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Estimates of Public Sector Transaction Costs in NRCS Programs

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ABSTRACT

When evaluating the economic efficiency of policies to reduce nonpoint source pollution, administrative or transaction costs are usually not taken into account. While the importance of transaction costs has been recognized in the theoretical literature, the fact that they are not incorporated in empirical analyses means that, in effect, these costs are given a zero value. This issue is examined quantitatively using data collected by the National Resource Conservation Service (NRCS). Transaction costs are found to be a significant portion (38 percent) of overall conservation costs. This provides strong support for including these costs in economic evaluations of alternative policy instruments.

Key Words: *NRCS, transaction costs, nonpoint pollution, conservation practices, abatement costs, environmental policy.*

In a seminal article, Coase (1960) argued that evaluation of alternative options for addressing externality problems should incorporate both pollution-abatement costs and transaction costs. Transaction costs are defined by Gordon (1994) as the expenses of organizing and participating in a market or implementing a government policy. The literature suggests that the magnitude of transaction costs depends on a variety of factors; however, actual magnitudes of transaction costs are rarely measured for either market transactions or government policy implementation. This is important because if polluters implicitly or explicitly have the right to pollute, including transaction costs in economic policy evaluation will have the effect of reducing the amount of pollution abatement that is optimal from the point of view of society and may also affect the choice of policy (Coase 1960, McCann and Easter 1999). It may also lead to the design of more efficient policies and institutional arrangements. This research examines the magnitudes and determinants of transaction costs associated with a government conservation program.

The National Resource Conservation Service (NRCS), part of USDA, which began as the Soil Conservation Service (SCS) with the passage of the Soil Conservation Act in 1935, is one of the key federal agencies dealing with nonpoint pollution. Over the years the emphasis has been on maintaining and enhancing agricultural productivity. On-site rather than off-site benefits of erosion control have tended to be the major concern. In the 1990s, SCS was

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Table 1. Natural Resource Conservation Service Data Set Description

Region	East, Midwest, Northern Plains, South Central, Southeast, West
NRCS Planning Cost/Acre	Average annual agency cost to plan conservation system on an acre
NRCS Application Cost/Acre	Average annual agency cost to implement conservation system on an acre
NRCS Support Cost/Acre	Average annual agency cost to "support" conservation system on an acre (maps, office equipment, rent etc.)
Total NRCS Cost/Acre	Sum of planning, application, and support costs
NON NRCS Cost/Acre	Average annual other agency (e.g., conservation districts) cost to plan & implement a conservation system on an acre
Financial Assistance Cost/Acre	Average annual cost-sharing assistance per acre
Private Cost/Acre	Average annual producer cost of installing and maintaining a conservation system on an acre
Total Cost/Acre	Sum of NRCS costs, other agency costs, financial assistance and private costs
All practices	Lists the NRCS National Handbook Practice Codes found on the survey point
System	A narrative description of the conservation system

Source: NRCS, 1996b.

renamed NRCS to reflect its broadened mission to preserve resources such as water and wildlife as well as soil (NRCS 1996a) and the shift in primary focus from on-site to off-site effects. NRCS field staff are posted in 2500 locations around the country, primarily in counties, and represent 72 percent of NRCS employees. Field staff help individual landowners and organizations by providing technical and financial assistance and they also manage land reserve programs such as the Conservation Reserve Program (CRP). Among science and technology occupations in NRCS, 43 percent are engineers, 27 percent are soil scientists, and only 4 percent are agronomists (NRCS 1996a).

NRCS conducted a nationwide study of conservation system costs in 1995. These costs pertain to technical assistance and cost sharing. The purpose of their survey was to enable NRCS district conservationists to indicate to clients the costs of achieving a resource goal (NRCS 1996b). Public costs were included for those points where NRCS or another agency had been involved. The data set was designed to focus on public versus private costs of conservation activities. This NRCS cost data, as described in Table 1, is used to estimate the magnitude and determinants of transaction costs associated with the existing conservation systems. For the purposes of this research, therefore, the important distinction is between abatement costs (private landowner costs plus public cost-sharing amounts) and transaction costs (support, planning, and application costs). Both private landowners and the public, represented by government programs, incur abatement and transaction costs.

Transaction Costs

A large literature on transaction costs exists. Many studies, following the work of Coase (1937) and Williamson (1985), seek to explain forms of firm organization in terms of transaction-cost minimization. The cost of a transaction is related to attributes such as frequency, uncertainty, and asset specificity (Williamson 1985). Beginning with Coase (1960), transaction costs have also been examined with respect to environmental policy. The literature suggests that the magnitude of transaction costs involved with eliminating externalities is affected by the number and diversity of agents, technology, policy under consideration, level of uncertainty, asset specificity, institutional environment, and amount of abatement (and thus abatement costs) or the size of the transaction (Oates 1986, North 1990, Coase 1960, Stavins 1995, Williamson 1985). In this paper transaction costs levels are hypothesized to depend on abatement costs, region (due to travel distances or homogeneity of practices), and type of conservation system, which is related to both technology and asset specificity (low salvage value for some assets used to implement conservation practices). Other determinants of transaction costs that have been suggested in the literature, such as uncertainty and different institutional arrangements, are not represented in the NRCS data set.

In order to measure transaction costs a typology is needed. Griffin and Bromley (1982) discussed some of the transaction costs involved with nonpoint water pollution. "Policy transaction costs include the costs of initial information for a specific instance of market failure and of deciding whether or not to invoke a nonmarket allocation mechanism, the costs of policy design, the structural costs of the administering agency, variable enforcement costs (for monitoring, assessment, and litigation), and the costs of periodic policy reevaluation" (p. 550). For the current research, the framework suggested by Thompson (1999) has been used. Transaction or administrative costs of environmental policies can be categorized as 1) Research and information, 2) Enactment, 3) Design and implementation, 4) Support and administration, 5) Prosecution and 6) Monitoring (Thompson 1999). Since the technical-assistance and cost-sharing programs are not new, this data set does not include program enactment costs, although the costs of modifying existing programs would be embedded in support costs. In addition, since the NRCS program is essentially voluntary, prosecution and monitoring costs are not relevant. However, NRCS does incur monitoring costs for other government programs such as conservation compliance and these costs would also be embedded in support costs. As indicated, in this study transaction costs are calculated as the sum of the planning, application, and support costs in the NRCS data set. Planning would include some information costs as well as design and implementation costs. Application costs would represent implementation costs. Support costs would be similar to those in Thompson's classification scheme. In this analysis transaction costs also include the technical support provided by other agencies. No data was available on transaction costs borne by farmers. Abatement costs are calculated as the private-farmer cost plus the government cost-sharing amount.

NRCS Data Set

The data was collected in a nationwide survey, and consisted of 6007 National Resource Inventory points. At each survey point the conservation practices that had been installed were ascertained and the point was then categorized by NRCS into one of 60 conservation systems. For example, manure crediting and banding of starter fertilizer would make up a nutrient-management system. When there were practices that belonged to different conservation systems, the dominant practice as determined by NRCS was used for classification purposes. Combining practices into systems was a way to make the data more manageable since there are over 180 practices listed in the *NRCS National Handbook of Conservation Practices* and a particular point could involve several practices. The systems approach also recognizes that one practice in isolation will be less effective than if it is combined with other practices into a conservation system (NRCS 1996b). Data on producer characteristics such as age and educational level were not available.

The NRCS data set (Table 1) is divided into six regions: east, southeast, midwest, south central, northern plains, and west. Average per-acre-cost components were determined by NRCS for the private land user as well as for public agencies. These public costs include planning of the system, application (implementation) of the system, support or overhead[1] costs, and cost-sharing by NRCS and other agencies. Abatement costs (defined in this study as private costs plus the cost shar-

[1] Allocating overhead costs to activities is necessarily arbitrary (Stigler 1987).

ing amount borne by the public) were based on the useful life of the system and included operating and maintenance costs as well as installation costs. The private-cost calculation also took account of increased yields that may have resulted from the practice, so in some cases there are actually negative private costs associated with a conservation system.[2] Private costs thus represent a net cost with some on-site benefits included in the calculation; consequently, abatement costs are net costs to some extent.

Public costs of conservation consist of financial assistance or cost-sharing assistance (e.g., to purchase trees for a windbreak) as well as technical assistance (e.g., the design of the windbreak). Financial assistance may be provided for installation of the practice as well as operation and maintenance of the practice. In the data set, technical assistance is divided into support cost and direct field costs. Support cost is calculated as the share of NRCS overhead which is prorated down to the sampled field. It includes a field office component that depends on the planning and application costs as well as an "above field office" component that varies by state and which includes state and federal overhead costs. Direct field costs were determined from a field office questionnaire and represent the time NRCS personnel spent planning and applying practices on a sampled field (NRCS 1996b). The salary rate for a district conservationist was used for the planning component since they would evaluate the problem and design the appropriate system or set of practices to address it. The salary rate for the technician was used to calculate the cost of the application component. As an example, once a terrace was designed, the technician would oversee its installation by a contractor. The technical assistance costs for other agencies were not broken down into categories. Further information on the calculation of these costs is available through NRCS (1996b).

For the purposes of this research an ideal data set would include marginal abatement costs and marginal benefits of abatement as well as marginal transaction costs associated with various levels of abatement. This would allow identification of the optimal abatement level, taking transaction costs into account. This data set does not relate the practices to abatement levels or benefits of abatement. In addition, not all of these practices are tied solely to natural resource conservation since some of them, such as drainage, are primarily to increase productivity. This relates to an original objective of SCS, to increase productivity as well as conserve resources. There is also the question of whether these practices and their associated costs represent the least-cost method of resource conservation. Several sources have indicated that there has been a bias in NRCS toward structural rather than management solutions to problems even though the management solutions may be more cost effective. From the data, we do not know the abatement level or productivity increase that was achieved, only the costs. Therefore, instead of examining the relationship between pollution abatement levels and transaction costs, this data set is used to examine the relationship between the costs of installing and maintaining practices to achieve an (unknown) abatement or productivity objective versus the transaction costs involved with achieving the same objective.

Transaction Cost Estimates

The analysis is based on the subset of data (1446 records) where a conservation practice had been installed with public sector involvement.[3] NRCS support costs represent the larg-

[2] Negative private costs imply that no government intervention or less government intervention would have been appropriate. Positive private costs may indicate that not all farmer benefits from the practice were measured.

[3] There are three types of observations in the data set. In addition to the observations analyzed in this paper, there were 4116 observations on which no conservation practice had been installed and 445 observations where a conservation practice had been installed without public-sector involvement. Private cost per acre was lower for the subset of conservation practices with no public-sector involvement (mean $12.49,

Table 2. Summary Statistics of All Points with Either NRCS or Other Agency Involvement (n = 1,446)

Item	Mean	Standard Deviation	Median
NRCS Planning Cost/Acre	$2.85	$7.27	$0.70
NRCS Application Cost/Acre	1.14	3.53	0.14
NRCS Support Cost/Acre	6.93	17.94	1.64
Total NRCS Cost/Acre	10.93	27.35	2.63
Non-NRCS Cost/Acre	1.58	12.58	0
Transaction Costs/Acre (Total NRCS + Non-NRCS)	12.52	30.33	3.31
Financial Assistance/Acre	5.50	25.19	0
Private Cost/Acre	14.82	37.05	2.78
Abatement Cost/Acre (Financial Asst. + Private)	20.32	50.84	3.99
Total Conservation cost/Acre (Abatement plus Transaction)	32.84	62.87	10.73

est component of transaction costs (Table 2). The mean support cost is $6.93 per acre followed by planning costs of $2.85 per acre, non-NRCS cost of $1.58, and application costs of $1.14. Mean financial assistance costs per acre are 27 percent of the mean of total abatement costs per acre. For each variable, the mean is higher than the median indicating some data points with high costs. Mean transaction costs represent 38 percent of the mean of total conservation costs. The variation in costs may be due to the heterogeneous nature of land and climate nationwide and, therefore, the variation in the appropriate conservation practices to be used in a particular area (Barbara Fecso, personal communication).

Determinants of Transaction Costs

In addition to examining the magnitude of transaction costs associated with NRCS programs, another objective of this study was to identify determinants of transaction costs. As mentioned earlier, it was hypothesized that transaction costs would increase as the cost of the practice or system of practices increased and would vary by region and conservation practice. Tables 3–5 examine the relationship between transaction costs, abatement costs, regions and type of practice. All the costs are continuous variables. Dummy variables were created to incorporate regional effects in the model with the western region used as the base. The coefficients on the other regional dummy variables thus represent differences from the western region. The sixty systems that were used to categorize the sampled points were grouped by an NRCS official into those that were primarily structural and those that were primarily management. A dummy variable was created to incorporate these two types of systems into the models. The variable is equal to 1 if it is a structural practice and 0 otherwise. This was of interest due to the perceived structural-versus-management bias in government conservation programs.

In Table 3 the natural log of NRCS planning and application costs was used as the dependent variable since these costs vary directly with the number of practices installed while support costs can be thought of as having a fixed component. The intercept is not significant which is what would be expected if support costs represent a fixed component of costs. Abatement costs was the only significant variable in this specification. In Table 4

median $0.89) compared to the subset with public-sector involvement (mean $14.82, median $2.78). When both public and private costs are taken into account (Table 2), abatement cost per acre for the assisted acres was $20.32 so conservation practices installed with government assistance were more expensive than those installed by farmers with no assistance. This is to be expected since farmers would be more likely to search out assistance for costly practices and/or install a more costly practice when they are only paying part of the cost.

Table 3. Estimated Relationship Between Ln NRCS Planning and Application Costs and Abatement Costs, Regions, and Structural Practices (n = 1362, Adj. R^2 = 0.061)

Variable	Coefficient	Standard Error	T-statistic
Intercept	−0.172	0.160	−1.073
Abatement Costs	0.008***	0.001	7.601
Region-East	0.120	0.335	0.358
Region-Midwest	−0.191	0.176	−1.083
Region-Northern Plains	0.178	0.179	0.999
Region-South Central	0.348	0.199	1.754
Region-Southeast	0.201	0.203	0.992
Structural Practice in Place	0.119	0.100	1.188

* p < .05, ** p < .01, *** p < .001.

the natural log of transaction costs was used as the dependent variable. The R^2 was slightly higher for this model and the coefficients on the intercept and abatement cost terms are highly significant. The midwest, northern plains, and south central region transaction costs were significantly lower than for the western region. The log of transaction costs was significantly lower for structural practices than for management practices.[4]

To try to determine whether a more detailed examination of the different conservation systems would help explain the variation in transaction costs, the type of system was added to the model. The model in Table 5 includes only a subset of the conservation systems in the data set. The "common" systems included were those for which there were at least 35 data points. The category of conservation tillage consisted of a more narrow range of practices than the conservation tillage system.

Contrary to what was expected, transaction costs were not lower for these "common" systems. For the full data set the mean transaction costs were $12.52 (median $3.31), while for the set of "common" systems, the mean transaction costs were $13.67 (median $3.78) and the standard deviation was also larger. Abatement costs were also greater, $20.32 for the full set and $22.94 for the subset of "common" systems.

Including types of conservation systems in addition to abatement costs and regions dramatically improved the adjusted R^2 of the

[4] Other model specifications were examined which increased the explanatory power of the models as measured by adjusted R^2 but did not affect which variables were significant or the signs of the coefficients. Changes involved removing data points with standardized residuals greater than 2 in absolute value and using the natural log of abatement costs as an explanatory variable. With both modifications, adjusted R^2 increased to 0.183. Further information is available from the authors.

Table 4. Estimated Relationship Between Ln Transaction Costs and Abatement Costs, Regions, and Structural Practices (n = 1,446, Adj. R^2 = 0.084)

Variable	Coefficient	Standard Error	T-statistic
Intercept	1.464***	0.152	9.600
Abatement Costs	0.010***	0.001	9.864
Region-East	0.441	0.320	1.377
Region-Midwest	−0.483**	0.171	−2.835
Region-Northern Plains	−0.626***	0.175	−3.570
Region-South Central	−0.646**	0.197	−3.274
Region-Southeast	−0.120	0.199	−0.603
Structural Practice in Place	−0.385***	0.102	−3.777

* p < .05, ** p < .01, *** p < .001.

Table 5. Estimated Relationship Between Ln Transaction Costs (assisted acres) and Abatement Costs, Regions, Selected Practices n = 1032, Adj. R^2 = 0.235

Variable	Coefficient	Standard Error	T statistic
Intercept	2.530***	0.227	11.165
Abatement Costs	0.005***	0.001	4.548
Region-East	0.046	0.373	0.123
Region-Midwest	−0.864***	0.203	−4.247
Region-Northern Plains	−1.056***	0.189	−5.587
Region-South Central	−0.412*	0.209	−1.974
Region-Southeast	−0.293	0.225	−1.300
Conservation Cover (n = 68)[a]	−2.104***	0.239	−8.787
Conservation Cropping Sequence (n = 54)	−0.610*	0.260	−2.349
Conservation Tillage (n = 39)	−1.526***	0.293	−5.200
Conservation Tillage system (n = 141)	−0.251	0.194	−1.294
Crop Residue Use System (n = 161)	−0.053	0.194	−0.273
Grassed Waterway System (n = 73)	−0.376	0.241	−1.562
Irrigation Water management (n = 39)	−0.118	0.298	−0.397
Pasture and Hayland Mgmt. System (n = 69)	−1.068***	0.244	−4.376
Pasture and Hayland Planting System (n = 78)	−0.310	0.231	−1.343
Proper Grazing Use System (n = 172)	−1.850***	0.202	−9.155

* $p < .05$, ** $p < .01$, *** $p < .001$.
[a] Number of observations. N = 137 for the Terrace System which serves as the base.

model so that it now explains one fourth of the variation in the natural log of transaction costs. The intercept, abatement costs, and the midwest, northern plains, and south central regional dummy variables were still significant. Terrace installation was the conservation system that was dropped from the model to serve as the base. Conservation cover, conservation tillage, pasture and hayland management, and proper grazing use system all had significantly lower transaction costs than terraces. When more specific practices were included in the model, the abatement costs variable remained highly significant and the coefficient became smaller than in previous models. Abatement costs are a determinant of transaction costs but the low R^2 in all models indicates that other factors are involved. These may include complexity of the farming system and topography (practices for a farm with a corn/soybean rotation and homogeneous soils will be easier to design than for a mixed crop/livestock farm with varying soil types and topography), management ability of the farmer, expertise of the NRCS agent, how often that particular practice has been implemented by the NRCS agent in the past, farming practices of neighbors, and frequency of transactions.

Discussion and Conclusions

The results are consistent with our expectations even though the data set had some obvious limitations. For example, farmer time spent gathering information or talking to NRCS personnel has not been added to the transaction costs since this information was not included in the data set. Discussions with NRCS personnel indicated the amount of time that a farmer spends with the NRCS staff depends on the practice. For a practice such as a waste containment system, the percentage of time is fairly small, whereas for management practices such as contour farming it is higher; in many cases close to 100 percent of the time spent by NRCS is spent with farmers. Failure to include information costs of farmers means that the magnitude of transaction costs estimates in this study may be understated. On the other hand, since private costs are net of some on-site benefits, the percentage of transaction costs may be overstated and therefore further information is needed to clarify these issues. In addition, some planning and application costs may be thought of as abatement costs. The NRCS data set was not designed to identify determinants of transaction costs, which may explain the low explanatory power of the models.

Still, inclusion of transaction costs in the total cost of this technical-assistance and cost-sharing program greatly increases the estimated cost to society and has important ramifications for environmental policy. The optimal abatement level will be lower because the total costs of achieving a given level of abatement are much higher. There should also be a shift away from practices and areas with high transaction costs to ones with lower transaction costs, *ceteris paribus*. The magnitude of the transaction costs, 38 percent of total conservation costs, is startling. However, it is similar to estimates by Wallis and North (1986) who found that public and private sector transaction costs represented about half of the U.S. GNP.

As the models in Tables 3–5 show, abatement costs are a small but significant determinant of transaction costs. The results in Table 3 are consistent with support costs having a fixed component since the intercept is not significant when support costs are deleted from the model. While models including region and structural practice versus management practice explained some of the variation in transaction costs, including more specific data on conservation systems greatly improved the explanatory power of the model. Abatement cost within systems and within regions continued to have a small but highly significant effect.

It was expected that structural systems would have higher transaction costs than management systems.[5] This was because as assets become increasingly specific to the given conservation practice, transaction costs increase. When the 60 conservation systems were divided into structural versus management, this was not the case and in fact the opposite result was obtained; transaction costs were higher for systems based on management practices. This may be explained by the fact that structural practices require less interaction with the farmer compared to management practices which may require a significant amount of technical assistance before the practice is successfully implemented. In the dataset, only 39 percent of the observations had a primarily structural practice installed while the rest were management. This aggregated analysis does not support the claim that there is a bias towards structural rather than management solutions in NRCS. To fully examine this issue, however, it would be necessary to have information on the benefits obtained as well as the costs.

In the case where specific systems were compared, transaction costs were higher for terraces, a structural practice, as was originally expected. Management practices such as conservation tillage and pasture management had relatively lower transaction costs. It may be that grouping practices into two large categories obscured important information. However, similar to the aggregate analysis, transaction costs do not explain the frequency of the different practices. The most common practice, proper grazing use system, had lower transaction costs than terraces, but terraces were more common than several practices, including conservation tillage, which had significantly lower transaction costs. Frequency of the practices may be related to the on-site and off-site benefits, which are not included in this data set, as well as the abatement costs and transaction costs. What is clear, however, is that transaction costs do vary according to the type of practice being applied and therefore further research in this area is justified.

It should be noted that the practices put in place may have other objectives than reducing environmental degradation. Another issue that cannot be addressed with this data set is whether the per-acre cost of these practices is justified by the benefits obtained. Future research that includes only practices with a clear resource conservation objective and that mea-

[5] For the subset of 11 practices in Table 5, 92 percent of the structural practices had public sector involvement and 72 percent of the management practices had public sector involvement.

sures the expected pollution abatement from those practices would allow more precise answers to questions posed as to the magnitude and determinants of transaction costs in the case of agricultural nonpoint source pollution.

This analysis shows that transaction costs represent a significant component of overall conservation costs for NRCS. In contrast to the implicit assumption of most empirical analyses, transaction costs are not negligible and should be taken into account in policy evaluation. Transaction costs increase with the level of abatement costs and vary according to region and conservation practice. Further research is needed to design conservation practices and agri-environmental policies that economize on the sum of transaction costs and abatement costs.

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