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IN SEARCH OF THE BEST SOLUTION FOR NON-POINT POLLUTION: EFFLUENT TAXES OR COST-SHARE SUBSIDIES?

by

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Abstract

An empirical analysis compared the theoretically more efficient effluent tax with commonly used subsidies and with regulatory policies for reducing agricultural sedimentation in an Iowa river basin. The criteria used in comparing the policies were social cost, equity, administrative cost, political acceptability and cost to farmers.

In Search of the Best Solution for Non-Point Pollution: Effluent Taxes or Cost-Share Subsidies?

Soil erosion poses the dual problems of reduced productivity of the soil resource and degraded water quality through increased concentration of agricultural residuals, including sediment, in surface waters.

For reducing the discharge of point source pollutants, many economists have advocated an effluent tax over uniform standards for emissions, uniform treatment of discharges, and regulatory bans on the basis of lower social cost (Pigou, Baumol 1972, Kneese and Bower, Baumol and Oates). Will a tax allow the control of non-point source pollutants also with the lowest social cost?

Public policy to date has stressed cost-share subsidies to encourage practices for reducing soil loss and sedimentation. Perhaps this reliance on subsidies was encouraged by the ease of administration and by farmer acceptance of this approach. The regulatory approach has been avoided for the most part, probably because regulations are politically unpopular due to their coercive nature. In this paper the implications of policy choice with regard to social cost, farmer cost, size of transfer payment, administrative feasibility and political acceptability are explored for an Iowa river basin.

Effluent Tax

The tax remedy to pollution requires an effluent charge which is set at the level where marginal social benefit from pollution abatement is equal to marginal social cost of abatement. In practical application, these social values are not known precisely. As an expedient, a standard for environmental quality is selected and an appropriate effluent tax can then be found which will achieve the desired standard (Baumol and Oates). Polluters react to the effluent charge by curtailing their activity as long as marginal cost of pollution abatement is less than the tax. Polluters who are more efficient at cleaning up will reduce their pollution more than those whose marginal cost of clean-up is higher. In this manner an effluent tax achieves the desired standard for environmental quality at the lowest social cost.

Until lately, few economists have challenged this reason for advocating an effluent tax. A recent article by Taylor and Frohberg compared a soil loss tax, a uniform standard or per acre restriction on soil loss and a ban on straight row cultivation. The soil loss tax resulted in lower social costs for achieving a given level of soil loss control. The authors continued, however, by showing that the cost to farmers is greater with the tax than with the other policies because the tax payment, which is an irrelevant transfer in the accounting of social costs, is an explicit cost burden for farmers.

Another recent article by Jacobs and Casler compared an effluent tax with a mandate for uniform reduction in phosphorous discharge in an agricultural watershed. For reductions in phosphorous discharge up to 60%, the marginal social cost was lower for the effluent tax than for the uniform reduction policy. However, including the tax payment, the total cost to farmers of the tax policy was between 2.7 and 13.3 times the cost of the uniform reduction policy depending on the level of discharge abatement. Jacobs and Casler proposed an alternative effluent tax policy which retains the advantage of lower social cost and yet is not financially burdensome to farmers.

This paper extends the earlier analyses to compare a soil loss tax with a uniform standard[1] for soil loss control, a regulatory ban on erosive practices, and cost-share subsidies in an Iowa river basin. Since the study area for this analysis is smaller than that in Taylor and Frohberg, a more detailed modeling of production costs and physical soil loss coefficients is practical. The Iowa study area is also four times more erosive as measured by baseline soil loss, presenting a greater challenge for erosion control policy. Policy simulation with a linear programming model of the Iowa river basin confirms the lower social cost with the soil loss tax for reducing sedimentation. Nevertheless, in dealing with non-point source pollution, practical concerns other than efficiency are raised which might restrict the implementation of either the traditional effluent tax or the modified effluent tax proposed by Jacobs and Casler. Finally, the customary reliance by some public agencies on fixed percent cost-share subsidies is examined and found lacking.

Description of Study Area and Model

The study area for this analysis was the Nishnabotna River Basin which contains 1.8 million acres from parts of 12 counties in Southwest Iowa. The river basin which contains five percent of Iowa's land area, annually produces between 4% and 6% of the corn, soybeans, oats and hay grown in the state.

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[1]The uniform standard analyzed here is a uniform limit on soil loss to no more than 5 tons per acre and differs from the uniform reduction policy in the Jacobs and Casler article which required that all operators reduce their discharge by a uniform percentage.

A profit maximizing linear programming model of the river basin was based on an average-sized 320 acre representative farm reflecting physical conditions and production costs existing in the study area. Simulation results indicated the effect of alternative policies on social cost, net farm income, cropping patterns, average annual per acre soil losses, and agriculture contribution to stream sediment loads.

Social Cost and Other Costs

Social cost is the cost to society of sediment reduction from the baseline level under each of the alternative policies. The basis for measuring social cost is the change in baseline crop production and prevailing practices as a result of soil loss/sediment control policy. The social cost of a terrace subsidy, for example, includes the cost to society of crop production foregone plus the annualized cost of additional inputs required for terrace construction. For this study social cost was estimated by the value of producer surplus lost from foregone agricultural production and from increased operating costs.

Some results of policy simulation with the model are shown in Table 1 where five policies capable of achieving approximately a 90% reduction in soil loss are displayed. Since agricultural soil loss contributes about three-fourths of total stream sedimentation [USDA, 1968], controlling erosion from croplands would greatly reduce stream sediment concentrations. A dual ban against fall plowing and straight-row plowing on slopes over 2% reduced average soil loss in the basin to 2.1 tons per acre and reduced the agricultural contribution to stream sedimentation from 9650 mg/liter to 900 mg/liter based on a delivery ratio of .25. The dual ban entailed a social cost of $10,240,000. A uniform standard limiting soil loss to

5 tons per acre on all land reduced average soil loss to 2.5 tons per acre and sediment to 1010 mg/liter with a social cost of $13,669,000. A terrace subsidy of $16.60 per acre compares closely with the soil loss limit in terms of sediment reduction but involves slightly higher social cost, $13,847,000. A terrace subsidy of $25.90 per acre reduced average discharge level to 2.2 tons per acre, which is comparable to the dual ban. This subsidy entailed nearly twice the social cost compared with the dual ban, $20,126,000.

Table 1: Cost-Effectiveness of Alternative Abatement Policies in an Iowa River Basin

	Avg. Soil Loss (T/A)	Sedimentation (mg/L)	Net Farm Income	Farmer Cost	Social Cost	Subsidy/Tax Transfer
			- - - - - -	thousands	of dollars	- - - - - -
Base run	20.3	9,650	143,631	----	----	----
Tax of $1.00	2.1	900	130,662	12,969	9,549	-3,420
Dual ban	2.1	900	133,391	10,240	10,240	----
Soil loss limit	2.5	1,010	129,962	13,669	13,669	----
Terrace subsidy $16.60	2.6	1,050	144,822	----	13,847	15,038
Terrace subsidy $25.90	2.2	840	153,378	----	20,126	29,873

The soil loss tax which reduced average soil loss to 2.1 tons per acre, incurred the lowest social cost, $9,549,000, of all policies considered thus far. The subsidy policies above entailed higher social cost than the tax, soil loss limit, and dual ban because the subsidies encourage a particular practice which may not be the most cost efficient on all land classes. These findings of lowest social cost with a tax for reducing sediment discharge, agree with the results for point sources.

For practical policy implementation, however, other policy ramifications besides economic efficiency are relevant. Even though social cost was lowest with the effluent tax, the cost to farmers was considerably higher, $12,969,000, because of the tax payment of $3,420,000. The cost to farmers with the tax was higher than with the dual ban and almost as high as with the uniform standard for limiting soil loss to 5 tons per acre. While the soil loss tax results in the same level of soil loss and sediment control as the dual ban, the equity of the additional $2,729,000 in costs borne by farmers with the former policy is not self-evident. In addition, the increased cost to farmers from the tax may make that policy less politically acceptable.

Farmers generally prefer subsidies to taxes; but are the common cost-share subsidies the best approach for controlling sediment? The redistribution of income from the subsidies considered here is even greater than from the soil loss tax. Compared with the tax transfers, the subsidy transfer payments are over four times as great with the lower subsidy and nearly nine times as great with the larger subsidy (Table 1).

On the premise that multiple subsidies would allow greater flexibility in selecting efficient practices and would result in lower social cost, a policy combining several subsidies was sought which might provide the same sediment reduction and social cost as the cost-effective tax policy. The closest alternative incorporated subsidy payments of $15.40 per acre for terracing, $3.80 per acre for minimum tillage (mintill), and $.40 per acre for contouring (Table 2).

This combined subsidy policy resulted in nearly the same soil loss, 2.0 tons per acre, as the soil loss tax. The social cost, $10,250,000, while greatly reduced compared to both singular terrace policies, was slightly higher than with the soil loss tax. The transfer payment with the multiple subsidy was considerably higher, however, at $12,454,000.

Table 2: Multiple Subsidy Policy Compared With Soil Loss Tax

	Avg. Soil Loss (T/A)	Sedimentation (mg/L)	Net Farm Income	Farmer Cost	Social Cost	Subsidy/Tax Transfer
			- - - - - - thousands of dollars - - - - - -			
Tax of $1.00	2.1	900	130,662	12,969	9,549	-3,420
Multiple Subsidy[a]	2.0	880	145,835	----	10,250	12,454

[a]Terrace subsidy $15.40, mintill subsidy $3.80, contour subsidy $.40.

Determining appropriate subsidy rates is a complex task requiring considerable information on production costs and returns with the various cultural practices and structures as well as knowledge of the interactions between subsidy rates. In some cases there may be only a narrow range of subsidy values for which the desired outcome is stable with the multiple subsidy policy. The range of values for each subsidy which would achieve a 90% reduction in sediment, assuming the other two subsidies are assigned the indicated rates, is shown in Table 3. Increasing the terrace subsidy or reducing the mintill subsidy slightly would cause a different choice of practices resulting in significant changes in social cost and transfer cost.

Table 3: Range of Subsidy Values for 90% Sediment Reduction with Multiple Subsidy

Subsidy	Subsidy Rate	Range
Terrace	$15.40	$15.31 to $15.45
Mintill	3.80	3.75 to 22.18
Contour	.40	.35 to infinity

Simulating with a mintill subsidy of $3.70, along with unchanged values for the other subsidies, encouraged greater reliance on terraces and less use of mintill resulting in a soil loss of 1.8 tons per acre (Table 4).

Table 4: Multiple Subsidy with Mintill Rate Reduced to $3.70.

Avg. Soil Loss (T/A)	Sedimentation (mg/L)	Net Farm Income	Social Cost	Subsidy Transfer
		---Thousands of Dollars----		
1.8	760	145,720	15,269	17,358

Compared with the original multiple subsidy (Table 2), both the social cost and transfer cost increased, because more land was terraced. To avoid these unnecessary costs, policy-makers must set subsidy levels accurately.

This task is complicated by interactions between the individual subsidy policies. Increasing the mintill subsidy to $7.00 in the multiple subsidy package, changed the range of values for the terrace subsidy and contour subsidy as shown by Table 5. The low range for the contour subsidy

Table 5: Range of Subsidy Values for 90% Sediment Reduction with $7.00 Mintill Subsidy.

Subsidy	Subsidy Rate	Range
Terrace	$15.40	$15.31 to $18.65
Contour	.40	.34 to infinity

fell slightly to $.34 and the upper range for the terrace subsidy increased to $18.65. Because of interactions such as this, the sensitivity of the outcome to subsidy rates, and the need to combine practices on some land classes, the public agency tradition of setting cost-share subsidy rates at a fixed percent of estimated cost of the practice or structure appears to be too simplistic and too costly.

Administrative Feasibility

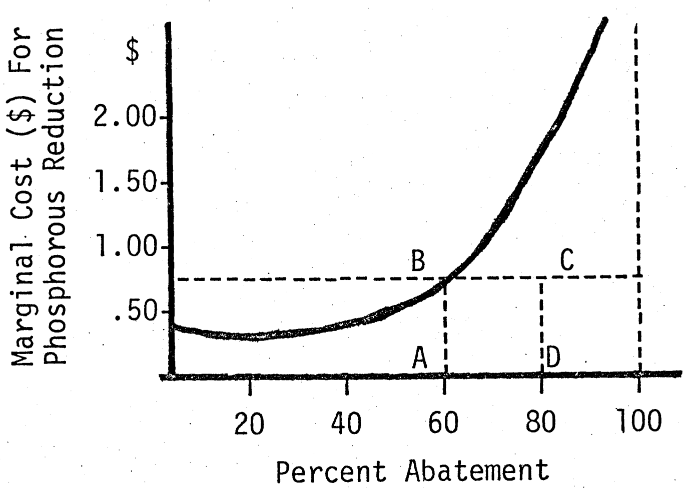
Both the uniform standard for allowable soil loss and the soil loss tax entail greater administrative costs when compared to the regulatory dual ban because of the need to monitor or at least estimate soil loss in implementing the two former policies. Administering the dual ban, on the other hand, requires only a cursory check of tillage practices to insure compliance. Similarly, administration of cost-share subsidies is simple, requiring only verification of the amount of acreage treated with the subsidized practice to determine the subsidy payment.

An administrative problem arises with the modified effluent tax proposed by Jacobs and Casler. The alternative effluent tax policy is designed to maintain the advantage of an effluent tax, efficiency or lower social cost, while avoiding a major disadvantage, a burdensome tax bill on farmers. The proposed policy would exempt from the tax an allowed level of phosphorous discharge for which the low level of phosphorous concentration in streams would not constitute a pollution problem. Discharges above the deisred amount would be subject to a tax set equal to the marginal cost of abatement at the desired discharge level. Since it is less expensive to reduce discharge than pay the tax, farmers would reduce discharge to the desired level. Those farmers who are more efficient at abatement would reduce their discharge more than farmers whose marginal cost of abatement is higher. Therefore the modified effluent tax would result in the desired level of abatement at the lowest social cost. The remaining discharge, the desired level, would not be taxed under the modified effluent tax policy so the total cost to farmers under the modified tax proposal would be equal to the social cost.

In practice, the tax proposal would be difficult if not impossible to administer. How would the allowable (untaxed) level of discharge be determined for each farmer? To achieve a desired overall level of phosphorous reduction at the lowest social cost, those farmers who are more efficient at abatement must be encouraged by the threat of tax to reduce their discharge more. However, the remaining allowable discharge level would not be a uniform percentage of original discharge levels. A unique desirable discharge level would need to be determined for each farmer according to his efficiency in abatement.

For the hypothetical farmer's cost curve depicted in Figure 1, the allowable level of phosphorous discharge would be 40% of original discharge based on a tax of 75¢ which is assumed to be the tax level consistent with the desired overall reduction in discharge.

Figure 1: Modified Effluent Tax



If, through lack of information about this farmer's cost function, allowable discharge were set at 20% of original levels, he would still reduce discharge by only 60% because abatement beyond that level is more costly than the tax. He would then be taxed the amount A B C D on his remaining discharge above the allowable level. Other farmers might pay more or less tax depending on their abatement cost curves and allowable discharge levels.

In practice, information on the shape of the marginal cost of abatement curve for each farmer is not available. Since it is therefore impossible to determine the appropriate level of allowable discharge for each farmer, any attempt to implement the modified tax policy with arbitrary or even uniform levels of allowable discharge would impose arbitrary and unequal tax burdens on farmers. If the allowable level of discharge were set too high for some farmers they would not reduce discharge to the level where the tax equals the marginal cost of abatement and the desired overall reduction in discharge would not be realized. Furthermore, the level of reduction achieved would not be accomplished with the lowest social cost.

Conservation Versus Environmental Goals

This study demonstrated that a standard for water quality in a river basin could be achieved at the lowest social cost with a soil loss tax as a result of reducing average soil loss per acre. Under a soil loss tax, farm operators could choose to curtail those activities where the soil loss per dollar of net income earned was the highest, achieving the desired reduction in sedimentation at the smallest social cost.

While controlling total soil loss and sediment load, that strategy could still result in excessive soil loss on some land classes. Farmers might choose to produce high-profit row crops on moderately sloped lands resulting in excessive soil loss from those lands, but in order to reduce total soil loss and sedimentation within limits, they might curtail row crop porduction on the highly erosive but marginally productive steeper lands. Thus, a reduced level for suspended sediment in the stream could be achieved by means of a soil loss tax but the productivity of the moderately sloped lands might still be depleted through excessive soil loss over time. If the objective were to preserve the productivity of the land by reducing soil loss on all land classes to tolerable levels, enforcement of a ban on highly erosive practices or an outright soil loss limit on each acre might be preferred to a tax.

Conclusion

The selection of a soil loss control or water quality policy option should not be based solely on the criteria of theoretical economic efficiency. Even though soil loss taxes provide lower social cost, when other policy concerns such as the equity of the incidence of abatement costs, political acceptability, the costs of administration, and conservation versus environmental goals of the policies are taken into consideration by policymakers, the alleged superiority of soil loss taxes becomes less certain.

Commonly employed cost-share subsidies do not offer a clear-cut advantage either. The fixed fractional percent of cost formula used by some public agencies in determining cost-share subsidy rates, is not likely to achieve the desired reduction in sediment discharge at the lowest social cost. Furthermore, the transfer payment with a cost-share subsidy may be higher than with a comparable tax.

While progress has been made during the 44 years subsidies have been employed, soil loss exceeded five tons per acre on 97 million acres in 1977, and sedimentation in streams still exceeds clean water objectives. Based on the study results, the regulatory approach may be able to achieve desired water quality and offer reasonable social cost, farmer cost, and administrative cost. The regulatory approach could avert the high transfer payments with subsidies and could avoid the difficult task of setting multiple subsidy rates properly. While offering lower farmer cost than a tax, the regulatory approach addresses both conservation and environmental goals of erosion/sediment control, unlike a tax. Regulations should not be implemented on a wide scale without further research, but these findings suggest that this overlooked approach may deserve further consideration. The major drawback to the regulatory approach is the question of political acceptability.

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