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An Economic Evaluation of Adoption of the Conservation Compliance Program: A Stochastic Dominance Approach

Ramu Govindasamy and Mark J. Cochran

Abstract: *Using stochastic dominance, this paper examines the adoption of the Conservation Compliance Program (CCP) in twelve Iowa soil types. Subsidies necessary to compensate producers for the increased risk of compliance strategies are estimated. Results indicate that to promote voluntary compliance with the CCP, the government should provide a subsidy of between $4.55 to $19.88 per acre, depending on the soil type.*

Key Words and Phrases: *Conservation compliance, Stochastic dominance, Adoption, Risk premium, Erosion.*

Despite the numerous measures taken by the U.S. government to prevent soil erosion, it remains one of the most important agricultural issues of the 1990s (Govindasamy and Huffman). The importance of soil conservation is reflected in the newest farm bill, the Federal Agricultural Improvement and Reform (FAIR) Act of 1996, which supports conservation programs, such as conservation compliance, with the aid of conservation funding which has been increased by more than $2.2 billion (Tavernier and Brumfield). Title III, which is devoted to conservation, is expected to help farmers with their conservation efforts by giving them flexibility to produce as they see fit and by providing them with more financial assistance to adopt conservation measures. FAIR also created the National Natural Resources Conservation Foundation (NNRCF) as a charitable nonprofit corporation to fund research and educational activities relating to conservation on private lands. The NNRCF will promote innovative solutions to conservation problems through public-private partnerships.

Soil erosion has been increasing as a result of intensive agriculture (Miranowski). Numerous economic studies have been conducted that analyze soil erosion in terms of productivity losses, land values and management alternatives to control soil erosion (Wade and Heady; Council for Agricultural Science and Technology; Saliba and Bromley; Govindasamy and Duffy; Govindasamy and Huffman; and Govindasamy and Cochran). Given current production practices, cropland erosion rates in the major crop producing regions exceed the rate of top-soil genesis. Forty-four percent of all

U.S. cropland is eroding at levels greater than the soil-loss tolerance. The U.S. government has formulated many soil conservation programs, such as the Conservation Compliance Program (CCP), to combat the continuing soil erosion problem.

The CCP requires any landowner farming "highly" erodible land to develop and implement a suitable conservation plan for that land to be eligible for payments from the U. S. Department of Agriculture (U.S. Department of Agriculture). Numerous studies have examined the efficiency and distributive impacts of the CCP and the least cost method of achieving target soil erosion (For example, see Dinehart and Libby; Grumbach; Erwin et al.; Batie and Sappington; Govindasamy and Duffy; and Govindasamy and Huffman). Although the CCP is considered important, little attention has been paid to the economic analysis of adoption of the conservation compliance program under risk. Subsidy programs designed to persuade producers to voluntarily adopt may need to include compensation for additional risk associated with these management practices. The purpose of this paper is to examine the effect of risk on the adoption of the CCP in twelve major Iowa soil types, given the distribution of expected net returns and soil erosion.

Specifically, the net returns and soil erosion levels from five crop rotations in each of the twelve major Iowa soil types are compared and ordered using stochastic dominance techniques. Efficient sets for alternative ranges of risk aversion are compared. The premiums producers would need to receive, as a subsidy through government programs to induce compliance with the CCP, for various intervals of risk aversion coefficients are also estimated.

Use of Stochastic Dominance

Stochastic dominance techniques are ways to rank alternative strategies consistent with the Expected Utility Hypothesis (EUH). Generalized Stochastic Dominance (GSD) identifies a subset of the management alternatives for which it cannot be shown that there exists any alternative with a higher expected utility. This subset is known as the efficient set and at least one member of the efficient set will be the preferred alternative of every individual for whom the efficiency criterion applies. An efficient set can be identified for each class or interval of risk preferences.

Mathematically, GSD can be stated as:

$$\min \int_0^1 [F(x) - G(x)]\, U'(x)\, dx \qquad (1)$$

subject to:

$$r_1(x) \le -U''(x)/U'(x) \le r_2(x) \quad \forall x \in [0,1] \qquad (2)$$

where F(x) and G(x) are any two cumulative distributions of outcomes normalized on the interval [0,1] (Meyer). The expected utility, U(x), is assumed to be increasing and twice differentiable. Risk aversion, r(x), is the absolute risk aversion function, which represents a unique measure of an individual's attitude to risk.

Given the information on the distribution of net returns as well as soil erosion, the use of stochastic dominance is superior to other techniques, such as partial budgeting and linear programming, because stochastic dominance takes into account the variability in net returns (Zacharias and Grube). The bounds on the risk aversion function can either be determined by the process discussed in King and Robison (1981) or can be provided explicitly by the researcher to identify the optimal choices for various classes of decision makers. This paper takes the latter approach. The range of intervals provided for $r_i(x)$ takes the form of a sensitivity analysis in which strategies are defined with respect to the magnitude of risk aversion coefficients.

A decision maker's willingness to comply with the CCP depends on the benefits from the government program, which can be thought of as a subsidy or a premium the government may have to pay the producers to encourage them to comply with the CCP. Let us denote the premium as α. This premium equals the amount the decision maker must receive in each state of nature before the decision maker is indifferent to comply with the CCP. This occurs when the expected utility of non-compliance with the CCP equals the expected utility of complying with the CCP by receiving the program benefit or the subsidy, α. Utilizing stochastic dominance criteria rather than specifying an exact utility function requires slight modification to the perspective of the program benefits.

Lower and upper bounds on this premium can be obtained with stochastic dominance by appropriate interpretations of the efficient set (Mjelde and Cochran). To obtain these bounds, two distributions on net returns are necessary. The choice distribution, F(x), is generated from the net returns by not complying with the CCP. The second distribution G(x), is generated from the net returns by complying with the CCP. When F(x) dominates G(x), it is known that for all admissible utility functions the expected utility associated with distribution F(x) is greater than the expected utility associated with distribution G(x). The lower bound on the subsidy or premium, α, is such that F(x) no longer dominates $G(x+\alpha)$. The program benefit or premium is added to each element in the distribution G(x). This is equivalent to a parallel shift in distribution of G(x). At this point, for at least one utility function in the admissible class of utility functions, the expected utility associated with distribution of $G(x+\alpha)$ is greater than or equal to the expected utility associated with distribution F(x). Mathematically, the lower bound is given by

$$\min \alpha \text{ such that } E\,U(F(x)) - E\,U(G(x+\alpha)) \leq 0 \text{ for at least one } U \in \mu, \qquad (3)$$

where E is the expectation operator and μ is the admissible class of utility functions.

The upper bound is the minimum subsidy or premium, α, such that $G(x+\alpha)$

dominates F(x). At this point, for all preferences in the admissible class, all decision makers would prefer to receive the subsidy and select alternative G(x) rather than adopt the previously dominant alternative F(x). This bound is given by

$$\min \alpha \text{ such that } E\,U(F(x)) - E\,U(G(x+\alpha)) < 0 \text{ for all } U \in \mu. \qquad (4)$$

Given the information on risk preferences and probabilities, the range of subsidy or farm program benefits associated with distribution G(x) that would be necessary to ensure adoption is given by the upper and lower bounds. Between the two bounds, stochastic dominance is unable to rank the two distributions for the given class of admissible utility functions. In order to rank the distributions between the bounds, additional information on the risk preferences are required, i.e., a narrowing of admissible class utility functions.

The Data and Estimation

Twelve major types of soils selected in Iowa are Marshall (5-10%), Monona (5-10%), Kenyon (2-5%), Kenyon (5-10%), Tama (2-5%), Clarion (2-5%), Clarion (5-10%), Downs (5-10%), Fayette (5-10%), Otlet (2-5%), Galva (5-10%) and Sharpsburg (2-5%). These soils types comprise the majority of soils found in Iowa (Govindasamy and Huffman). Five rotations considered in this analysis are corn-corn (CC), corn-bean (CB), corn-corn-bean (CCB), corn-bean-oats (CBO), and corn-bean-oats-meadow-meadow (CBOMM). Six observations were used in the stochastic dominance analysis for each of the rotations in each of the soil types. Table 1 provides the summary statistics of the distribution of net returns for six soil types discussed in detail.

Cost of production estimates such as machinery costs by operation for corn in CC and CB rotation, soybean, oats and alfalfa were derived using 1987 crop production budgets and crop prices for Iowa (Duffy). The cost of production estimates also incorporate the costs of adopting management practices to control soil erosion. Yield estimates for each soil type were simulated using procedures developed by Miller. The effects of using alternative management practices to control soil erosion on major soils were captured using the demerits/merits approach used in Miller's worksheet on soil erosion and yield predictions. These yield estimates were consistent with those found under normal growing conditions and management practices. Depending on cultivation method and soil type, production cost estimates and gross returns were based on three yield levels: 90, 115 and 135 bu/acre for corn, 30, 38 and 46 bu/acre for soybeans; 80 bu/acre for oats; and 4, 6 and 8 tons/acre for alfalfa hay. The cost of production estimates for alfalfa include the annual establishment costs, the annual variable costs, and the land cash equivalent. Using Sinner, the costs of controlling soil erosion under the various cropping practices were estimated.

Table 1:
Summary Statistics on the Distribution of Net Returns ($/acre) By Soil Types [a]

Rotation [b]	Mean	Standard Deviation	Highest Value	Lowest Value	Skewness
Marshall (5-10%)					
CC	44	4	51	39	.36
CB	93	9	105	81	-.04
CCB	77	7	87	67	.04
CBO	96	7	106	86	.01
CBOMM	89	6	96	81	.03
Monona (5-10%)					
CC	29	3	34	26	.51
CB	95	20	116	67	-.49
CCB	73	14	89	53	-.42
CBO	94	14	109	73	-.37
CBOMM	76	6	85	67	-.03
Kenyon (5-10%)					
CC	40	21	60	13	-.61
CB	95	13	110	75	-.31
CCB	77	15	93	55	-.45
CBO	99	10	112	84	-.16
CBOMM	93	10	105	78	-.20
Clarion (5-10%)					
CC	30	5	35	22	-.47
CB	85	12	99	67	-.34
CCB	66	8	75	55	-.25
CBO	85	9	95	71	-.20
CBOMM	75	6	83	68	.12
Fayette (5-10%)					
CC	37	6	43	29	-.37
CB	95	12	114	80	.28
CCB	76	7	87	66	.09
CBO	93	9	107	81	.23
CBOMM	85	6	91	79	.01
Downs (5-10%)					
CC	43	18	62	20	-.38
CB	106	10	121	94	.33
CCB	85	11	102	71	.35
CBO	105	8	117	95	.19
CBOMM	101	8	113	90	.07

[a] Soils types where the dominant solutions are also conservation compliance program solutions are omitted from this table.
[b] Rotationare Corn-Corn (CC) ,Corn-Beans (CB),Corn-Corn-Beans (CCB), Corn-Bean-Oats (CBO), and Corn-Bean-Oats-Meadow-Meadow (CBOMM).

Net returns are defined as returns over variable and fixed expenses. Net return for each rotation per year is calculated by summing the profit for each crop in a particular rotation as follows

$$NPR_{j,k} = \sum_{I=1}^{N} \pi_{i,j,k} / n \qquad (5)$$

where:

I = crops: corn, beans, oats and meadow
j = soil types: twelve
k = rotation: CC, CB, CCB, CBO and CBOMM
$NPR_{j,k}$ = Net return for each soil type (j) and rotation (k) ($/acre)
$\pi_{i,j,k}$ = Net return for each crop (I), soil type (j) and rotation (k) ($/acre)
n = Number of crops involved in the rotation

The Universal Soil Loss Equation (USLE) was used to estimate the soil loss for each of the soil types and for each of the rotations. Components of USLE are rainfall (R), soil erodability (K), slope and length (LS), support practice (P) and crop (C). The USLE can be written as

$$A = R*K*LS*P*C \qquad (6)$$

where:

A = soil loss in tons/acre/year

In estimating the soil loss, R, K and LS were treated as given and C and P were used to control soil erosion. We used the Cochran and Raskin Stochastic Dominance program to estimate the premiums for various preference intervals.

The Results

Table 1 presents the summary statistics such as per-acre mean net return, standard deviation, highest value, lowest value and the skewness for soil types Marshall (5-10%), Monona (5-10%), Kenyon (5-10%), Clarion (5-10%), Fayette (5-10%) and Downs (5-10%). These six soil types will be referred to as highly erodible soil types, with the remaining soil types referred to as low erodible soils. Due to data limitations, this study analyzes six types of highly erodible soils. Figure 1 presents the cumulative probability distribution of net returns for Downs (5-10%). Figure 2 presents the cumulative probability distribution of net returns for Marshall (5-10%). Figure 3 presents the cumulative probability distribution of soil erosion for Downs (5-10%). The examination of Figure 1 indicates that the CB and CBO rotations are first degree

Figure 1.
Cumulative Probability of Net Profits for Downs (5-10%)

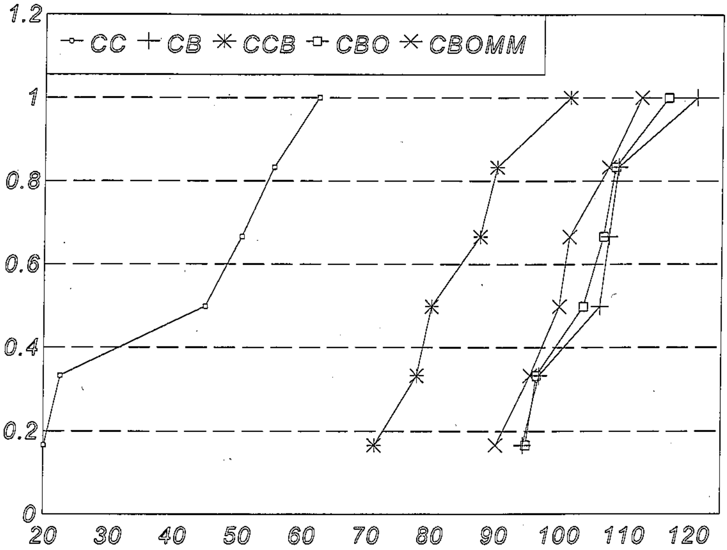


Figure 2.
Cumulative Probability of Net Profits for Marshall (5-10%)

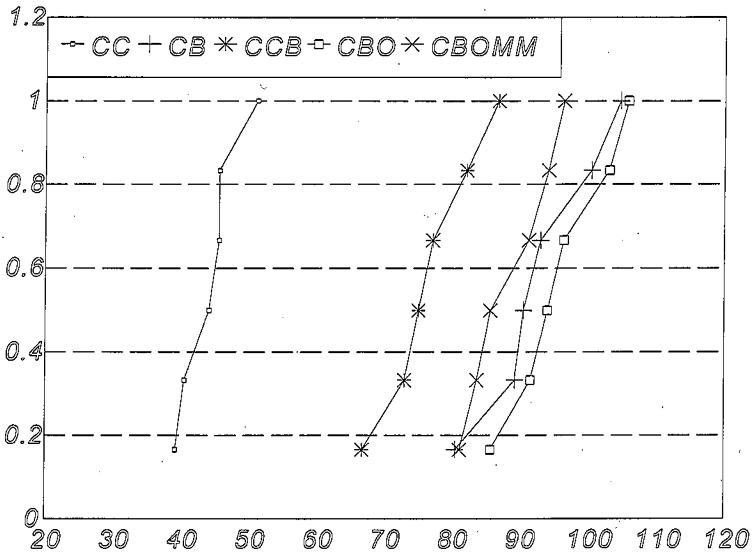
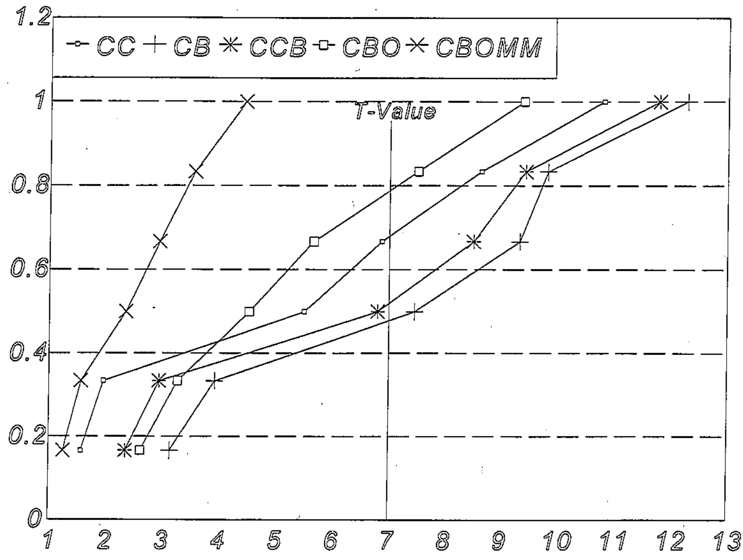


Figure 3.
Cumulative Probability of Soil Erosion for Downs (5-10%)



stochastic dominant to other rotations for Downs (5-10%). This is also true for soil type Monona (5-10%), Clarion (5-10%) and Fayette (5-10%). Figure 2 indicates that CBO rotation is dominant to other rotation for soil type Marshall (5-10%), which is also true for Kenyon (5-10%). Since substantial overlapping exists among the remaining distributions, a further ability to rank depends on specification of $r_i(x)$ and the procedure for evaluating the areas of integration.

To examine the adoption of the CCP, one must compare the cumulative distribution of net income to that of the soil erosion T-values. The soil loss tolerance level (T) is the maximum rate of annual soil erosion that may occur and still permit a high level of crop productivity to be obtained economically and indefinitely. For the low erodible soils, the cumulative distribution of soil erosion for all rotations lies to the left of a T-value of about 7 tons/acre/year. The T-value for soil type Downs (5-10%) is indicated by the vertical line in Figure 3.

In the case of low erodible soils, the optimal decision is to comply with the CCP because the dominant distribution for each of these soil types does not erode more than the T-value for the respective soil type. That is, compliance with the CCP does not increase the cost of production, but, at the same time, enables the producers to become eligible for the government program benefits. In the case of highly erodible soils, the dominant distributions lie to the right of the T-value for the respective soil types. That is, if the producer chooses the first degree stochastic dominant rotation, then there is some probability that the actual erosion will exceed the T-value for the respective soil types and that the producer may not be eligible for the government program benefits. To encourage the producers to choose the CCP solution, the government may need to compensate the producers in the form of a subsidy or farm program benefit. In the case of high erodible soils, the producers may have to incur increased costs to bring down the soil erosion below the T-values. The government program benefits may be targeted to compensate the producers for increased cost of production due to implementation of soil erosion control measures. The CCP solution refers to the dominant solution, given that the distribution lies to the left of the soil erosion T-value.

Table 2 provides estimates on the size of subsidy (farm program benefit) necessary to entice the producers to comply with the CCP. These estimates are provided for three upper and lower bounds on the risk aversion coefficients. To determine the premium, the dominant distribution was compared to the CCP solution. The class of low erodible soils have zero subsidy because the cumulative distributions of soil erosion for these classes of soils lie to the left of T-values for respective soil types. However, the case for the class of highly erodible soils is different. The subsidy that would make the CCP risk efficient for producers with soil type Monona (5-10%) ranges from $13.82 per acre to $19.68 per acre, depending on the level of risk aversion. The soil type Monona requires the greatest subsidy or benefits from government programs to encourage producers to comply with the CCP compared to other soil types. The soil type Downs requires the least amount of subsidy among the class of highly erodible soils ranging from $4.5 per acre to $4.69 per acre, depending on the risk aversion coefficient.

Policy Implications

The policy implication of this study is that if the benefits from the government program, such as the base acreage program or conservation reserve program, exceed $19.68 per acre, then the CCP is risk efficient for producers and voluntary adoption is most likely. The average government payments per acre excluding Conservation Reserve Program (CRP) and Wetland Reserve Program (WRP) payments ranged from $16.34 in Fremont county to $37.78 in Scott county with a mean of $23.84 for Iowa. Given that the average size of a farm in Iowa is 325 acres, the average government payment per farm is $7,748.00.

Among the high erodible soils, Marshall (5-10%), Kenyon (5-10%), Clarion (5-10%), Fayette (5-10%) and Downs (5-10%) are likely to comply with the CCP in Iowa because the premium/subsidy required to comply with the CCP is less than $16.34. In Monona (5-10%), the low risk averse farmers are likely to comply with the program, whereas, the compliance of high risk averse farmers depends on the government payments received by individual producers.

Table 2.
Premium/Subsidy to Comply With the Conservation Compliance Program (CCP) Given the Dominant Solution

Soil Type	Dominant Solution	CCP Solution	Risk Aversion Coefficient Range					
			0.01 to Lower	0.035 Upper	.0035 to Lower	.01 Upper	–.0035 to Lower	.0035 Upper
			premiums in $/acre					
Monona (5-10%)	CB	CBOMM	13.82	17.68	17.68	18.66	18.66	19.68
Clarion (5-10%)	CBO	CBOMM	8.70	9.22	9.22	9.35	9.44	9.77
Downs (5-10%)	CB	CBOMM	4.55	4.62	4.55	4.62	4.62	4.69
Fayette (5-10%)	CB	CBOMM	8.48	9.54	9.54	9.84	9.84	10.16
Kenyon (5-10%)	CBO	CBOMM	5.99	6.03	6.03	6.04	6.04	6.05
Marshall (5-10%)	CBO	CBOMM	7.11	7.30	7.30	7.34	7.34	7.40

The decision to comply with the CCP primarily depends on the government payments in relation to the cost of controlling soil erosion under various cropping practices. The introduction of the 1996 farm bill may affect government payments for some individual farmers through a Production Flexibility Contract. As a result, the decision to comply with the CCP may also be affected. The Production Flexibility Contract payments replace the familiar deficiency payments as a market transition payment each year for the next seven years. Given that the Production Flexibility Contract payments approximately equal deficiency payments, the compliance with the CCP may be expected until 2002. In 2002, Congress will determine whether to continue this program, terminate the payments or establish other programs in a new farm bill. Conservation compliance beyond 2002 will depend on the status of the Production Flexibility Contracts after seven years. Although the results suggest that most Iowa producers will comply with the CCP, participation by an individual farmer depends on his or her risk preferences and share of the government payments.

Notes

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