un proceso riguroso de selección por parte de los administradores de los programas.

Introduction

Conservation cost-sharing contracts in agriculture (Wu and Babcock, 1996) are monetary agreements between federal or state governments and farmers for the provision of environmental goods and/or the protection of natural resources. By these contracts, farmers receive rental or cost-sharing payments for the implementation of environmentally friendly practices on working land. Cost-share payments are seen as a means of counteracting underutilization of conservation practices in agriculture. Some of the benefits from conservation measures —such as protection of wildlife habitat and reduction of nutrient emissions— take place beyond farm borders and thus do not necessarily enter into the farm operation decision process. As a result, the private benefits of conservation may not outweigh the costs, hence inducing a suboptimal level of conservation.

A key issue in conservation contract design is the existence of information asymmetries. Farmers are better informed than conservation agencies about their land quality, production parameters, and conservation costs and thus they can disguise their true opportunity and conservation costs in order to obtain a higher rental payment or cost-sharing rate. Two consequences of asymmetric information are adverse selection and moral hazard. Adverse selection happens if a farmer with a low potential to produce environmental goods (relative to the non-contract situation) has greater incentives to sign a conservation contract than a farmer with a high potential. Complementarily, since a cost-efficient conservation agency is expected to target farms on which a contractual agreement is going to make a difference, adverse selection grows larger if farms willing to exert a high level of conservation even in absent of contractual obligations have high probabilities to obtain conservation funding. Moral hazard refers to situations where farmers have the incentives to take advantage of weak enforcement capabilities and deceive their contractual obligations. Thus, they receive the compensation payment without complying with the level of conservation they agreed to implement. At the end, information asymmetries can reduce the efficiency of conservation programs by increasing the cost of the environmental goods provided by program participants.

For about two decades, theoretical research has focused on cost-efficient mechanisms to reduce the negative impacts of information asymmetries in conservation contracts (examples are Smith, 1995; Wu and Babcock, 1986; Latacz-Lohmann and Van der Hamsvoort, 1997; Stoneham *et al.*, 2003; Ozzane *et al.*, 2001; Hart and Latacz-Lohmann, 2005; Cason *et al.*, 2003; Bystrom and Bromley, 1998). Despite of this rich theoretical discussion, no empirical evaluation about the magnitude or even the existence of information asymmetries in conservation contracts has been carried out. This article aims to contribute to fill this gap in the literature.

Empirical testings for information asymmetries have been carried out in other areas of economics, most notable in insurance markets (Puelz and Snow, 1994; Chiappori and Salanié, 2000) and credit markets (Ausubel, 1999; Cressy and Toivanen, 2001). Departing from Chiappori and Salanié (2000) and Dionne *et al.* (2001), we test for information asymmetry effects by analyzing the statistical significance of the *conditional correlation* between the dependent variables of two equations: a selection equation and a response (ex-post) equation. Thus, the idea is to analyze the correlation between the dependent variables in the two equations *after* controlling for the factors observed by the insurer *(*the program administrator in our case*)*.

As a part of their study, Chiappori and Salanié (2000) use a bivariate probit model in which the dependent variable in the selection equation takes the value 1 if the individual has bought comprehensive car coverage and 0 if he has bought the minimum legal coverage. Their response variable takes the value 1 if the individual has had at least one accident in which he has been judged to be at fault and 0 otherwise. A positive conditional correlation is postulated between both variables because of either: *(i)* adverse selection resulting from the better knowledge that individuals have about their true riskiness, which makes that riskier individuals buy greater coverage; or *(ii)* moral hazard, which makes that agents who choose contracts with greater coverage have less incentives to reduce ex-post accident probability.

The dependent variable in our selection equation is dichotomous as well; however, instead of using a bivariate probit, we chose an endogenous switching approach to model farmer response to voluntary participation in a conservation program. A switching framework allows obtaining two conditional correlation coefficients instead of one. They are the correlations between the selection and response variables for participants and no participants, which permit to control for structural differences between the two subpopulations and possible interactions between participation and observed or unobserved characteristics of the individuals. Furthermore, our response variable is continuous (although censored) instead of dichotomous, which allow us not only testing for the existence of information asymmetry effects but also quantifying their magnitudes relative to total program effects.

Additionally, we make a thorough analysis of the effects of heteroscedasticity in our model, both to rule out the possibility of inconsistency and to increase the efficiency of our estimations.

We use Maryland cross-sectional farm-level data to assess the effects of information asymmetries on working-land conservation contracts. Specifically, we focus on the consequences of asymmetries of information on permanent vegetative cover and use of conservation cropping techniques.

As in Chiappori and Salanié (2000), we acknowledge that disentangling moral hazard from selection effects in cross-sectional data is generally not feasible except under restrictive assumptions. In consequence, hereafter we name our estimates using the generic label of "information asymmetry" effects instead of using a more specific term. We claim that any statistically significant information effect we estimate is, potentially, the result of selection and moral hazard acting together.

Allocation of Cost Share Funds

Application for cost sharing is voluntary and applicants may request funding for projects that involve the use of one or more conservation practices. Project proposals must be reviewed and approved by technicians employed by the Natural Resource Conservation Service (federal programs) or local soil conservation districts (state programs) to ensure that they are in accord with the farmer's approved conservation plan (and hence overall conservation goals in the state). Once approved by a technician, project proposals are forwarded to a decision making body that makes awards from project applications subject to budget limitations. In federal programs, funding award decisions are made on a county basis and overseen by a committee elected from and by those involved in agricultural businesses in the county. In the Maryland Agricultural Cost Share Program (MACS), the MACS program office in the Maryland Department of Agriculture makes the award decisions. In both cases proposals are ranked in accordance with local priorities and awards are made on the basis of those rankings (Bastos and Lichtenberg, 2001; Cattaneo, 2003).

Project applications contain only information about the proposal itself; they contain no additional information about the farm operation or finances. As a result, those applications give the agencies administering cost sharing programs little ability to screen out those for whom cost sharing would make little or no difference in regard to their conservation preferences. Agencies have limited enforcement capabilities as well. A Government Accounting Office (2003) report found that enforcement of the farm bill's cross-compliance provisions has been highly inconsistent due to agencies' discomfort with an enforcement role, inadequate staff resources, and weak oversight of field offices.

Conservation Cost Sharing in Maryland

Maryland presents relatively favorable conditions for an investigation on conservation cost-sharing contracts due to its aggressive attempts to meet goals for water quality improvements in the Chesapeake Bay. Fostering widespread use of conservation practices on working farmland has been the centerpiece of the state's strategy for reducing nutrient runoff from agriculture for more than 20 years. The state established its own cost-sharing program in 1983 —the MACS—, which spent about $41 million over the period 1987-1996. By comparison, expenditures by federal cost sharing programs over that same period amounted to only $9 million (Bastos and Lichtenberg, 2001).

Our data come from a survey of farm operators conducted by the Maryland Agricultural Statistics Service in 1998. Stratified random sampling was used to ensure a sufficient number of responses from commercial operations, especially larger ones. The survey asked 487 farmers whether they used any of two dozens of best management practices during the 1998 growing season. They included practices targeting soil erosion, nutrient runoff, animal waste management, nutrient management, and protection of permanent vegetative cover and wildlife habitat. The data indicate that almost 70% of Maryland farmers used one or more of these conservation practices, with an average of 4.6 practices. Farmers were asked how much acreage was served by each eligible practice used in 1998, whether they had ever received cost-sharing for each practice, and, if so, the latest calendar year they had received cost-sharing funds.

The survey included information about potential water quality effects of each farm operation as well. Each respondent was asked whether there was a body of water on the land operated and, if so, the type of water body (pond, stream, wetland, the Chesapeake Bay). Farmers who did not have an on-farm water body were asked the type of the nearest water body and the distance to it. The responses indicated that about three quarters of Maryland farms have some kind of water body on site. Overall, the average distance to the nearest water body was less than a mile (Table 2).

Model Specification and Estimation

We model the problem as an equation system with endogenous switching

$$
\begin{array}{lll}
 & y_{1i}^{*} = X_{1i}\beta_1 + \eta_{1i} & \text{Cost sharing (participation) equation} \\
 y_{1i}=0 \; [& \qquad] \; y_{1i}=1 & \\
y_{2i}^{*0} = X_{2i}\beta_2^{0} + \eta_{2i}^{0} & y_{2i}^{*1} = X_{2i}\beta_2^{1} + \eta_{2i}^{1} & \text{Vegetative cover equation} \\
y_{3i}^{*0} = X_{3i}\beta_3^{0} + \eta_{3i}^{0} & y_{3i}^{*1} = X_{3i}\beta_3^{1} + \eta_{3i}^{1} & \text{Conservation cropping equation}
\end{array}
\qquad (1)
$$

Where the left-hand side variables are defined as it follows:

y_{1i}^{*} is a latent variable giving the propensity of farm i to apply for and be awarded cost sharing. Only a binary variable, y_{1i}, is observed. It takes the value one if the farm has participated in a cost sharing program in the period 1983 (the year MACS program was first implemented) to 1998 and zero if not.

To capture any spillover effect that may exist, we consider that a farm becomes a program participant if it has received funding for the implementation of any practice targeting soil erosion or protection of permanent vegetative cover or wildlife habitat.

Latent variable y_{2i}^{*} measures the level of permanent vegetative cover. Its observable counterpart y_{2i} was constructed by aggregating the acres under permanent vegetative cover and/or wildlife habitat. In order to generate a variable measuring farmer's conservation effort, we divided y_{2i} by total acreage operated to standardize the variable. Variable y_{3i}^{*} measures the level of conservation cropping used in the farm. Its observed counterpart y_{3i} was constructed by adding up the acres on which contour, strip cropping and/or cover crops are used. To standardize this variable, we divided y_{3i} by total acreage cropped instead of total acreage operated. Thus, y_{2i} and y_{3i} give us complementary measures of farmer conservation effort. The first one gives us the proportion of the farm under set-aside land, while the second one provides us with a measure of how much of the cropped share is under conservation practices. Variable y_{3i} may exceed one in the case of overlapping coverage, when farmers report that the total acreage cropped was served by more than one practice. As noted previously, roughly 30% of Maryland farmers reported using no conservation practices, hence we treat our response variables as censored from below at zero.

Vectors $X_{ji}\ j=1,2,3$ represent exogenous explanatory variables. Coefficients β_j^0 y β_j^1 are parameter vectors related to exogenous regressors for regimes $y_{1i}=0$ and $y_{1i}=1$, respectively. Vectors $\left(\eta_{1i}\quad \eta_{2i}^0\quad \eta_{3i}^0\right)$ and $\left(\eta_{1i}\quad \eta_{2i}^1\quad \eta_{3i}^1\right)$ are normally distributed disturbances with zero means and 3x3 covariance matrices Σ^0 y Σ^1. Variance of ε_{1i} is set equal to one according to the usual standardization required to identify the parameters in equations that involve dichotomous dependent variables.

The first of our response variables focuses in permanent vegetative cover and wildlife habitat, land usages that provide rather off-farm benefits. The second response variable, on the other hand, focuses in the use of conservation cropping practices, which are strongly linked to production activities. Historically, agricultural programs in the US have been biased towards production and income support; therefore, we expect that program administrators are more familiar with the production preferences of farmers than with their preferences about conservation. Hence, we expect that any adverse effect (if existing) generated by information asymmetries will be larger for "pure" green practices.

Some of the practices under study are compatible with crop production only, which might create a selection problem since many farms choose producing no crops. We circumvent this source of inconsistency by restricting the analysis to the subsample of farms that run cropping operations. Additionally, in order to rule out hobby farmers, we consider farms with cropping operations larger than 5 acres. Elimination of farms without cropping operations, combined with non-respondents, reduced the number of observations to 366.

A consistent estimation of the conditional correlation between participation and conservation effort requires careful attention to the specification of the model in order to avoid the omission of variables observed by program administrators. Otherwise, we may capture the correlation between the omitted variables instead of the correlation between the actual unobserved characteristics. We describe below the variables considered in the model; descriptive statistics are provided in Table 1, while more detailed statistics for the treated and untreated subsamples are provided in Appendix 1.

Participation in the program is a matter of willingness to apply for cost sharing and willingness to provide it. Therefore, the participation equation must consider explanatory variables that may influence decisions of both farmers and program administrators. Farmer characteristics like AGE (both current and at the last year of receiving cost-share funding) and two dummies for the level of formal education were considered in the analysis (COLLEGE, POSTGRAD). Farmer age is used as a measure of farmer's time horizon; while, in the participation equation, farmer education is used as a proxy for transaction costs associated to the application process. In the conservation effort equations, education is also used to proxy farmer perception about private and social benefits from the use of conservation practices. The dummy POSTGRAD is expected to proxy level of off-farm income as well.

Farm topography is considered by introducing the variables HIGHLY and MODERATE, which give the percentages of land operated with a slope higher than 8% and between 2 and 8%, respectively. From the farmer standpoint, these variables proxy the amount of land on which conservation cropping is likely to be more profitable. From the agency viewpoint, they measure the share of the farm on which traditional cropping should be used or where cropping should be replaced by permanent vegetative cover. We control for tenancy by incorporating a variable (RENTED) giving the percentage of land operated that is rented in. Renters are widely believed to have less incentive to invest in conservation since long run returns accrue to the property owner, not the tenant. Although information like tenancy, and farmer age and education are not included in the application forms, it is easy to obtain by program technicians who are in permanent contact with farmers. Therefore we included these variables both in the selection and response equations.

Total acreage (LAND) operated was included to control for the effects of farm size. Large farms may have more incentives to apply for cost sharing since they are likely to have a more diverse topography. Program administrators, on the other hand, may target preferentially those farms that are likely to be large pollution sources. Variable LAND was considered in its linear and quadratic forms.

A dummy DISTANCE indicating whether the distance to the closest water body (stream, lake, pond, wetland, or the Chesapeake Bay) was less than 0.5 miles or not was included in the participation equation. Since protection of water quality in the Bay and its tributaries is the expressed top priority of Maryland's conservation programs, it is expected that proximity to water bodies increases the likelihood to receive funding.

We included in the response equations the number of years since the signing of the last cost-sharing contract (if any) for implementing any of the practices under study. We considered linear and quadratic forms of this TIME variable in order to capture at least part of the dynamics of conservation effort as time since contract signing increases.

Finally, we included a dichotomous regressor indicating whether the farm has been awarded cost sharing for any type of conservation program in the past, *i.e.* if there is a previous history of participation in conservation programs. In the participation equation, this variable carries valuable information on the level of knowledge that program administrators have about conservation history of awarded farmers. It is also a good proxy for transaction costs, as we expect that farmers that have participated more frequently have less transaction costs. Regressors that were included in each equation are indicated using superscripts in Table 1.

In an equation system like (1), a misspecification of any of the equations can be transmitted to the rest of the system by the disturbance terms. Therefore, we test the robustness of our estimations by calculating four sets of estimators. We estimate separately the two 2-equation systems that combine the selection equation and one of the two response equations, *i.e.* we estimate by full information maximum likelihood (FIML) the system

$$y_{1i}^{*} = X_{1i}\beta_1 + \eta_{1i}$$

$$^{y_{1i}=0}\,[\qquad\qquad\qquad]\,^{y_{1i}=1} \qquad\qquad j = 2,3$$

$$y_{ji}^{*0} = X_{ji}\beta_j^0 + \eta_{ji}^0 \qquad\qquad y_{ji}^{*1} = X_{ji}\beta_j^1 + \eta_{ji}^1$$

We proceed this way by assuming first homoskedasticity and then relaxing that assumption. A third set of estimates was obtained by estimating the three equations simultaneously by FIML. Finally, we estimate the 3-equation system again, but now controlling for heteroscedasticity. Since we are interested in the correlation between error terms, controlling for heteroscedasticity is crucial as it influences directly the structure of the error covariance matrix. Besides, it is known that FIML is inconsistent in models with limited-dependent variables in presence of heteroscedasticity unless we account for it (Hurd, 1979). We model heteroscedasticity by assuming a multiplicative form, *i.e.*

$$E\left[\eta_{1i}\right]=\exp\left(Z_{1i}\gamma_1\right) \qquad E\left[\eta_{ji}^k\right]=\sigma_{j,k}^2\exp\left(Z_{ji}\gamma_j^k\right) \qquad j=2,3 \quad i=1,\ldots N \quad k=0,1$$

$$E\left[\eta_{1i}\eta_{ji}^k\right]=\sigma_{1j,k}\exp\left(\frac{Z_{1i}\gamma_1+Z_{ji}\gamma_{ji}^k}{2}\right)=\rho_{\eta_1\eta_j^k}\sigma_{j,k}\exp\left(\frac{Z_{1i}\gamma_1+Z_{ji}\gamma_j^k}{2}\right)$$

$$E\left[\eta_{2i}^k\eta_{3i}^k\right]=\sigma_{23,k}\exp\left(\frac{Z_{2i}\gamma_2^k+Z_{3i}\gamma_3^k}{2}\right)=\rho_{\eta_2^k\eta_3^k}\sigma_{2,k}\sigma_{3,k}\exp\left(\frac{Z_{2i}\gamma_2^k+Z_{3i}\gamma_3^k}{2}\right)$$

Where Z_{ji} is a set of heteroscedasticity determinants, $\left(\sigma_j^2,\sigma_{1j,k},\sigma_{23,k},\gamma_j\right)$ are parameters to estimate, $\rho_{\eta_1\eta_j^k}$ are correlation coefficients, and $\sigma_1^2=1$ for identification in the dichotomous selection equation. Preliminary estimations proved that heteroscedasticity was proportional to farm size only. This finding makes sense since the practices under study target soil erosion and nutrient runoff, pollution problems that are prevalent on highly sloped land. As larger farms should have more topographic heterogeneity, it is not surprising that heteroscedasticity depends on farm size. Thus, our matrix Z contains the variable LAND only, which we use in its log form.

Due to the latent nature of the dependent variables, the likelihood function is highly nonlinear and it involves 3-dimensional integrals. Additionally, maximization of the likelihood function of this type of problems is sensitive to the selection of starting values. To make FIML feasible, we programmed a Monte Carlo EM algorithm (MCEM) in MATLAB. By restoring the latent continuum, a MCEM approach (Wei and Tanner, 1990) has the advantages of reducing the problem to a generalized linear estimation in each iteration of the algorithm, avoiding the high dimensional integration, and reducing significantly the sensitivity to the selection of starting values due to its stochastic approximation to the optimum.

Testable hypotheses

We are interested primarily in the existence, direction, and magnitude of information asymmetry effects. We are interested secondarily in the criteria and observable farm characteristics that seem to be associated with allocation of cost-share awards and with conservation effort.

Note that, under voluntary participation, individuals whose unobservable attributes give them comparative advantages under the program will be more willing to participate. Thus, the first question we investigate is whether, conditional on the observables, does exist the potential for information asymmetry effects. Mathematically, this corresponds to evaluate the hypotheses $H_0: \rho_{\eta_1\eta_j^0} = 0$, $j = 2,3$ on the untreated subpopulation. If H_0 is accepted, it means that no conditional correlation between the decision to participate and conservation effort exists, i.e. the participation decision and the ex-ante conservation decisions are independent. On the other hand, if H_0 is rejected and $\rho_{\eta_1\eta_j^0} < 0$ ($\rho_{\eta_1\eta_j^0} > 0$), then the farmers whose unobservables give them greater ex-ante advantages under the program are those whose unobservables also push them to exert a lower (higher) ex-ante conservation effort even in absence of funding. Notice there is a potential source of adverse selection if $\rho_{\eta_1\eta_j^0} > 0$, since it means that the farmers most willing to participate are those who are already exerting a high level of conservation.

A second and probably more important question has to do with the ex-post situation, i.e. does actually exist negative information asymmetry effects? To answer it we need to evaluate $H_0: \rho_{\eta_1\eta_j^1} = 0$ on the treated subpopulation. If the hypothesis is rejected and the correlation estimate results negative for practice j, then we have evidence of detrimental effects of information asymmetries (such as moral hazard). On the other hand, if $\rho_{\eta_1\eta_j^1}$ is positive and $\rho_{\eta_1\eta_j^1} > \rho_{\eta_1\eta_j^0}$ then contract incentives have been successful in driving farmers to higher levels of conservation effort.

Information asymmetry effects

Consider the expected program effect (or expected treatment effect on the treated, ETET) for participant i and practice $j = 2,3$ (terms appear adjusted by censoring and self-selection), which is

$$
\begin{aligned}
ETET &= E\left[y_{ji}^1 \mid y_{1i} = 1\right] - E\left[y_{ji}^0 \mid y_{1i} = 1\right] = \\
&\underbrace{\frac{\Phi_2\left(X_{1i}\beta_1, \frac{X_{ji}\beta_j^1}{\sigma_j^1}, \rho_{\eta_1\eta_j^1}\right)}{\Phi(X_{1i}\beta_1)} X_{ji}\beta_j^1 + \frac{\sigma_j^1\phi\left(\frac{X_{ji}\beta_j^1}{\sigma_j^1}\right)}{\Phi(X_{1i}\beta_1)} \Phi\left(\frac{X_{1i}\beta_1 - \rho_{\eta_1\eta_j^1}\frac{X_{ji}\beta_j^1}{\sigma_j^1}}{\left(1-\rho_{\eta_1\eta_j^1}^2\right)^{1/2}}\right) - \frac{\Phi_2\left(X_{1i}\beta_1, \frac{X_{ji}\beta_j^0}{\sigma_j^0}, \rho_{\eta_1\eta_j^0}\right)}{\Phi(X_{1i}\beta_1)} X_{ji}\beta_j^0 - \frac{\sigma_j^0\phi\left(\frac{X_{ji}\beta_j^1}{\sigma_j^0}\right)}{\Phi(X_{1i}\beta_1)} \Phi\left(\frac{X_{1i}\beta_1 - \rho_{\eta_1\eta_j^0}\frac{X_{ji}\beta_j^0}{\sigma_j^0}}{\left(1-\rho_{\eta_1\eta_j^0}^2\right)^{1/2}}\right)}_{{}_1\Delta_{ji}} + \\
&\underbrace{\sigma_{\eta_1\eta_j^1}\frac{\phi(X_{1i}\beta_1)}{\Phi(X_{1i}\beta_1)} \Phi\left(\frac{\frac{X_{ji}\beta_j^1}{\sigma_j^1} - \rho_{\eta_1\eta_j^1}X_{1i}\beta_1}{\left(1-\rho_{\eta_1\eta_j^1}^2\right)^{1/2}}\right) - \sigma_{\eta_1\eta_j^0}\frac{\phi(X_{1i}\beta_1)}{\Phi(X_{1i}\beta_1)} \Phi\left(\frac{\frac{X_{ji}\beta_j^0}{\sigma_j^0} - \rho_{\eta_1\eta_j^0}X_{1i}\beta_1}{\left(1-\rho_{\eta_1\eta_j^0}^2\right)^{1/2}}\right)}_{{}_2\Delta_{ji}} \\
&= {}_1\Delta_{ji} + {}_2\Delta_{ji} \qquad (2)
\end{aligned}
$$

The expectation has two components. We name term ${}_1\Delta_{ji}$ as the "treatment" effect or TE, which, if evaluated at $\rho_{\eta_1\eta_j^1} = \rho_{\eta_1\eta_j^0} = 0$, provides the expected treatment effect as if cost sharing was allocated randomly. Term ${}_2\Delta_{ji}$, on the other hand, is the "information asymmetry" effect or IE component since its sign and magnitude depend directly on error covariance terms. Note that the expectation in (2) decreases if $\sigma_{\eta_1\eta_j^1}$ is negative and/or $\sigma_{\eta_1\eta_j^0}$ is positive. It is tempting to measure the effect of information asymmetries by using only the "information asymmetry" component ${}_2\Delta_{ji}$. However, the correlation terms appear in ${}_1\Delta_{ji}$ as well, which makes the evaluation of the impact of information asymmetries a bit more complicated. A more accurate sample estimate of the effect on practice j is obtained by calculating

$$IE_j = \frac{1}{N_j}\sum_i w_i \left\{ E\left[y_{ji}^1 \mid y_{1i}=1\right] - E\left[y_{ji}^0 \mid y_{1i}=1\right] - {}_1\Delta_{ji}\Big|_{\rho_{\eta_1\eta_j^0}=\rho_{\eta_1\eta_j^1}=0} \right\} \qquad j = 2,3 \qquad (3)$$

Where w_i is the weight for p i, the sum is over all the N_j farms participating in the program with practice j, and ${}_1\Delta_{ji}\Big|_{\rho_{\eta_1\eta_j^0}=\rho_{\eta_1\eta_j^1}=0}$ is the "treatment" component evaluated at $\rho_{\eta_1\eta_j^1} = \rho_{\eta_1\eta_j^0} = 0$. The information asymmetry effect, IE_j, provides us with a measure of the allocation efficiency of the cost-sharing program relative to the situation in which funds are allocated randomly. A negative and statistically significant value for IE_j is evidence of a detrimental information effect.

Estimation Results

Correlation coefficients and corresponding standard errors are reported in Table 2. Regarding to the determinants of participation, since our model is nonlinear, adequate discussion of the results must be based on marginal effects rather on estimated parameters. Accordingly, we report both coefficient estimates and marginal effects with respective asymptotic standard errors for the selection equation in Table 4. The quadratic terms for LAND were dropped from all the equations at the last estimation, as they were not statistically significant both individually and jointly.

According to Table 2, the signs of the conditional correlation coefficients are consistent across model specifications under homoscedasticity. Correlations do not change qualitatively by moving from a 2-equation to a 3-equation model. However, the correlation coefficients do change dramatically when controlling for heteroscedasticity. This outcome shows the importance of testing (and controlling) for heteroscedasticity in nonlinear models since, different from linear specifications, it affects not only efficiency but consistency as well.

Information Asymmetry Effects

The discussion below is based on the estimates from the 3-equation heteroscedastic model (Table 2). Correlation $\rho_{\eta_1\eta_2^0}$ is negative and not significant statistically, which indicates that -after controlling for observables- participation decisions and ex-ante effort on conservation of permanent vegetative cover are independent. Thus, we do not observe evidence of adverse selection due to unobservables affecting the amount of set-aside land in the farm. An analogous result is observed for the treated regime. The correlation coefficient $\rho_{\eta_1\eta_2^1}$ is positive but not significant statistically, which is evidence of absence of ex-post consequences of information asymmetries. In accordance with these outcomes, Table 3 shows a negligible "information effect" (IE).

Regarding to conservation cropping, $\rho_{\eta_1\eta_3^0}$ is negative and statistically significant. Hence, farmers having a (ex-ante) low level of use of these practices are the most willing to participate (or being selected for enrolling the program), which is desirable from a social standpoint. Complementarily, $\rho_{\eta_1\eta_3^1}$ is positive but, despite of his high magnitude (0.508), not significant. A positive value for $\rho_{\eta_1\eta_3^1}$ is also desirable from a cost-benefit viewpoint because it implies that those more willing to participate are also the ones that exert a higher (ex-post) level of conservation. Thus, our results show evidence of advantageous selection in conservation contracts that cost share contour/strip cropping and cover crops. Most notable is the statistically significant value for the IE of conservation cropping in Table 3, which attains a magnitude of 0.507 and it accounts for a half of the total expected treatment effect.

The negative value for $\rho_{\eta_1\eta_3^0}$ also means that farms willing to exert a high level of conservation even in absent of contractual obligations have a low probability to obtain conservation funding. An outcome like this is an indication of low risk of observing adverse selection, but the reason this happens is an open question. Some alternative explanations might be: *i)* it is likely that conservation cropping is profitable for commercial farms even in absence of cost sharing, and they prefer to implement conservation practices by themselves to avoid compliance restrictions included in conservation contracts; *ii)* program administrators select out farms with higher levels of conservation since, from the agency standpoint, more environmental benefits are achieved by targeting farms exerting an ex-ante low level of conservation; and/or iii) conservation cropping is profitable, but farmers exerting (ex-ante) low conservation effort are financially constrained and, therefore, they are more willing to sign a conservation contract since private benefits outweigh transaction costs and costs from compliance restrictions.

Overall, our results show no evidence of detrimental effects from information asymmetries on conservation contracts. We do not observe statistically significant effects neither on the level of vegetative cover nor on wildlife habitat and, after controlling for the observables, participation decisions seem indifferent to the level (both ex-ante and ex-post) of land set aside from production. However, the information effects on the use of conservation-cropping practices were substantial. As a matter of fact, and according to Table 3, self-selection mechanics seem to be the primary reason explaining the positive impact of cost-sharing programs on the level of adoption of conservation cropping practices.

Treatment effects and determinants of participation

Table 3 shows that program effect differs across practices. The components of the expected treatment effect on the treated (ETET) are the TE (direct treatment effect) and the IE (information effect). The TE prevails in the impact that cost-sharing programs have on conservation of vegetative cover, while the prevailing component on conservation cropping is the IE. As theoretical literature predicts (Malik and Shoemaker, 1993; Khanna *et al.*, 2002), the direct impact on set-aside land is negative (a reduction of 7 percentage points according to Table 3).

Surprisingly, the direct treatment effect on conservation cropping, which measures the change in the share of land under cropping on which conservation practices are used, is not significant. The total expected effect, however, is positive and significant, but only thanks to the information effect (which attains a positive impact of 50 points[1]).

According to Table 4, it seems that farm's environmental features matter little in the cost-sharing awarding decisions (for the practices and by the time considered in this study at least). Neither topography nor distance to water bodies appears relevant. Rather, the only statistically significant marginal effects (farm size, farmer age, cost-share awarding history) are those somehow related to transaction costs. Therefore, it seems that agency screening is not very stringent and the information effects discussed previously are rather a consequence of self-selection than agency targeting

[1] Recall that the total expected effect on conservation cropping ranks from a potential value of 0 to a potential value of 300 points. This happens because it aggregates the impact of three practices, each one with a potential impact of 100 points if the practice is used on all the land cropped.

Conclusions

This paper has investigated empirically the impact of informational asymmetries on the performance of conservation contracts. As a first result, we showed that using correlation coefficients to test for information asymmetries could be a misleading exercise if the covariance matrix of the model is not correctly specified. In particular, and complementing previous literature, we demonstrated the importance of controlling for heteroscedasticity when the response variables are censored. Secondly, in our analysis of Maryland farms we found no evidence of detrimental effects of information asymmetries in contracts for implementing conservation practices. As a matter of fact, no information effect whatsoever was detected on area under permanent vegetative cover, while a positive effect was observed on the use of conservation cropping practices. Surprisingly, the no existence of detrimental information effects seem to have happened not as result of a stringent targeting based on environmental considerations but mainly on farmer self-selection. Finally, it must be note that the existence of positive information effects does not imply a positive overall impact of conservation contracts on conservation behavior. Actually, our results indicate a negative program effect on permanent vegetative cover and a positive, but decreasing in time, effect on the use of conservation cropping practices.

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Appendix 1

TABLE 1. DEPENDENT AND EXOGENOUS EXPLANATORY VARIABLES

Variable	Description	Mean	Standard Deviation
Dependent variables			
Cost share	Binary variable indicating whether the farmer has participated in a program that cost share any type of conservation cropping practice (including cover crops, contour/strip cropping) and/or protection of permanent vegetative cover or wildlife habitat in the period 1983-1998 (yes=1).	0.112	0.315
Vegetative cover	Proportion of land under permanent vegetative cover or wildlife habitat to total acreage operated.	0.144	0.285
Conservation cropping	Proportion of land cropped using contour/strip cropping and/or cover crops to total acreage cropped.	0.475	0.678
Explanatory variables			
CSage [1]	Age of the farmer in the most recent year cost share funding for implementing at least one of the practices under study was received since 1983 (participants only)	51.255	11.740
Age [2]	1998 farmer age	58.984	11.740
College [1,2,3]	Farmer has college education or attended to technical school but has not postgraduate education (yes = 1)	0.270	0.444
Postgrad [1,2,3]	Farmer has postgraduate education (yes = 1)	0.081	0.273
Highly [1,2,3]	Proportion of total acreage operated with slope equal to or greater than 8%	0.082	0.170
Moderate [1,2,3]	Proportion of total acreage operated with slope greater than 2% but less than 8%.	0.313	0.341
Land [1,2,3]	Total acreage operated (10^3 acres)	0.204	0.291
Distance [1]	The farm distance to the nearest water body is less than 0.5 mile (yes=1).	0.738	0.439
Time [2,3]	Number of years since last time cost sharing was received (participants only)	4.538	4.290
PreviousCS [1,2,3]	The farm has been awarded cost sharing in the past (yes=1).	0.038	0.192

[1] Included as a regressor in the participation equation; [2] included as a regressor in the vegetative cover equation; [3] included as a regressor in the conservation cropping equation.
Sample size N = 366.

TABLE 2. CORRELATION COEFFICIENTS FOR DIFFERENT MODEL SPECIFICATIONS

		Vegetative cover (equation $j=2$)		Conservation cropping (equation $j=3$)	
Model	**Coefficient**	**Estimate**	**Std. error [b]**	**Estimate**	**Std. error [d]**
2 equations	$\rho_{\eta_1\eta_j^0}$	-0.4417	0.3374	-0.6570 [b]	0.2566
	$\rho_{\eta_1\eta_j^1}$	-0.5643 [a]	0.1902	-0.0553	0.2494
3 equations	$\rho_{\eta_1\eta_j^0}$	-0.3819	0.2750	-0.6167 [a]	0.1910
	$\rho_{\eta_1\eta_j^1}$	-0.5519 [a]	0.1892	-0.0174	0.2534
2 equations with heteroscedasticity	$\rho_{\eta_1\eta_j^0}$	-0.0721	0.5581	-0.7905 [a]	0.1193
	$\rho_{\eta_1\eta_j^1}$	0.0778	0.2219	0.3340	0.2463
3 equations with heteroscedasticity	$\rho_{\eta_1\eta_j^0}$	-0.0249	0.2160	-0.7870 [a]	0.1154
	$\rho_{\eta_1\eta_j^1}$	0.0753	0.2307	0.5082	0.3442

[a] Significant at 1% significance; [b] significant at 5% significance; [c] significant at 10% significance;
[d] Asymptotic standard errors by the delta method.

TABLE 3. ESTIMATED INFORMATION EFFECTS ON ADOPTION OF CONSERVATION PRACTICES

Practice	**Effect**	**Estimate**	**As. std error [d]**
Vegetative cover	ETET	-0.0660 [c]	0.0386
	TE	-0.0726 [a]	0.0251
	IE	0.0067	0.0265
Conservation Cropping	ETET	0.9510 [a]	0.3096
	TE	0.4440	0.4141
	IE	0.5070 [a]	0.1619

[a] Significant at 1% significance; [b] significant at 5% significance; [c] significant at 10% significance;
[d] Asymptotic standard errors by the delta method.

TABLE 4. COEFFICIENT ESTIMATES AND MARGINAL EFFECTS

Equation	Variable	Coefficient	Std. error	Mg. Effect	Std. error
Cost-Sharing (participation)	Constant	-0.30699	0.24663		
	Csage	-0.00916	0.00480	-0.0025 [b]	0.0011
	College	0.14372	0.11014	0.0436	0.0352
	Postgraduate	-0.16610	0.23482	-0.0342	0.0397
	Highly	-0.82081	0.53078	-0.2249 [c]	0.1337
	Moderate	0.10136	0.15444	0.0278	0.0415
	Land	0.06902	0.31676	0.4988 [a]	0.0969
	Distance	0.16340	0.12287	0.0401	0.0277
	PreviousCS	1.43629	0.44257	0.8131 [a]	0.0887
		Regime $y_{1i}=0$		**Regime $y_{1i}=1$**	
Equation	**Variable**	**Coefficient**	**Std. error**	**Coefficient**	**Std. error**
Vegetative Cover	Constant	-0.14619	0.15864	-0.01333	0.10074
	Age	-0.00180	0.00249	0.00003	0.00179
	College	0.16182	0.06719	-0.03480	0.04224
	Postgraduate	0.08721	0.11159	-0.00920	0.09735
	Highly	0.34572	0.15294	-0.14268	0.17998
	Moderate	0.26452	0.08242	0.05448	0.05924
	Land	-0.00515	0.06186	-0.00420	0.02378
	Time			-0.00203	0.01495
	$Time^2$			-0.00002	0.00122
Conservation cropping	Constant	0.65409	0.28461	0.89611	0.87967
	Age	-0.01425	0.00447	-0.00787	0.01310
	College	-0.20333	0.12194	-0.26420	0.29474
	Postgraduate	0.21040	0.19999	0.53671	0.63337
	Highly	-0.57306	0.37121	1.75388	0.92446
	Moderate	0.90046	0.15128	0.65640	0.50449
	Land	0.14337	0.20596	-0.13466	0.43292
	Time			-0.19508	0.11585
	$Time^2$			0.01103	0.00932
Covariance matrix	σ_{12}	-0.00750	0.06514	0.00378	0.01192
	σ_{13}	-0.77660	0.16764	0.36883	0.30280
	σ_{22}	0.09120	0.02792	0.00252	0.00184
	σ_{23}	-0.04162	0.02542	0.02480	0.01702
	σ_{33}	0.97381	0.26347	0.52674	0.28682
	γ_1	0.71806	0.20220		
	γ_2	-0.36511	0.12637	-1.41424	0.32027
	γ_3	0.11684	0.11661	-0.09367	0.25407

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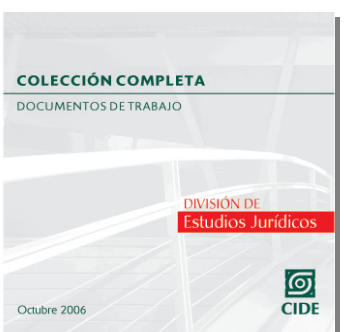

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