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MOTIVATING ADOPTION OF BEST MANAGEMENT PRACTICES: IMPLICATIONS FOR COST EFFECTIVENESS

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Abstract

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The traditional cost effectiveness framework was broadened to incorporate some key motivations underlying the adoption of erosion control practices in irrigated agriculture. Selected financial factors were found to be important determinants of adoption. Failure to incorporate such factors promotes overestimation of cost effectiveness, improper ranking of BMPs, and ultimately faulty policy prescriptions.

MOTIVATING ADOPTION OF BEST MANAGEMENT PRACTICES: IMPLICATIONS FOR COST EFFECTIVENESS

by Donald G. Killingsworth and Scott C. Matulich*

Identifying Best Management Practices (BMPs) for irrigation return flow management is but one aspect of the 208 planning process; motivating their adoption is the other. Collectively, these two aspects require accurate decisions regarding efficient use of resources, i.e., development of accurate cost effectiveness estimates for erosion control practices. To date, economists have stressed the first aspect of the problem--identifying cost effective BMPs. Less attention has been given to questions underlying adoption motivations despite the fact that these two components are not separable. Consequently, many of our recommendations have fallen on deaf ears.

Traditional applications of cost effectiveness in irrigation return flow management are constructed around single period models of a "typical" or "representative" profit maximizing farm. Such applications are conceptually appealing since they are based upon neoclassical theory and are analytically tractable given the generally available tools and data. Moreover, the findings are readily understandable by farmers and policy makers alike. However, this traditional analytical framework appears to force the problem into a convenient but somewhat artificial model structure. By confining the producer's adoption or non-adoption decision into a static (single period) concept of production efficiency, abatement prescriptions

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may seriously err. Not only might the ranking of control practices differ from the order in which they would be adopted, but the actual cost of implementing a given practice might be overestimated. Inappropriate cost share strategies could result.

Considerations such as farm size, financial structure, legal organization, tax treatment, managerial objectives and capacity, and the ability to bear risk most certainly figure as prominent factors in the ultimate choice and speed of adopting control practices. The analysis presented in this paper illustrates the importance of selected financial factors in the adoption of erosion control practices in irrigated agriculture. Specifically, four interrelated financial factors are examined: farm size, debt/equity position, cash flow and federal income taxes. The empirical analysis is couched in context of irrigation return flow management in Washington's Columbia Basin.

Analytical Framework

Irrigation return flow management can take many forms, ranging from subtle changes in cultural practices to sizeable capital commitments. Thus, abatement practices may be classified as either nonstructural or structural. A problem arises in that financial motivations affecting the adoption of structural control practices differ from those affecting nonstructural practices. In particular, federal income tax statutes favor structural control practices relative to nonstructural control practices; structural practices benefit from tax deferral and investment credit. Practices which are more capital intensive realize a larger tax benefit.

The extent to which erosion control practices reduce the tax liability is largely a consequence of the amount of associated tax deductible expense, the corresponding marginal income tax bracket, and investment credit. Farm size and debt/equity position are two factors that collectively impact tax liability. Apart from any consideration of economies of size, gross receipts and thus, taxable income are functions of size. Debt/equity position directly influences the percent of expenses that are deductible in otherwise comparable farm scenarios. The higher the equity position the greater the deduction benefits. Both farm size and debt/equity were incorporated into the analysis.

A multiperiod linear programming model was developed to capture the essence of firm-level decision making in the adoption of erosion control practices. Present value of net worth was maximized over a ten year planning horizon; horizon length was chosen to be consistent with depreciation schedules associated with structural control practices. Within each year, four general activity classifications comprised the model: crop production activities, purchasing activities, separable income tax activities and transfer activities. The crop production activities involved five crops (wheat, field corn, late potatoes, alfalfa and dry beans) grown under eight irrigation systems. Rill irrigation provided the benchmark system to which all other systems were compared (rill with sediment pond, cutback, pumpback, gated pipe, side roll, center pivot, center pivot with corner catcher).[1] Purchasing activities included payment for land, labor, irrigation system, operating loans and a fixed annual living expense. Tax activities included 1979 federal tax rates and investment credits attending structural control practices. Transfer activities provided for the carry-forward of surplus capital and unused investment credit. Rotational requirements and

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[1]Thorough discussion of alternative irrigation practices may be found in Jensen (1980).

irrigation method were fixed for each model run. The resultant solutions reflect intertemporal cash flow variations originating from differential impacts of selected financial factors on erosion control practices. See Killingworth (1980) for a more detailed discussion of the model.

Both before and after-tax income estimates were developed for two farm sizes (160 and 640 acres), each under two debt/equity positions (25 and 75 percent land equity). All before and after-tax income estimates were developed as present values of ten year income streams. Included in these estimates are residual values from structural practices that extended beyond the terminal period. A fixed family living expense was also deducted from all income estimates.

Findings

Last year at these meetings, Johnson and Baker (1980) presented a thorough, descriptive overview of the role of current tax policy in soil conservation. They concluded that "Some tax provisions offer positive economic incentives for landowners to employ soil conserving measures but at best, these incentives are only mildly effective" (p. 11). The findings of this study appear to contrast, at least in part, with those of Johnson and Baker--the importance of an after-tax cash flow analysis in estimating the cost effectiveness of erosion control cannot be over emphasized. The convential before-tax analytical framework not only systematically overestimated cost effectiveness, but lead to an inappropriate ranking of control practices (see Tables 1 and 2). Cost of sediment control was found to be up to five times greater than corresponding after-tax estimates. The largest differential was found with the high equity large farm scenario, the smallest differential was found with the low equity small farm scenario.

TABLE 1

BEFORE AND AFTER-TAX COST EFFECTIVENESS OF ALTERNATIVE IRRIGATION SYSTEMS AND CROP ROTATIONS FOR 160 ACRE FARMS BY EQUITY LEVEL

System	25% Land Equity				75% Land Equity			
	Before-Tax Cost Effectiveness	After-Tax Cost Effectiveness	Ranking Before-Tax	Ranking After-Tax	Before-Tax Cost Effectiveness	After-Tax Cost Effectiveness	Ranking Before-Tax	Ranking After-Tax
Sediment Pond	$.94	$ .57	1	1	$ .93	$ .46	1	1
Cutback	3.30	2.05	3	4	3.25	1.66	3	4
Pumpback	2.07	1.22	2	2	2.02	.98	2	2
Gated Pipe	3.65	1.99	4	3	3.58	1.60	4	3
Side-Roll	-	-	5	5	7.93	4.18	5	5
Rill Rotation 2[a]	-	42.33	-	7	-	34.02	-	7
Rill Rotation 3[b]	-	7.09	-	6	-	6.15	-	6

NOTE: Cost effectiveness is the decrease in net income divided by the tons of soil saved. Comparisons are made with the benchmark rill irrigation and crop rotation of one-third potatoes and two-thirds wheat.

[a]Rotation 2 is one-fifth potatoes, one-fifth beans, one-fifth corn, and two-fifths wheat.

[b]Rotation 3 is five-sixths alfalfa and one-sixth wheat.

TABLE 2

BEFORE AND AFTER-TAX COST EFFECTIVENESS OF ALTERNATIVE IRRIGATION SYSTEMS AND CROP ROTATIONS FOR 640 ACRE FARMS BY EQUITY LEVEL

System	25% Land Equity				75% Land Equity			
	Before-Tax Cost Effectiveness	After-Tax Cost Effectiveness	Ranking Before-Tax	Ranking After-Tax	Before-Tax Cost Effectiveness	After-Tax Cost Effectiveness	Ranking Before-Tax	Ranking After-Tax
Sediment Pond	$.93	$ .30	1	1	$.92	$.25	1	1
Gated Pipe	1.98	.42	2	2	1.97	.32	2	2
Cutback	3.27	1.08	4	5	3.23	.89	4	5
Pumpback	2.03	.62	3	3	2.01	.51	3	3
Center-Pivot with corner catcher + 10%[a]	3.75	.99	5	4	3.66	.65	5	4
Center-Pivot + 10%[a]	4.78	1.40	6	6	4.73	1.05	6	6
Side-Roll	7.45	2.66	7	7	7.18	1.82	7	7
Center-Pivot with Corner Catcher	7.92	2.95	8	8	7.58	1.95	8	8
Center-Pivot	8.30	3.12	9	9	8.06	2.16	9	9
Rill Rotation 2[b]	-	20.37	-	11	-	16.84	-	11
Rill Rotation 3[c]	-	3.59	-	10	-	2.86	-	10

NOTE: Cost effectiveness is the decrease in net income divided by the amount of soil saved. Comparisons are made with the benchmark rill irrigation and crop rotation of one-third potatoes and two-thirds wheat.

[a]Center-pivot system includes a 10 percent yield advantage for potatoes.

[b]Rotation 2 is one-fifth potatoes, one-fifth beans, one-fifth corn, and two-fifths wheat.

[c]Rotation 3 is five-sixths alfalfa and one-sixth wheat.

Several interrelated factors contributed to the before and after-tax differentials. Three such factors include the tax deductible nature of erosion control practices, the progressive income tax structure, and resultant cash flow changes. Erosion control practices shelter income from taxes, thus reducing the actual after-tax cost of control. The amount of this reduction is dependent largely upon the marginal tax bracket which the farm faces. But the progressive nature of federal income taxes contributes to a more subtle outcome. Cost effectiveness estimates are based upon income comparisons to the benchmark (rill) irrigation system. Within any farm size and debt/equity setting, the benchmark system attains a greater taxable income. After-tax income differentials are thereby compressed simply because the benchmark system incurs the greatest tax liability, it also incurs the greatest increase in debt, which in turn reduces after-tax net income most.

Changes in cost effectiveness ranking were also found for both farm sizes. Differential tax treatment between structural and nonstructural practices was the source of these changes. Additional tax savings attending only structural control practices moved gated pipe ahead of cutback for the 160 acre farm, while center-pivot with corner catchers (10 percent additional potato yield) moved ahead of cutback for the 640 acre farm. Relatively close before-tax cost effectiveness estimates appear to be necessary ingredients for a ranking change. In no situation was debt/equity position found to affect system ranking.

After-tax cost effectiveness estimates for the high equity position ranged from \$.46 to \$4.18 per ton for the 160 acre farm size (Table 1). Sediment ponds were most cost effective (\$.46) followed by pumpback (\$.98), gated pipe (\$1.60), cutback (\$1.66) and side roll (\$4.18). These figures contrast with before-tax cost effectiveness estimates: sediment ponds ($.93), pumpback ($2.02), gated pipe ($3.58), cutback ($3.25) and side-roll ($7.93). A modest increase in cost effectiveness estimates was found to correspond to the low equity situation. In contrast, the high equity 640 acre farm after-tax cost effectiveness estimates averaged 50 percent less than those for the 160 acre farm. Sediment ponds ($.25) again were most cost effective followed by gated pipe ($.32), pumpback ($.51), center-pivots with corner catcher plus yield advantage ($.65), cutback ($.89), center-pivots plus yield advantage ($1.05), side-roll ($1.82) and average yield center-pivots with and without corner catchers ($1.95 and $2.26, respectively). Before-tax cost effectiveness estimates ranged from $.92 to $8.06. Similar to the smaller farm size, low equity after-tax cost effectiveness estimates were slightly higher than the high equity estimates. Changing crop mix was found to be a relatively inefficient method of controlling sediment loss.

Implications

Voluntary adoption of pollution abatement practices requires, in general, some form of tax or subsidy to the farmer. Cost sharing is currently the dominant incentive used to motivate the adoption of soil conservation practices. It is apparent from the analysis presented here that relevant agencies involved in cost sharing (e.g., ASCS and state departments of ecology) should include federal income tax considerations in determination of an "efficient" subsidy rate. When the goal is to leave the farmer no worse off than before pollution abatement, the more efficient rate of compensation per ton of soil loss coincides with an after-tax estimate of cost effectiveness.

The findings of this research support a program of variable incentives depending upon farm size and debt/equity position. No single rate of compensation will be "most efficient" for all farms. Such variable rate programs undoubtedly would be politically unacceptable, though. A regional perspective on pollution abatement appears to offer a more politically palatable framework to capture available program efficiencies resulting from current income tax statutes. A fixed rate subsidy high enough to encourage all farms, regardless of size, to adopt control practices will promote over subsidization of large farms. By basing subsidy rates on larger farm cost effectiveness estimates, region-wide abatement goals could be achieved at a lower social cost. Larger farm sizes may adopt erosion control practices at a lower cost per unit of abatement. This implication would be especially true of large farms in a high equity position. Smaller farms would find a relatively low subsidy inadequate to motivate adoption, while larger farms should be willing to adopt.

Underlying the above analysis is a marginal objective of profit/networth maximization. A more complex goal structure may temper or condition farmers' decisions to adopt a particular control practice. Factors such as leisure, risk aversity, and asset accumulation (among others) may weigh heavily in the decision process. To illustrate the potential importance of such factors, consider the impact of leisure upon the adoption of capital intensive irrigation systems. Freedom from managing irrigation labor would contribute to realizing more leisure time, thereby placing a premium on capital intensive systems. This phenomenon (combined with others, such as less risk of improper water timing) may in fact explain the dramatic increase in center-pivot irrigation systems evident in the Columbia Basin, despite the fact that traditional economic models consistently find center-pivots less efficient than rill irrigation.[2]

Parametric analysis on the price of hired labor reveals that an increase from the current $4.50 hourly wage rate to just under a $7.75 wage rate renders center pivots with corner catchers and 10 percent potato yield advantage more cost effective than even sediment ponds. Though a 70 percent increase in the price of labor, the $7.75 wage rate appears to be well above the implicit wage rate perceived by many farmers when considering the "nuisance" cost associated with managing irrigation labor. A small sample of approximately 30 Columbia Basin farmers suggest the implicit wage associated with not having to manage irrigation labor is considerably greater, averaging $10-$15 per hour. However, each of the farmers surveyed owned center pivots, possibly biasing their response. Further research is necessary to refine estimates of farmers' perceptions of implicit wages.

Closer examination of an increase in the price of labor to $7.75 provides additional insight into the revealed preference for center pivots. Rill irrigation, the benchmark system, is labor intensive relative to center pivots. Thus, the after-tax income differential between rill and center pivot irrigation narrows as the wage rate rises. After-tax cost effectiveness of center pivots with corner catchers and 10 percent potato yield advantage drops 62 percent, from $.65 per ton to $.25 per ton. In contrast, cost effectiveness of sediment ponds remains essentially unchanged at $.26 per ton. Both sediment ponds and rill irrigation employ the same quantity of labor and, thus are affected equally.

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[2]Center-pivot irrigated acreage in the Columbia Basin has increased from zero acres in 1967 to a quarter of a million acres in 1980.

Another potentially important element that may temper the foregoing analysis is the role of risk in adopting structural control practices. Viewed from a cash flow perspective, structural control practices are far more risky than nonstructural practices. Inability to service debt may threaten the economic viability of the farm. This extreme would seem more likely for the low equity farmer. However, insofar as structural practices also cut down on production risks, as center pivot irrigation allegedly does, a preference for structural practices may exist. Unfortunately, yield/grade variability data essential to analyze this dimension of risk do not exist. Regardless of the net effect of risk, both the relative rankings of BMPs and the incentives required to induce their adoption may be risk sensitive.

Conclusions

Incorporating both the ability and intent to adopt abatement practices should be essential ingredients of all environmental quality planning models. One aspect of the adoption decision process was addressed in this paper--the role of selected financial factors. Factors such as farm size and debt/equity position were found to be particularly important in determining the true after-tax costs of abatement strategies. While it is clear that federal tax statutes alone do not provide sufficient impetus to motivate adoption of erosion control practices, failure to include such considerations leads to serious overestimation of cost effectiveness, improper ranking of BMPs, and ultimately faulty policy prescriptions. As other critical decision variables are added to adoption models, a synergistic effect is certain to exist. Unfortunately, the seemingly infinite number of unique farm situations might appear to leave policy oriented research in the same hopeless predicament that has plagued farm growth research. Practicality, however, should limit the analysis to a few farm scenarios that focus on the most important characteristics of adoption motivations.

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