Cost Sharing, Transaction Costs, and Conservation

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The 2002 Farm Security and Rural Investment Act envisages a dramatic expansion of subsidies to promote conservation, especially measures undertaken on working farmland. The Act authorizes an immediate doubling of federal cost sharing for the installation of conservation practices under the Environmental Quality Investment Program (EQIP) as the first step toward a sixfold increase in funding by 2007 and introduces a new Conservation Security Program (CSP) that offers both cost sharing and annual rental payments to farmers willing to implement conservation measures as part of their production operations. This growth in the importance of agricultural conservation programs, in particular, those subsidizing conservation on working farmland, is likely to continue. Subsidies for conservation measures are not classified as price supports under the General Agreement on Tariffs and Trade (GATT) and are thus exempt from current limits on price support payments. Also, environmental concerns, which have assumed increasing importance in Congressional coalition-building, have exerted growing pressure to reorient farm subsidy programs toward conservation and environmental protection.

To date, however, there has been relatively little examination of how well existing programs function. This paper conducts such an examination in both theoretical and empirical terms. We develop a theoretical model that incorporates the key features of the process through which conservation subsidies are allocated: (1) the voluntary nature of these programs; (2) the presence of substantial costs of participation, which include expensive design modifications as well as time costs of application and similar transaction costs; and (3) the possibility that, for historical reasons, agencies allocating funds take into account impacts on farm productivity and political considerations in addition to conservation. We show that these features of program design can have perverse effects. The voluntary nature of the program creates the possibility of adverse selection, broadly speaking, in the sense that those applying for cost sharing would have found conservation profitable even in its absence. Additionally, the costs involved in meeting program requirements can actually induce farmers to reduce the size and scope of proposed conservation projects. We test for these effects empirically using farm-level data from Maryland, a state which has used conservation cost sharing aggressively to meet goals for water quality improvements in the Chesapeake Bay. Our empirical results indicate that these effects have been pervasive and large enough that the environmental impacts of conservation cost sharing have been minimal.

Previous theoretical and empirical studies have suggested that selection effects due to voluntary participation and problems of administration might limit the efficacy of cost sharing as a means of promoting conservation on working farm land. Malik and Shoemaker (1993) modeled incentives for the adoption of a single conservation practice using the land-quality-based technology adoption model of Caswell and Zilberman (1986) and Lichtenberg (1989). They showed that many of the farmers applying for cost sharing could be those for whom adoption of a conservation technology would be profitable even without subsidies of any kind. In such cases, cost sharing is a pure transfer that accomplishes nothing in the way of additional conservation effort. Using a similar framework, Lichtenberg (2002) pointed out that cost sharing could actually worsen environmental problems by making it profitable for farmers to expand production onto land that would otherwise be unprofitable to cultivate. Empirical studies of farmers' adoption of conservation measures by Cooper (1997) and Lichtenberg (2001) suggest that many farmers may be willing to adopt conservation practices without subsidies, which implies that the scope for this form of adverse selection may be substantial.[1]

A few empirical studies have attempted to investigate the impacts of cost sharing on measures of overall conservation effort such as estimated reductions in erosion (Ervin and Ervin 1982) and acreage served by a conservation practice (Norris and Batie 1987). These studies treat the receipt of cost share funds as exogenous, ignoring selection both by farmers during the application process and by government agencies during the award determination process, so that the parameter estimates they obtain are biased and inconsistent.[2]

Both history and practical politics suggest that that non-environmental considerations may be important determinants of cost share funding award decisions. Programs that provide payments for the installation of conservation structures or establishment of management practices on working farmland (like EQIP and the CSP) are continuations of programs that were originally established to address problems of lost farm productivity due to erosion in the 1930s (as are paid land diversion programs like the Conservation Reserve Program). These programs were subsequently adapted to encompass broader environmental quality concerns (Magleby et al. 1995). As with any evolutionary process, vestiges of earlier goals may impair the extent and efficiency with which these new goals are met. Then, too, these programs may be administered as a means of augmenting subsidy payments to politically influential farmers, even if doing so diminishes the extent to which they meet their stated purposes.[3]

This paper differs from previous theoretical studies in a number of ways. Most importantly, we consider the transaction costs involved in obtaining conservation cost share funds, including the costs of meeting design changes and implementation requirements imposed by government technicians in addition to more widely recognized components of transaction costs such as the time and management costs involved in applying for conservation cost sharing programs. Cost share funding proposals require extensive consultation with technicians from the Natural Resource Conservation Service or local soil conservation district (whose approval is a prerequisite for filing an application) as well as considerable lead time (for a brief description of this process see Bastos and Lichtenberg 2001). Approval of proposals may be contingent on acceptance of changes in conservation project design or implementation that increase the expense involved. These transaction costs and anticipated cost increases due to changes in project design and implementation can be large enough to influence decisions about whether to apply. Second, we consider factors influencing government agencies' awards of cost share funding. As Bastos and Lichtenberg (2001) note, the actions of government agencies may worsen adverse selection problems by favoring projects proposed by influential farmers or choosing projects that enhance farm productivity over those that improve environmental quality. Third, we consider the impact of cost sharing on overall conservation effort (rather than the adoption of a single conservation practice) and use a framework that encompasses possible economies of scale and scope, rather than assuming constant returns to scale, so that our model is more general than those of Malik and Shoemaker (1993) or Lichtenberg (2002).

The empirical portion of the paper uses farm-level data to test for adverse selection in conservation cost sharing in Maryland. Maryland is an interesting state for such an investigation because of the prominent role cost sharing has played in efforts to improve water quality in the Chesapeake Bay. The State of Maryland's Agricultural Cost Share Program (MACS) spent more than $34.0 million over the period 1987-1996, during which time federal cost sharing programs spent $9.5 million (Lichtenberg and Bastos 1999). As a result, the number of farmers receiving cost share funds in Maryland is large enough to support statistical investigation of the determinants of cost share awards and the impact of cost sharing on conservation effort, i.e., whether adverse selection has been present in cost sharing. In contrast to previous studies such as Ervin and Ervin (1982) and Norris and Batie (1987), we control statistically for selection effects in modeling the impact of cost sharing on two measures of conservation effort, the number of conservation practices adopted and the acreage served by those conservation practices.

Theoretical Model

Both federal and state cost sharing programs are administered in much the same way. Application for cost sharing is voluntary. Applicants can request funding for 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. Technicians can and do require revisions to the proposal, including changes in the kinds of conservation measures used and in the ways that those conservation measures are implemented, that can increase their expense substantially, for example, by requiring more extensive conservation measures, more expensive conservation practices, or the use of approved contractors for installation (rather than letting farmers do their own installation). 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 by a county executive director overseen by a committee elected from and by those involved in agricultural businesses in the county (Bastos and Lichtenberg 2001). In the State of Maryland program, award decisions are made by the MACS program office in the Maryland Department of Agriculture.

We model this set of procedures as a three-stage process. In stage one, each farmer formulates conservation plans with and without cost sharing and, simultaneously, decides whether to apply for cost sharing, taking into account the full range of transaction costs, which include the additional expense of accommodating modifications that may be demanded by conservation technicians as well as the time and management demanded by the bureaucratic process. In stage two, the administrative body chooses how much of each funding request to grant given its preferences regarding environmental quality and political-economic considerations and its budget limitations. In stage three, each farmer makes a final decision regarding conservation effort conditional on cost share funding awards. The administrative body's preferences and budget are assumed to be common knowledge, as are the costs of conservation projects. Farmers are assumed act simultaneously and independently of each other. They are assumed to differ in terms of the profitability of conservation projects and the transaction costs associated with formulating a conservation project proposal, both of which are assumed to be the private information of each farmer, so that the administrative body cannot infer actual conservation project implementation from the project proposal.

Stage 1: Farmers' Ex Ante Conservation Decisions

Assume there are J risk neutral farmers. Let z_j denote the size of the conservation project being considered by farmer j, measured in terms of such items as the number of practices adopted, the acreage served by those conservation practices, the extent to which runoff or erosion is curtailed, etc. Let y_j denote a vector of outputs and x_j a vector of inputs, with p and w the respective vectors of their prices. Let k_j denote farmer j's vector of physical, natural, and human capital. Let $R(p,w,z_j,k_j)=\max_{x_j,y_j}\{p\cdot y_j - w\cdot x_j : y_j \in Y(x_j,z_j,k_j)\}$ denote the revenue generated by a conservation project of size z_j for a farmer with physical, natural, and human capital k_j and a concave producible output set $Y(x_j,z_j,k_j)$. Let $C(z_j,k_j)$ be the cost of a conservation project of size z_j, assumed to be convex in (z_j,k_j). Let $S(z_j,k_j,u_j)$ and $T(z_j,k_j,u_j)$ be the cost share funding award and the transaction costs associated with farmer j's application for cost share funding, respectively. Both are assumed to be quasiconvex functions of project size, the farmers capital endowment k_j, and a random element u_j representing farmer j's uncertainty about the technicians' and administrative body's decisions. Let δ_j be an indicator taking on a value of 1 if farmer j applies for cost sharing and 0 otherwise.

Farmer j chooses conservation project size with and without cost sharing, z_j^S and z_j^{NS}, respectively, and whether to apply for cost sharing δ_j to maximize expected profit $R(p,w,z_j,k_j)-C(z_j,k_j)+\delta_j E\{S(z_j,k_j,u_j)-T(z_j,k_j,u_j)\}$. The first order conditions for profit maximization include

$$\frac{\partial R}{\partial z_j} - \frac{\partial C}{\partial z_j} + \delta_j E\left\{\frac{\partial S}{\partial z_j} - \frac{\partial T}{\partial z_j}\right\} \le 0 \tag{1}$$

and

$$\delta_j = \begin{Bmatrix} 0 \text{ if } E\{S(z_j,k_j,u_j) - T(z_j,k_j,u_j)\} \le 0 \\ 1 \text{ if } E\{S(z_j,k_j,u_j) - T(z_j,k_j,u_j)\} > 0 \end{Bmatrix}. \tag{2}$$

Condition (1) states that a farmer not applying for cost share funding will choose a conservation project size that equates marginal revenue $\partial R/\partial z_j$ with marginal project cost $\partial C/\partial z_j$ while a farmer applying for cost sharing will choose a project size that equates marginal revenue with the expected total marginal cost of the project, including marginal project cost, expected marginal cost share funding $E\{\partial S/\partial z_j\}$, and expected marginal transaction cost $E\{\partial T/\partial z_j\}$. Condition (2) states that farmer j will apply for cost share funding if the expected cost share award given optimal project size z_j^S, $E\{S\}$, exceeds the expected transaction cost, $E\{T\}$.

Examination of conditions (1) and (2) together suggests that transaction costs can have some surprising effects on the design of conservation projects submitted for cost share funding awards. In particular, it is possible that conservation projects farmers propose to undertake with cost share funding can be smaller in size and scope than conservation projects they would undertake without cost sharing, i.e., $z_j^S < z_j^{NS}$. Specifically, suppose that condition (1) holds with equality for both $\delta_j = 1$ and $\delta_j = 0$ do that both z_j^S and z_j^{NS} are positive. Then $z_j^S < z_j^{NS}$ when applying for cost sharing is optimal ($E\{S(z_j^S)\} > E\{T(z_j^S)\}$) but the expected marginal transaction cost of applying for cost sharing exceeds the expected marginal cost share award ($E\{\partial T(z_j^S)/\partial z_j\} > E\{\partial S(z_j^S)/\partial z_j\}$). In such cases the marginal cost of conservation with cost sharing exceeds the marginal cost without conservation. Clearly, the prospect of cost share funding can decrease the size and scope of conservation project plans only when expected marginal transaction costs are positive, i.e., when transaction costs increase with the size and scope of proposed conservation projects. This effect is more likely to occur when the marginal increase in cost share funding $E\{\partial S(z_j^S)/\partial z_j\}$ is small, as tends to be the case when cost share budgets are extremely tight, or when awards are subject to stringent payment caps.

The circumstances under which the prospect of cost share funding has this effect are perhaps easiest to see graphically. Figures 1 and 2 depict circumstances under which the standard rationale for cost sharing is valid. The marginal profitability of conservation is downward sloping in project size and scope z_j, reflecting diminishing marginal productivity. The profit-maximizing project size occurs at the point where the marginal profitability of conservation intersects the horizontal axis. To simplify the exposition, all transaction costs are assumed fixed, so that $E\{\partial T/\partial z_j\} = 0 \ \forall \ z_j$. As a result, the marginal profitability of conservation with cost sharing always exceeds that without cost sharing at a project size of zero (i.e., the point where the curves intersect the vertical axis). The cost sharing application criterion $E\{S(z_j,k_j,u_j)-T(z_j,k_j,u_j)\}$ is upward sloping in project size in this case because $S(\cdot)$ is increasing in project size z_j while T is constant. Applying for cost sharing is optimal when the cost share application criterion is positive ($E\{S(z_j^S,k_j,u_j)-T(z_j^S,k_j,u_j)\} > 0$) at the profit-maximizing project size z_j^S.

In figure 1, conservation would be unprofitable without cost sharing; cost sharing makes a conservation profitable ($z_j^S > 0$) as long as the cost sharing application criterion is positive (case A, which differs from case B in having a lower fixed transaction cost T, i.e., $E\{T_A\} < E\{T_B\}$). In figure 2, conservation is profitable without cost sharing (z_j^S, $z_j^{NS} > 0$) but project size is greater with cost sharing than without it ($z_j^S > z_j^{NS}$), so that cost sharing has the intended effect of increasing conservation effort. As before, the farmer will find it profitable to apply for cost sharing when $E\{S(z_j^S,k_j,u_j)\} > E\{T\}$ (case A, which again differs from case B in having a lower fixed transaction cost).

Now assume that some conservation is profitable both with and without cost sharing and that expected marginal transaction costs $E\{\partial T/\partial z_j\}$ are positive and increasing in z_j. In this case, it is possible that the marginal profitability of conservation declines more rapidly with cost sharing than without it, since $E\{\partial T/\partial z_j\}$ can increase more rapidly than $E\{\partial S/\partial z_j\}$. Figure 3 depicts a case in which applying for cost sharing is profitable (case A, which again features lower transaction costs than case B) and farmers applying for cost sharing propose smaller projects than they would have undertaken without cost sharing. As can be seen from Figure 3, three conditions must hold for this perverse effect to occur: (i) the farmer expects cost sharing to be profitable, i.e. $E\{S(z^S\}> E\{T(z^S)\}$; (ii) at a project size of zero, conservation is more profitable with cost sharing than without it; and (iii), there exists a positive project size, z^C, less than the optimal project size with cost sharing z^S at which the difference $E\{\partial S/\partial z_j\}$ - $E\{\partial T/\partial z_j\}$ changes from positive to negative. (Under these conditions, the cost share application criterion $E\{S\}$-$E\{T\}$ is increasing in project size up to z^C and decreasing thereafter.)

Stage 2: Cost Share Funding Award Decisions

For ease of exposition, assume that farmers $j = 1, \ldots, n$ apply for cost sharing while farmers $j = n+1, \ldots, J$ do not. Each application consists of a proposed project size z_j^S and information about some (but not all) of the farmer's natural and physical capital stocks,

k_j. Let κ_j denote the observed portion of farmer j's physical, natural, and human capital stocks and θ_j the unobserved portion. Then each application consists of a vector (z_j^S,κ_j). The administrative body chooses funding award levels from this set of applications. To simplify the analysis, assume that it does so by choosing the project size z_j. Since cost share awards are monotonically increasing in project size, this assumption involves no loss in generality. We assume that the administrative body cares about the environmental and productivity effects of conservation projects, which are functions of the size of the conservation project and observed natural capital stocks $B(z_j,\kappa_j)$, and political-economic considerations, which are functions of the cost share funding award $S(z_j)$. Let $\Lambda(B(z_1,\kappa_1), \ldots, B(z_n,\kappa_n))$ denote the environmental and productivity benefits of cost share awards (project sizes $z_1, \ldots, z_n$) to the administrative body and $\Gamma(S(z_1), \ldots, S(z_n))$ denote the political-economic benefits of those cost share awards. The administrative body chooses a vector of cost share awards (project sizes) to maximize the sum of environmental/productivity and political-economic benefits subject to constraints that total cost share funding awards not exceed its budget M.

Formally, the administrative body chooses ($z_1, \ldots, z_n$) to

$$\begin{aligned} &\max \Lambda(B(z_1,\kappa_1),\ldots,B(z_n,\kappa_n)) + \Gamma(S(z_1),\ldots,S(z_n)) \\ &s.t. \quad \textstyle\sum_{j=1}^{n} S(z_n) \le M . \end{aligned} \tag{3}$$

The first order conditions can be written

$$\frac{\dfrac{\partial \Lambda}{\partial B_j}\dfrac{\partial B_j}{\partial z_j}}{\dfrac{\partial S}{\partial z_j}} + \frac{\partial \Gamma}{\partial S_j} \le \mu , \tag{4}$$

where μ is the Lagrange multipliers associated with the administrative body's budget constraint. Condition (4) implies that for any project awarded cost share funding, the marginal environmental/productivity benefit per dollar of cost sharing awarded, $[(\partial\Lambda/\partial B_j)(\partial B_j/\partial z_j)]/[\partial S/\partial z_j]$ plus the marginal political-economic benefit per dollar of cost sharing awarded, $[\partial\Gamma/\partial S_j]$, must be no less than the marginal cost of the award to the administrative body in terms of the budget constraint, μ.

Stage 3: Conservation Project Implementation

Let $z_1^a, \ldots, z_n^a$ denote project sizes approved by the administrative body, with corresponding cost share funding awards $S(z_1^a), \ldots, S(z_n^a)$. Farmers not awarded cost sharing (both those who did not apply for cost sharing and those whose approved project size was zero) will implement conservation projects of size $z_j^{NS} \geq 0$. Farmers awarded cost share funding must implement conservation projects of at least those approved sizes but are free to augment them should they so choose. Let Δz_j denote an increment to conservation project size considered by farmer j, so that farmer j's total conservation project size is $z_j^a+\Delta z_j$. Increasing project size above and beyond that approved by the administrative body may involve additional transaction costs $T(\Delta z_j,k_j)$. Each farmer awarded cost share funding then chooses how much to increase project size Δz_j in order to maximize profit

$$R(p,w,z_j^a+\Delta z_j,k_j)-C(z_j^a+\Delta z_j,k_j)+S(z_j^a)-T(\Delta z_j,k_j) \tag{5}$$

subject to a non-negativity constraint on Δz_j, corresponding to the requirement that farmers awarded cost share funding must implement conservation projects of at least the approved size.

The first order conditions are

$$\frac{\partial R}{\partial(\Delta z_j)} - \frac{\partial C}{\partial(\Delta z_j)} - \frac{\partial T}{\partial(\Delta z_j)} \leq 0\,, \qquad (6)$$

the marginal revenue generated by the increment equals the marginal cost of the increment plus its marginal transaction cost. In cases like those depicted in figures 1 and 2, cost sharing will have the intended effect: Farmers awarded cost sharing will implement larger conservation projects than they otherwise would have. But in cases like that depicted in figure 3, cost sharing will not have its intended effect. At best, farmers will implement conservation projects of the same size with cost sharing as they would have without ($z_j^a + \Delta z_j = z_j^{NS}$). As can be seen by comparing condition (6) with condition (1) when $\delta_j = 0$, such outcomes occur when the marginal transaction cost of implementing an increment to approved project size equals zero. If the marginal transaction cost of implementing an increment to project size is positive, however, then farmers awarded cost share funding will implement smaller conservation projects than they would have in the absence of cost sharing.

Discussion: Transaction Costs, Payment Limitations, and Conservation Effort

The preceding analysis indicates that cost sharing programs, as they are presently structured, can actually reduce farmers' conservation efforts. The transaction costs involved in the cost share funding application process—which include revising project plans and installation methods to meet requirements imposed by conservation technicians as well as time and money spent on paperwork and delays caused by administrative body deliberations—play a key role in producing such an outcome. When marginal transaction costs are initially lower but rise faster than marginal cost share awards, farmers applying for cost sharing may find it desirable to propose smaller projects for cost share awards than those they would undertake on their own. Under these circumstances, those awarded cost share funding will implement conservation projects no larger than those they would have undertaken on their own. When increasing project size beyond the level approved by the body administering the cost sharing program also involves transaction costs, conservation projects awarded cost share funding can actually be smaller in size and scope than those undertaken without cost share funding. It follows, of course, that in such cases cost sharing actually inhibits improvements in environmental quality rather than enhancing them.

Intuitively, two sets of factors make such perverse outcomes more likely. One occurs when paperwork requirements, the stringency of oversight, and required adjustments to project proposals increase rapidly as the size and scope of conservation projects increases. Another occurs when payment limitations are binding, so that marginal cost share awards are no longer increasing in project size. Both sets of circumstances may occur for valid reasons. Marginal participation costs may increase rapidly with the complexity of the proposal because more technical oversight is needed to ensure that projects actually accomplish their intended conservation goals. Payment limitations may be needed to prevent awards from being overly skewed toward politically influential farmers. Nevertheless, it is important to realize that both more stringent oversight and payment limitations can have unintended negative consequences.

Conservation Cost Sharing in Maryland

We test for the presence of adverse selection in conservation cost sharing using farm-level data from Maryland. A survey of Maryland farm operators was conducted by the Maryland Agricultural Statistics Service (MASS) in 1998. The sample of farmers was drawn from the MASS master list of farmers. Stratified random sampling was used to ensure a sufficient number of responses from commercial operations, especially larger ones. MASS provided expansion factors for deriving population estimates. The survey was administered using a computer assisted telephone survey instrument (CATI) and contains information from farms across all Maryland counties.

The data from the 1998 survey contain information about the farm operation, farm finance, farm topography, human capital of the farm operator, and the use of 24 different conservation practices on 487 farms. Information about the farm operation included acreage (owned, rented in, rented out, and total amount operated), crop acreage (corn, soybeans, small grains, vegetables, tobacco, and other crops), double cropping, and livestock numbers (cattle, poultry, hogs, sheep, horses, and other animals). Farm financial information included annual farm sales (measured categorically) and the percentage of household income earned from farming. Topographical information included acreage with moderate (2 to 8 percent) and steep (over 8 percent) slopes. Human capital information included the age of the farm operator, education, measured categorically in terms of formal schooling, and experience, measured as years managing a farm. Farmers were asked whether they used any of the following best management practices: critical area seeding, filter strips, riparian buffer(s), contour farming, strip cropping, cover crop, reduced tillage, grade stabilization, grass/rock-lined waterway, terraces, diversions, ponds, sediment troughs, manure storage structure/lagoon, permanent vegetative cover, wildlife habitat, measures protecting streams from livestock (fencing, crossing, installation of watering troughs), pre-plant soil testing, pre-sidedress nitrogen testing, manure crediting, split fertilizer application, manure incorporation, fertilizer incorporation, manure composting, and dead bird composting. Farmers were also asked the acreage served by each practice used, whether they had ever received cost-sharing for each practice, and, if so, the latest calendar year they had received cost-sharing funds (see Table 1 for descriptive statistics on cost share awards by practice).

The 1998 survey also included information about potential water quality effects of each farm operation. Each respondent was asked whether there was a body of water on the farm and, if so, the type of water body (pond, stream, wetland, the Chesapeake Bay). Farmers who did not have a water body on-farm were asked the type of the nearest water body and the distance to that water body.

The data did not include direct measures of transaction costs. The effects of transaction costs were inferred from the estimation results, as discussed below.

The data included qualitative indicators of cost share funding awards (i.e., whether or not cost sharing was awarded) and two quantitative measures of conservation project size and scope.

We used the responses to the question about receipt of cost share funding for individual practices to construct an aggregate indicator of cost share funding awards. If a farm operator reported having received cost sharing for at least one conservation practice during the most recent three-year period (1996 through 1998), this indicator was given a value of one. If the farm operator reported not having received cost sharing for any conservation practices during that period, the indicator was set to zero. Non-responses to the cost sharing questions reduced the number of usable observations to 350.

The number of conservation practices used and the acreage served by those conservation practices served as indicators of the size and scope of conservation projects. Acreage served was first aggregated across practices and then normalized by dividing by the total amount of land operated to obtain a measure of the scope or coverage of conservation measures used.

Data on the attributes of the farm operation, farm finance, human capital of the farm operator, topography, and potential water quality effects were used to model both determinants of cost share funding awards and the size and scope of conservation projects (see Table 2 for descriptive statistics of these variables). The theoretical analysis indicates that both cost share funding awards and the ultimate size and scope of conservation projects are determined jointly by (i) the profitability of conservation and of applying for cost sharing given transaction costs and (ii) the decision criteria employed by the agencies administering cost share programs. The coefficients associated with the variables used in these models should thus be expected to combine the effects of both farm operator and administrative agency incentives. These considerations suggest the following hypotheses about those coefficients.

Human capital. The human capital variables used in the cost share award and conservation project size models were operator age, experience, and education. None of this information is provided to administrative bodies making cost share funding awards decisions; none of it seems relevant to those decisions, either. As a result, the coefficients of these three variables should reflect only farmers' incentives.

It is widely believed that older farmers tend to invest less due to shorter time horizons and, possibly, resistance to change. If they tend to invest less, they should also be less likely to apply for cost sharing. We therefore hypothesize that the coefficients of farmer age should be negative in the cost share and conservation project size models.

The costs of implementing conservation practices and the transaction costs involved in applying for cost sharing should be decreasing in experience and education, suggesting that farmers with more experience and education should be more likely to apply for cost sharing and will tend to invest more in conservation projects. We therefore hypothesize that the coefficients of these variables should be positive in the cost share and conservation project size models.

Farm operation characteristics. Attributes of the farm operation used in the cost share award and conservation project size models included the total amount of land operated, the share of operated land rented, and indicators of the presence of crop, dairy, other cattle, and poultry operations. Much of this information is provided to the administrative bodies making cost share funding decisions. (The share of land rented is a notable exception.) The theoretical analysis suggests that much of it is relevant to both farmers' and administrative bodies' decisions for the reasons noted below.

If conservation projects exhibit economies of size and/or scope, farmers operating larger acreage will have an incentive to invest more in conservation. Administrative bodies are similarly more likely to award cost share funding in such cases because economics of size and scope increase the marginal environmental benefits obtained per dollar of cost sharing awarded, $[(\partial\Lambda/\partial B_j)(\partial B_j/\partial z_j)]/[\partial S/\partial z_j]$. Farmers operating larger acreage are likely to be more familiar with farm programs and thus more used to dealing with government officials and paperwork, suggesting lower transaction costs and thus a greater likelihood of applying for cost sharing. Farmers operating larger acreage are also likely to be more influential politically. If political-economic considerations affect cost share funding decisions ($\partial\Gamma/\partial z_j > 0$), they are more likely to be awarded cost share funding. We therefore hypothesize that the coefficient of acreage operated should be positive in the cost share award and conservation project size models.

There is no apparent reason for administrative bodies to concern themselves with land ownership, so the coefficient of the share of land rented variable should reflect only farmers' incentives. Farmers are widely believed to have less incentive to invest in conservation on rented land since long run returns accrue to the landlord, not the tenant. Farmers who rent a larger share of the land they operate should thus be less likely to apply for cost sharing and should invest in conservation projects that are smaller in size and scope.

The data set includes information on the acreage of major crops and numbers of livestock present on each farm operation. It seems likely that cropping patterns and livestock numbers are determined simultaneously with conservation investments. We therefore used qualitative indicators of whether crops, dairy, other cattle, and poultry operations were present, since decisions about whether to engage in these operations are likely made over a longer term than adjustments to the quantitative extent of each type of operation. Farmers with crops and dairy cattle are likely to invest more in conservation in order to protect the long run productivity of these operations. They are also more likely to apply for cost sharing due to greater familiarity with farm programs (and thus lower transaction costs). If protecting farm productivity is a goal of the agencies administering conservation programs, then farms with crops and dairy cattle are more likely to be awarded cost share funding. We therefore hypothesize that the coefficients of these variables should be positive in both the cost share award and conservation project size models.

Farm finance. Annual farm sales were used to measure farm financial condition. They were measured categorically. To economize, we aggregated the eleven categories used in the survey into five broader classes: hobby farmers (those with annual sales under $20,000), part-time farmers (those with annual sales between $20,000 and $99,999), medium-size commercial farmers (those with annual sales between $100,000 and $249,999), large commercial farmers (those with sales between $250,000 and $499,999), and very large commercial farmers (those with sales of $500,000 or more). Farmers with higher annual sales are likely to have greater borrowing capacity and are thus likely to invest more in conservation. They are likely to have more management expertise and thus lower transaction costs, suggesting that they are more likely to apply for cost sharing. They are also likely to have greater political influence, suggesting that administrative bodies are more likely to be award them cost share funding.

Topography and Water Quality. Characteristics of the farm operation indicating potential effects of conservation on both farm productivity and environmental quality include the share of land with moderate and steep slopes and the farm's proximity to surface water bodies.

Threats to productivity and the environment from erosion and nutrient runoff are greater on more steeply sloped land. One would thus expect farmers to have greater incentives to invest in conservation on more steeply sloped land. One would also expect administrative bodies to award more cost share funding to projects involving more steeply sloped land in order to protect both the environment and farm productivity. We therefore hypothesize that the coefficients of the shares of land with moderate and steep slopes should be positive in the cost share award and conservation project size models.

The data included information on whether a surface water body was present on or adjacent to each farm and, if not, the distance to the nearest surface water body. Categorical indicators of the type of water body present on or next to each farm (pond or lake, stream, wetland, the Chesapeake Bay) were included in the cost share award and conservation project models. If farmers' conservation investment decisions are driven by farm profitability considerations alone, proximity to surface water should have little or no influence on cost share application or conservation project size decisions, suggesting that the coefficients of these variables should reflect government agency decision criteria alone. If water quality protection is among those criteria, then farms with water bodies on or next to them are likely to be awarded more cost share funding and farms located farther away from water are likely to be awarded less cost share funding. We thus hypothesize that the coefficients of the indicators of the presence of water bodies on the farm should be positive while the coefficient of distance to the nearest water body should be negative in the cost share award and conservation project size models.

Farm location. Finally, we included in the cost sharing model categorical variables indicating the region in which the farm was located (Southern Maryland, the Upper Eastern Shore, the Lower Eastern Shore, and Central Maryland) to capture the effects of differences in the mix of agricultural activities, the importance of agriculture in the local economy, and conservation technicians and other agricultural officials. The Upper and Lower Eastern Shore and Central Maryland are the main agricultural areas in the state. The Upper Shore specializes in corn and soybean production, the Lower Shore in poultry. Central Maryland specializes in dairy.

Econometric Model

We estimated the impact of cost sharing on the size and scope of farmers' conservation projects using a simultaneous tobit model with sample selectivity. Let S_j* denote the amount of cost share funding awarded to farmer j. We measure conservation project size z_j* in two dimensions: the number of conservation practices used and the coverage those practices provide (i.e., total acreage served by those practices divided by total acreage operated). Let z_{1j}* denote the number of practices used by farmer j and z_{2j}* denote conservation coverage on farmer j's operation. For farmers awarded cost share funding, $z_{ij}* = z_{ij}^a + \Delta z_{ij}$, i = 1,2; for farmers who did not receive cost share funding, $z_{ij}* = z_{ij}^{NS}$. We assume that S_j*, z_{1j}*, and z_{2j}* are linear functions of a set of explanatory variables and a normally distributed white noise error term:

$$S_j* = X_{cj}\beta + \varepsilon_{1j}$$

$$z_{1j}* = X_{1j}\gamma_1 + \alpha_1 S_j * + \varepsilon_{2j}$$

$$z_{2j}* = X_{2j}\gamma_2 + \alpha_2 S_j * + \varepsilon_{3j}$$

where $\varepsilon \sim N(0,\Sigma)$ has a trivariate normal distribution with covariance matrix

$$\Sigma = \begin{pmatrix} 1 & \rho_{12}\sigma_2 & \rho_{13}\sigma_3 \\ \rho_{12}\sigma_2 & \sigma_2^2 & \rho_{23}\sigma_2\sigma_3 \\ \rho_{13}\sigma_3 & \rho_{23}\sigma_2\sigma_3 & \sigma_3^2 \end{pmatrix}.$$

Neither S_j* nor z_{ij}* are observed fully. For cost share funding awards, we observe only an indicator S_j taking on a value of one if cost share funding was awarded ($S_j* > 0$) and zero otherwise. Both the number of practices used and coverage are censored. We observe either only when the desired amount is positive, so that the actual amount z_{ij} equals the desired amount z_{ij}*; otherwise we observe only $z_{ij} = 0$.

The log-likelihood function is:

$$\ln L = \sum\nolimits_{\{j:S_j=z_{1j}=z_{2j}=0\}} n_j \ln \Phi_3\left(-\frac{X_{cj}\beta}{1},-\frac{X_{1j}\gamma_1}{\sigma_2},-\frac{X_{2j}\gamma_2}{\sigma_3},\rho_{12},\rho_{13},\rho_{23}\right)+$$

$$\sum\nolimits_{\{j:S_j=0,z_{1j}^*=z_{1j},z_{2j}^*=z_{2j}\}} n_j\left[\ln\phi_2\left(\frac{\varepsilon_{2j}}{\sigma_2},\frac{\varepsilon_{3j}}{\sigma_3},\rho_{23}\right)+\ln\Phi_1\left(-\frac{X_{cj}\beta+\frac{\rho_{12}-\rho_{13}\rho_{23}}{1-\rho_{23}^2}\frac{\varepsilon_{2j}}{\sigma_2}+\frac{\rho_{13}-\rho_{12}\rho_{23}}{1-\rho_{23}^2}\frac{\varepsilon_{3j}}{\sigma_3}}{\sqrt{(1-\rho_{12}^2-\rho_{13}^2-\rho_{23}^2+2\rho_{12}\rho_{13}\rho_{23})/(1-\rho_{23}^2)}}\right)\right]+$$

$$\sum\nolimits_{\{j:S_j=1,z_{1j}^*=z_{1j},z_{2j}^*=z_{2j}\}} n_j\left[\ln\phi_2\left(\frac{\varepsilon_{2j}}{\sigma_2},\frac{\varepsilon_{3j}}{\sigma_3},\rho_{23}\right)+\ln\Phi_1\left(\frac{X_{cj}\beta+\frac{\rho_{12}-\rho_{13}\rho_{23}}{1-\rho_{23}^2}\frac{\varepsilon_{2j}}{\sigma_2}+\frac{\rho_{13}-\rho_{12}\rho_{23}}{1-\rho_{23}^2}\frac{\varepsilon_{3j}}{\sigma_3}}{\sqrt{(1-\rho_{12}^2-\rho_{13}^2-\rho_{23}^2+2\rho_{12}\rho_{13}\rho_{23})/(1-\rho_{23}^2)}}\right)\right]$$

where n_j is the expansion factor for observation j, ϕ_i is an i-variate normal density, and Φ_i is an i-variate normal cumulative distribution. The likelihood function has three components, corresponding to: (1) farmers who did not receive cost sharing and did not exert any conservation effort ($S_j = z_{1j} = z_{2j} = 0$); (2) farmers who did not receive cost sharing but did exert positive conservation effort ($S_j = 0$, $z_{1j}^* = z_{1j} > 0$, $z_{2j}^* = z_{2j} > 0$); and (3) farmers who received cost sharing and thus necessarily exerted conservation effort ($S_j = 1$, $z_{1j}^* = z_{1j} > 0$, $z_{2j}^* = z_{2j} > 0$).

We estimated the parameters of this model ($\beta,\gamma_1,\gamma_2,\Sigma$) via maximum likelihood using MATLAB. To ensure convergence and minimize the prospect of obtaining a local, rather than global, maximum, we obtained starting values using a grid search over the three correlation coefficients ρ_{12}, ρ_{13}, and ρ_{23}.

Estimation Results

The estimated parameters of all three models are shown in table 3. The estimated parameters generally have the expected signs. The estimated correlation coefficients are all significantly different from zero, indicating the presence of sample selectivity in all three equations, so that ordinary least squares estimators would be biased and inconsistent. They are all positive, as one would expect. Overall, the estimated parameters also suggest that adverse selection has been quite prevalent in conservation cost sharing in Maryland.

Consider first the model of cost share funding awards. The estimated parameters of this model suggest that political influence and protection of crop productivity are important determinants of cost share awards, while concerns about water quality are not. The importance of political influence is indicated by the positive coefficients of the indicator of very large operations (annual sales in excess of $500,000) and of total acreage operated; both suggest that larger operators, who tend to have the greatest political influence in the farming community, are significantly more likely to be awarded cost share funding than farmers with smaller operations. The importance of maintaining crop productivity is indicated by the positive coefficients of the indicator of crop production and of the percentage of highly sloped land operated, which indicates the presence of a greater threat to productivity from erosion. The lack of importance of environmental quality improvements is indicated by the negative coefficients of the indicators of streams and wetlands on the farm and the fact that the coefficient of distance to the nearest water body is not significantly different from zero. Taken together, these estimated coefficients suggest that operations in closer proximity to water bodies—that presumably pose greater threats to water quality—the predominant environmental concern in Maryland—are not more likely to be awarded cost share funding. To the contrary, farms that pose some of the greatest water quality risks, such as those with streams running through them (which pose a greater risk of nutrient runoff) or wetlands on them, are actually less likely to receive cost share funding. The coefficients of the water quality variables further suggest that the positive coefficient of acreage operated should not be attributed to potential economies of scale or scope in conservation.

The cost share funding award model results also suggest that transaction costs play an important role in applications for cost sharing. The coefficient of education at the college or postgraduate level is positive, suggesting that better educated farmers are more likely to be awarded cost share funding. As noted above, the coefficient of this variable should measure farmers' incentives only. This sign of this coefficient is consistent with the hypothesis that transaction costs are decreasing in education.

The two models of determinants of the size and scope of conservation projects (the number of practices used and coverage achieved) suggest that conservation cost sharing in Maryland has been characterized by a substantial degree of adverse selection. The coefficient of the cost share award indicator is negative in the model of the number of practices used, suggesting that farmers receiving cost share funding use fewer conservation practices on average than those who do not receive cost sharing. The coefficient of the cost share award indicator is negative but not significantly different from zero in the model of coverage, suggesting that, at best, cost sharing does not increase the scope of conservation, that is, that projects implemented with costs sharing serve the same amount of acreage as those implemented without it. These results suggest that cost sharing has not increased Maryland farmers' conservation effort and thus has resulted in little, if any, improvement in environmental quality. Moreover, they indicate that cost share funding awards lead to simpler projects that, in principle at least, are less able to accommodate within-farm heterogeneity of topography, soil quality, crop choice, and other conditions that influence the environmental effects of farming.

This latter finding has several possible (and not mutually exclusive) explanations. One, arising from our theoretical model, is that marginal transaction costs are positive and large relative to marginal cost share awards ($E\{\partial T/\partial z\} > E\{\partial S/\partial z\}$), so that farmers applying for cost share have smaller optimal conservation projects than those implementing conservation without cost sharing. Another is that agencies provide cost share funding for a restricted set of conservation practices that are readily observable in order to be able to verify recipients' compliance with cost share contracts at a low cost, so that cost share awards feature smaller numbers of practices. A third is that cost share awards are made preferentially to projects with economies of scope that allow the use of a smaller number of practices to achieve any given level of coverage. Whether the impetus for simplifying conservation projects comes from farmers, funding agencies, or both, any limitation on the flexibility of conservation projects due to cost sharing (as implied by the first two potential explanations) is disturbing given the need to adapt to heterogeneity in the factors influencing both productivity and environmental quality effects (the importance of which is indicated by the positive coefficient of total acreage in the model of the number of practices used, which suggests that larger operations require more complex conservation projects).

The results of the conservation project size and scope models corroborate the notion that political influence is a primary objective of conservation cost share awards. None of the coefficients of the indicators of annual sales is significantly different from zero in the model of the number of practices used. Only the coefficient of hobby farms (sales under $20,000 annually) is significantly different from zero in the model of coverage, and it is negative. These results indicate that very large operators do not engage in conservation projects that are larger in size or scope than smaller operators, which implies that neither the size nor the scope of conservation projects undertaken is a reason for awarding them cost share funding preferentially.

The results of the conservation project size and scope models also corroborate the importance of maintaining crop productivity as an objective of conservation projects. Farms that raise crops undertake conservation projects that are larger in terms of both the number of practices used and the coverage achieved. The extent to which protection of crop productivity simultaneously leads to improvements in environmental quality (i.e., the degree to which the two are complements) is open to question. The coefficient of distance to the nearest water body is negative in both the model of the number of practices used and the model of coverage, indicating more extensive conservation effort on farms having water bodies located on or immediately adjacent to them. However, none of the coefficients of the type of water body on the farm are significantly different from zero in the model of the number of practices used, while all except the coefficient of wetlands are negative in the model of coverage, suggesting that conservation effort is less extensive on farms with any water body except wetlands.

Finally, the coefficients of age and experience in the conservation project size and scope models suggest that transaction costs may be important in conservation project implementation as well as in cost share funding awards. The coefficients of both variables have the expected signs (negative for age, positive for experience) in both models.

Conclusion

Subsidies for conservation on working farmland have assumed a new importance in farm policy, a situation likely to last given the political strength of environmentalists and limitations on farm subsidies imposed by GATT. Yet there has been little examination of how well existing conservation subsidies for working farmland (primarily cost sharing of conservation projects) result in improvements in environmental quality. Implementation of the Conservation Reserve Program, the one environmentally-oriented program that has been studied to some degree, has been shown to have been skewed away from its stated environmental goals in favor of augmenting transfer payments to politically influential farmers.

A major potential problem for conservation cost sharing is cost share funding may be provided for projects that would have been profitable even without subsidization. In the presence of this form of adverse selection, cost sharing accomplishes at best no improvement in environmental quality; by diverting funds from projects that would only become profitable with cost sharing, this form of adverse selection can be seen as leading to lower environmental quality relative to what could have been achieved. When the transaction costs involved in cost sharing program requirements are large, the situation may be even worse. We show that these transaction costs may make it optimal for farmers applying for cost sharing to engage in less conservation effort than they would undertake without cost sharing, raising the possibility that, cost sharing actually reduces conservation effort and thus lowers environmental performance of the farm sector. Such outcomes are more likely when marginal transaction costs are large and when cost share awards are subject to stringent payment limitations. Our empirical study uses data from a

Maryland farm survey in a selectivity model of whether cost share funding was awarded and two measures of conservation effort, the number of practices used and the coverage achieved. We estimate the parameters of the model using full information maximum likelihood taking into account censoring of conservation effort in addition to the discrete nature of the cost share funding indicator. The estimated parameters suggest that political influence and protection of crop productivity have been important criteria of cost share funding awards, while protection of water quality have not. They also indicate that transaction costs have limited the environmental performance of Maryland conservation cost sharing programs: Farmers awarded cost sharing use fewer practices and achieve no greater (and possibly less) coverage than farmers not awarded cost sharing.

These results raise serious questions as to whether conservation programs aimed at working farmland are likely to improve environmental quality. Maryland is a good test case because cost sharing has been used extensively to help improve water quality in the Chesapeake Bay and because its crop mix and topography are similar to much of the rest of the nation. Nevertheless, it is a small state and our data come from a limited time period. If the results obtained here are confirmed by further research on different geographical areas and time periods, however, serious rethinking of the structure and administration of agricultural conservation programs will probably be in order.

Footnotes

[1] In a similar vein, Nickerson and Lynch (2001) found that enrolment in a farmland preservation program did not affect the value of farmland in Maryland, a state in which rapid growth of urban populations has created substantial returns to farmland conversion. This result is consistent with self selection, since it suggests that those enrolling in these programs do not expect the sale of their development rights to influence the planned operation of their farmland.

[2] Bastos and Lichtenberg (2001) used data on the characteristics of conservation project proposals derived from case tracking files to study implicit determinants of federal cost sharing funding decisions in Maryland during the period 1994-1996. They found that federal cost share funding appeared to have been awarded preferentially to projects that enhanced agricultural productivity and farm profitability, but that cost share awards were not inconsistent with stated environmental quality priorities. Their data contain information on conservation project proposals but not on characteristics of the farmers proposing those projects or their farm operations, so that they were unable to test hypotheses about the role of political influence or other farm- or operator-specific characteristics on cost share funding allocations. Moreover, they do not model the effects of cost sharing on the adoption of individual conservation practices or on overall conservation effort and thus do not address the extent to which existing cost sharing programs suffer from adverse selection problems.

[3] Studies of the CRP suggest that program administration can compromise the environmental performance of these programs substantially. Simulations by Reichelderfer and Boggess (1988), Ribaudo (1989), Babcock et al. (1997), and Feather

and Hellerstein (1997) examined CRP signups during the late 1980s, which still account for the bulk of acreage enrolled in the program. They found that CRP signups in those years were skewed toward the High Plains, where farmers were especially politically influential, where the farm sector was especially hard hit by the financial crisis of the time (suggesting that a substantial share of land enrolled might have been idled anyway), and where environmental benefits of land diversion were generally low. Simulations conducted by Babcock et al. (1997) and by Feather, Hellerstein, and Hansen (1999) indicate that these distortions were reduced, but not eliminated by a subsequent change in the criterion for selecting land for CRP enrollment from reductions in erosion to an environmental benefits index that measured broader changes in environmental quality.

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Table 1.

Conservation Practice	Proportion of Maryland Farmers		
	Using the Practice and Receiving Cost Sharing	Using the Practice Without Receiving Cost Sharing	Not Using the Practice
Critical area seeding	0.013	0.270	0.717
Filter strips	0.032	0.300	0.668
Riparian buffer(s)	0.009	0.190	0.801
Contour farming	0.014	0.200	0.786
Strip cropping	0.005	0.270	0.725
Cover crop	0.053	0.330	0.617
Minimum till or no till	0.027	0.450	0.523
Grade stabilization	0.002	0.150	0.848
Grass/rock-lined waterway	0.076	0.220	0.704
Terraces	0.002	0.050	0.948
Diversions	0.019	0.090	0.891
Sediment troughs	0.003	0.060	0.937
Manure storage structure/lagoon	0.053	0.100	0.847
Permanent vegetative cover	0.008	0.310	0.682
Wildlife habitat	0.025	0.280	0.695
Stream protection	0.018	0.190	0.792
Pre-plant soil testing	0.009	0.490	0.501
Pre-seeding nitrogen testing	0.002	0.170	0.828
Manure crediting	0.002	0.190	0.808
Split fertilizer application	0.001	0.380	0.619
Manure incorporation	0.001	0.270	0.729
Fertilizer incorporation	0.008	0.360	0.632
Manure composting	0.010	0.150	0.840
Dead bird composting	0.004	0.070	0.926

Table 2. Descriptive Statistics of the Variables Used in the Econometric Model

Variable Description	Mean	Standard Deviation
Cost share funding received for at least one practice in the period 1996-1998	0.11	0.29
Number of conservation practices used on the farm	5.92	4.04
Ratio of total acreage served by conservation practices to total acreage operated	1.67	1.82
Age of the farmer	60.06	11.49
Years of experience as farm operator	28.42	13.32
Age of the farmer in the most recent year cost share funding was received	59.95	11.51
Years of experience as a farm operator in the most recent year cost share funding was received	28.31	13.32
Farmer has college education or higher or has attended to technical school	0.36	0.45
Percentage of highly sloped land in the total acreage operated (slope > 8%)	7.52	15.57
Percentage of moderately sloped land in the total acreage operated (slope 2-8%)	30.56	32.11
Share of total operated land that was rented in	0.17	0.28
Total acreage operated	181.66	260.40
Farmer did not report annual sales (yes = 1)	0.16	0.34
Hobby Farmer (Annual Sales Less Than $20,000)	0.53	0.47
Part-Time Farmer (Annual Sales between $20,000 and $100,000)	0.17	0.36
Large Commercial Operator (Annual Sales Between $250,000 and $500,000)	0.09	0.27
Very Large Commercial Operator (Annual Sales $500,000 or More)	0.03	0.16
Hobby Farmer (Annual Sales Less Than $20,000)	0.02	0.12
Crop operation: at least 1 acre of any kind of crops (yes = 1)	0.67	0.44
Poultry operation: flock size greater than 25 chickens (yes = 1)	0.12	0.30
Dairy operation: dairy herd greater than 10 milk cows (yes = 1)	0.12	0.31
Other cattle operation: at least 1 non-dairy cow (yes = 1)	0.55	0.47
Farm has a stream on it or immediately adjacent to it (yes = 1)	0.43	0.46
Farm has a pond and/or a lake on it or immediately adjacent to it (yes = 1)	0.40	0.46
Farm is adjacent to the Chesapeake Bay (yes = 1)	0.04	0.19
Farm has a wetland on it or immediately adjacent to it (yes = 1)	0.04	0.19
If farm has no water bodies on it or immediately adjacent to it, distance to the nearest water body (miles)	0.78	2.93
The farm is in Western or Central Maryland[a]	0.61	0.46
The farm is in the Upper Eastern Shore[b]	0.10	0.29

The farm is in Southern Maryland[c]	0.17	0.35
The farm is in the Lower Eastern Shore[d]	0.13	0.31

[a] Includes Baltimore ,Carroll, Frederick, Harford, Howard, Montgomery, Washington, Allegany, and Garreyt Counties.
[b] Includes Caroline, Cecil, Kent, Queen Anne's, and Talbot Counties.
[c] Includes Anne Arundel, Calvert, Charles, Prince Georges, and St. Mary's Counties.
[d] Includes Dorchester, Somerset, Wicomico, and Worcester Counties.

Table 3. Estimated Parameters of the Cost Share Award and Conservation Effort Models

IndependentVariable	Dependent Variable		
	Cost Sharing Awarded	Number of Practices	Coverage
Constant	-0.788844967 (-0.791385181)	5.622794105** (3.477278058)	2.418600362** (3.200394747)
Cost Sharing Awarded 1996-1998 (Yes = 1)		-3.707928353** (-2.939001755)	-0.9233005 (-1.498193456)
Age in Year Cost Sharing Last Received	-0.022772457 (-1.323521521)		
Years Managing a Farm as of Year Cost Sharing Last Received	0.021213372 (1.576798407)		
Age in 1998		-0.087672698** (-3.482497298)	-0.021262052 (-1.757290111)
Years Managing a Farm as of 1998		0.059904919** (2.722206792)	0.024088746* (2.31740232)
College or Postgraduate Education	0.5193775* (2.078406948)	0.793536751 (1.537359165)	0.126263691 (0.518819755)
Percentage of Highly Sloped Land in Operation	0.018082217** (2.953480637)	0.016645856 (1.156748582)	-0.000769292 (-0.111457871)
Percentage of Moderately Sloped Land in Operation	-0.002546961 (-0.598540851)	0.017761989* (2.542520218)	0.012789425** (3.91940291)
Share of Operated Land Rented	-0.626791486 (-1.472170694)	-0.302132193 (-0.335726336)	0.27960069 (0.664268393)
Total Land Operated	0.000660215* (2.130076999)	0.002961993* (3.189176332)	0.000150468 (0.341471858)
Annual Sales Not Reported	0.236580812 (0.563337265)	0.965782951 (1.299679153)	0.029204581 (0.2955989)
Hobby Farmer (Annual Sales Less Than $20,000)	-0.505570592 (-1.16929698)	-0.429906606 (-0.526011608)	-0.951263273** (-3.166516134)
Part-Time Farmer (Annual Sales between $20,000 and $100,000)	-0.425906464 (-0.948343594)	1.187642442 (1.371881695)	-0.138883779 (-0.397203726)
Large Commercial Operator (Annual Sales Between $250,000 and $500,000)	0.775797577 (1.410348595)	1.956584471 (1.359952332)	1.092555669 (1.661595347)
Very Large Commercial Operator (Annual Sales $500,000 or More)	1.557423819* (2.241009205)	2.402883827 (1.206333774)	0.372089628 (0.406960519)
Crops Grown (Yes = 1)	0.801615687* (2.288319421)	2.780423192** (4.865120986)	0.931701151** (3.520374046)
Poultry Raised (Yes = 1)	-0.30578996 (-0.772449913)	0.86738765 (1.062753873)	-0.543830337 (-1.409070185)
Dairy Operation (Yes = 1)	-0.532124455 (-1.384202485)	2.297141889** (2.795174519)	0.549969321 (1.462756426)

Other Cattle (Yes = 1)	-0.23221687 (-0.791707748)	0.60636509 (1.617257874)	0.031143288 (0.573823957)
Stream on Farm	-0.745929658** (-2.779782948)	-0.472967552 (-0.940754657)	-1.062401396** (-4.411299182)
Pond or Lake on Farm	0.371583701 (1.401667534)	0.449580106 (0.9040553)	-0.618716352** (-2.63194423)
Farm Borders Chesapeake Bay	0.415623492 (0.822679342)	0.439938951 (0.359194343)	-1.27349048* (-2.159580483)
Wetland on Farm	-2.157786367** (-2.116369965)	0.575327108 (0.468497252)	-0.192851453 (-0.333308891)
Distance to Nearest Water Body (If None on Farm)	-0.109325148 (-1.002366088)	-0.368440819** (-3.639342406)	-0.175458622** (-3.458297728)
Southern Maryland	-1.904424207** (-3.290600071)		
Upper Eastern Shore	0.272377372 (0.743220086)		
Lower Eastern Shore	-0.271684852 (-0.478703645)		
σ_2			4.002813352** (19.45496233)
σ_3			1.882368363** (21.94988853)
ρ_{12}			0.733091287** (5.626599973)
ρ_{13}			0.412203286** (2.605895991)
ρ_{23}			0.654213683** (17.90715831)
** Significantly different from zero at a 1% level. * Significantly different from zero at a 5% level. Asymptotic t-ratios shown in parentheses.			

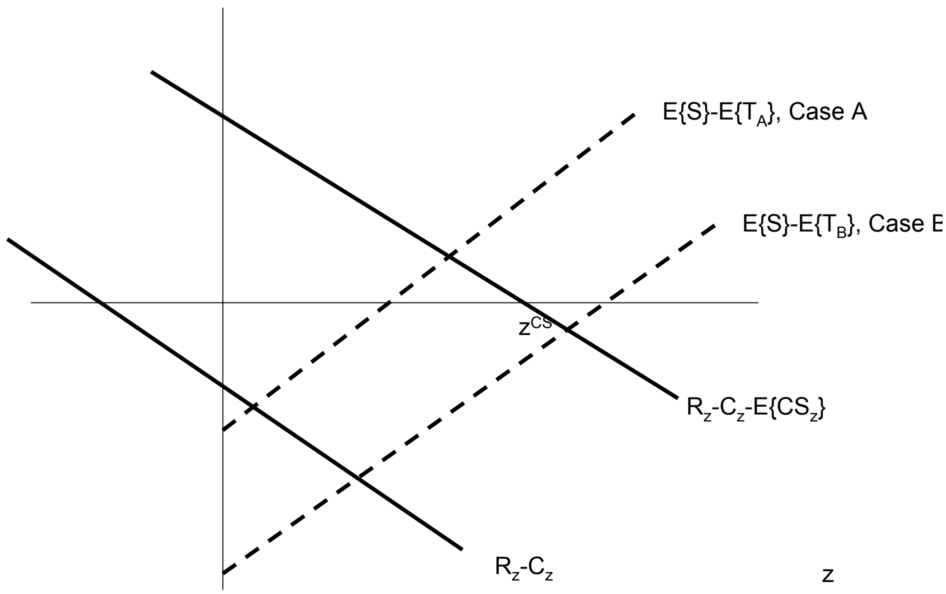

Figure 1. Situations in Which Cost Sharing Makes Conservation Profitable

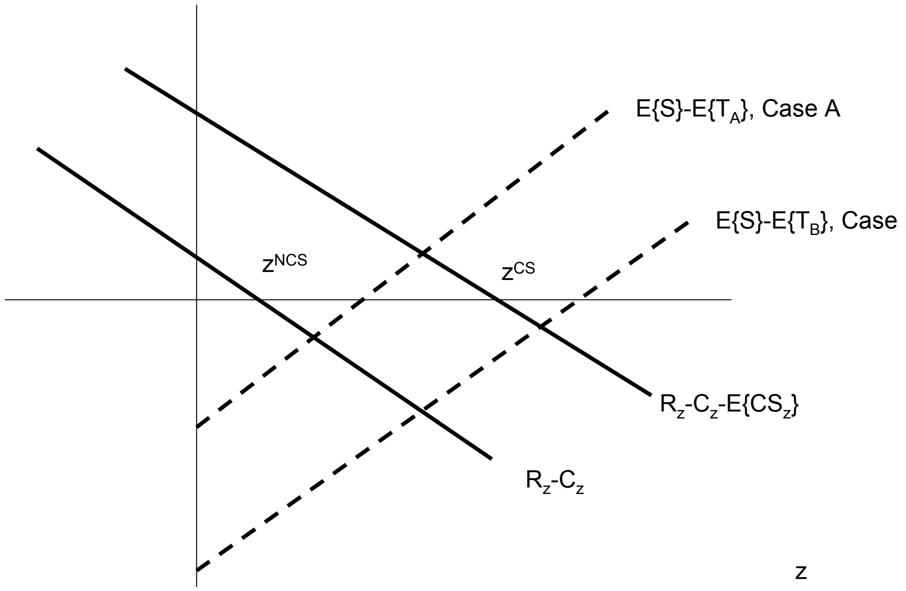

Figure 2. Situations in Which Conservation is Profitable but Cost Sharing Increases Conservation Effort

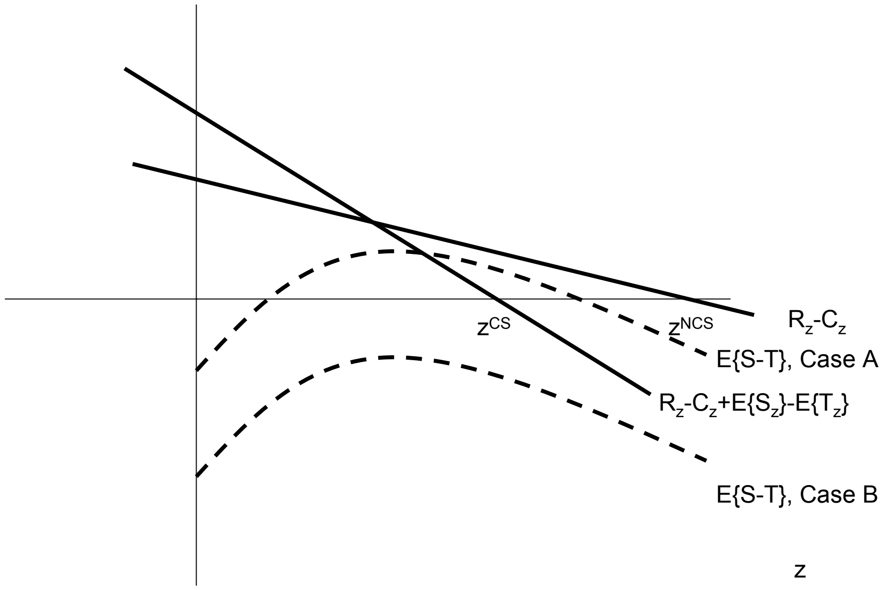

Figure 3. Situations in Which Cost Sharing Decreases Conservation Project Size