Estimating Producer Welfare Effects of the Conservation Reserve Program

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Abstract. *Using a farmland value survey that separated the value of farmland enrolled in the Conservation Reserve Program from all farmland, this article measures gains in producer welfare from program participation The results distinguish program participant welfare gains from the general income effects that benefit all producers through reduced crop supply Although program participants received substantial gains, all producers received additional income Producers have collectively benefited from a rise in the value of U S farmland of $11 to $22 per acre due to current and expected future benefits throughout the life of the program*

Keywords. *Conservation Reserve Program, farmland value, producer welfare, survey data*

Land conservation practices in the United States are traditionally encouraged through government subsidies Policies encouraging land conservation "appear to be observationally equivalent to policies intended to support the incomes of farmers as an interest group" (*1*, p 347) [1] In the case of the Conservation Reserve Program (CRP), farmers' incomes are supported through payments for converting highly erodible farmland to uses that significantly reduce soil erosion These payments may add to producers' welfare through a reduced income risk (*6*), an excess of payments received over enrollment costs, and a general increase in prices from reduced supplies of commodities that would have been produced on the program-enrolled land Although one, or a combination of all, of these factors constitutes an argument for a positive welfare effect to farmers from the government payments, the argument does not prove that farmers received any benefits A more convincing case for welfare gains is made with empirical evidence The direct and indirect producer welfare effects of the Conservation Reserve Program are measured here with U S Department of Agriculture survey data and then compared with recent studies, which estimate program effects through use of secondary, or market level, data

Background

The Conservation Reserve Program addresses multiple policy concerns The program's primary goal is to prevent further erosion of fragile farmland Other goals include reducing surplus crop production and maintaining a strong farm economy (*5*) The CRP targets highly erodible U S farmland for enrollment in the program The landowner receives an annual payment from the government in return for participation A landowner who participates must not grow crops on the enrolled land for a period of 10 years, but instead must plant a cover of grass or trees

Farmland owners benefit from the acreage reductions and program rental payments Each owner of program-eligible farmland submits a bid in the form of a per acre rental rate For the owner, this bid at least equals the opportunity costs of program enrollment No profit-maximizing farmland owner will submit a bid below perceived opportunity costs Thus, the government accepts bids equal to or greater than opportunity costs Any difference between accepted bids and opportunity costs of enrollment constitutes a direct net benefit to farmers for program enrollment

Nonparticipants benefit from the program also Once farmland is enrolled in the program, it is out of crop production, which reduces crop supply To the extent that program enrollment affects supply, market prices of the subsequent crop supply should increase, which benefits all producers in the affected markets

Measuring Welfare Effects of the CRP

Three facts must be recognized to identify the CRP benefits to producers Enrollment in the CRP is an alternative market in which a farmer can participate A fixed amount of the farm is classified as highly erodible, and therefore eligible for enrollment in the CRP The CRP is not a commodity-specific program, so assessing welfare effects on producers requires a multimarket framework

All farm operators have the option of producing many commodities, so we can assume the farm sector will operate such that the sum of profits from all products is maximized With the CRP, the sector produces n agricultural products plus an income-generating unit, q_{n+1}, which represents total acres of CRP-enrolled land selling at an annual price p_{n+1} per acre

Economic rent for the profit-maximizing firm producing output i is defined as total revenue less total variable costs The sum of rents from each of the n+1 markets defines total rent for a multiproduct farm sector [2]

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[1] Italicized numbers in parentheses cite sources listed in the References section at the end of this article

[2] The derivations in equations 1 through 4 parallel those for the general case of a multiproduct profit-maximizing firm as developed in appendix A in (*4*)

$$R = \sum_{i=1}^{n+1} p_i q_i - \sum_{j=1}^{m} w_j x_j, \quad (1)$$

where

p_i = unit price for output i,
q_i = total units of output i,
w_j = unit price for input j,
x_j = total units of input j,
R = total economic rent

From first-order conditions of profit maximization, q_i and x_j are solved for optimal levels, conditioned on input and output prices The rent function is then solved for optimal levels, conditioned on input and output prices Through first-order conditions of the profit function and the envelope theorem, the market supply and factor demand functions are obtained as follows

$$\frac{\partial R(P,W)}{\partial p_i} = \bar{q}_i(P,W) = \text{product supply for output } q_i \quad (2)$$

and

$$\frac{\partial R(P,W)}{\partial w_j} = -\bar{x}_j(P,W) = \text{derived demand for input } x_j, \quad (3)$$

where

$P = (p_1, p_2, \quad , p_{n+1}),$
$W = (w_1, w_2, \quad , w_m)$

For each product i, there exists a market shutdown price $\hat{p}_i$ such that $\hat{p}_i$ is just low enough to induce the farm sector to cease production of good i Denoting "*" as a flag that indicates a market equilibrium price with the CRP in effect, integration of equation 2, evaluating from $\hat{p}_i$ to p_i^*, will provide the rent generated in market i Integration from shutdown price to equilibrium price for all products sums to total rent R

Equation 4 (below) is the summation of total area above the supply curve and below price for all of the n+1 products in the sector The proof is as follows

$$\sum_{i=1}^{n+1} \int_{\hat{p}_i}^{p_i} \bar{q}_i (P, W^*)\, dp_i$$

$$= \sum_{i=1}^{n+1} \int_{\hat{p}_i}^{p_i} \frac{\partial R_i(P, W^*)}{\partial p_i}\, dp_i$$

$$= \sum_{i=1}^{n+1} [R_i (P (p_i^*), W^*)$$

$$- R_i (P (\hat{p}_i), W^*)] = R (P^*, W^*), \quad (4)$$

where

$P = (p_1^*, p_2^*, \quad , p_i, \quad , p_{n+1}^*)$, and recall $R_i (\hat{p}_i) = 0$

Welfare Effects in Market n+1

The direct welfare effects for CRP participants is defined by the difference between contract payments (p_{n+1}^*) and the opportunity costs of not farming the program land ($\hat{p}_{n+1}$) Prior to the program's inception, $p_{n+1} = \hat{p}_{n+1}$ and $R_{n+1} = 0$ From this initial equilibrium position, the U S Department of Agriculture (USDA) began accepting bids submitted by farmland owners Bids must have been at least equal to the rate $\hat{p}_{n+1}$ There has been an upper limit on acceptable bids Government-established bid caps represent the maximum acceptable rental rate paid to farmland owners for participation in the program The value $\hat{p}_{n+1}$ is defined as the rental rate at which the landowner is indifferent between program enrollment and farming the land in its maximum alternative income-generating usage Any discrepancies between $\hat{p}_{n+1}$ and accepted bids is due to an asymmetry of information between the landowner (who has a good idea of the land's earning potential) and government (which has inferior knowledge of the same value) The initial welfare effect of the program is propagated by creation of a market for q_{n+1} Measuring this effect is market n+1 amounts to measuring the difference between accepted CRP contract bids and opportunity costs of enrollment Since bids are in dollars per acre, the difference can be multiplied by total enrolled acres and then summed across the duration of the program This value, which represents the total welfare effect in market n+1 over the life of the program, is depicted in equation 5 (suppressing the n+1 subscript)

$$W = \sum_{i=1}^{7} \int_{t=0}^{9} \int_{\hat{p}_{t,i}}^{p_{t,i}^*} q_{t,i} e^{-\delta t} dp, \quad (5)$$

where

δ = discount rate,
t = life span of program, that is, 0 is initial year, 9 final year
i = signup period, that is, there are seven total signup periods,
W = welfare effect in market n+1 through termination of program

Equation 5 is difficult to estimate empirically Although CRP bids p_{n+1}^* are observable, economists usually do not know what individuals believe the alternative, but lower, expected earnings, $\hat{p}_{n+1}$, are If contract bids are equal to opportunity costs, then equation 5 equals 0 A strategy to determine $\hat{p}_{n+1}$ must be defined if $\hat{p}_{n+1}$ and p_{n+1}^* differ (At the time of this article's completion, a total of seven signup periods had been conducted)

Although there are problems estimating each program participant's actual values of p_{n+1}^* and $\hat{p}_{n+1}$, as well as their perceived capitalization rate (δ), each of these components is collectively revealed in the value of farmland Because farmland values are observable, and farmland value data exist for all geographic regions, equation 5 can be evaluated Farmland values will also reflect program benefits beyond the termination of program payments These benefits, which are not represented in equation 5, are realized when employment of the land is resumed by the owner upon termination of the program Such factors as improved soil quality and enhanced esthetic qualities, which are a direct result of program enrollment, are anticipated by program participants and capitalized into the present value of the land

Pricing Farmland

Asset value can be assessed by estimating the income an asset could produce The nonstochastic formula for pricing farmland postulates farmland value is, at equilibrium, equal to the present value of an income stream generated in perpetuity This income is generated through employing the land in its optimal profit-generating usage

$$V = \int_0^\infty Re^{-\delta t}dt = \frac{R}{\delta} \tag{6}$$

V represents the price of the parcel per acre, and R represents the per acre rental rate, discounted at a constant rate compounded continuously (see *8*, p 57) The improper integral in equation 6 converges, and the value R is defined as in equation 1 In the context of the multiproduct market of equation 5, R is also equivalent to p_{n+1}, which is the rental price per acre of farmland enrolled in the CRP If bids accepted by the government were equal to the opportunity cost of enrollment $\hat{p}_{n+1}$, then the value of land enrolled in the program would be equivalent to similar land not enrolled To the extent that the accepted bid (p^*_{n+1}) was greater than $\hat{p}_{n+1}$, the value of CRP-enrolled land is proportionally greater than similar land not enrolled in the program This difference can be calculated by expanding the expression in equation 6 The difference in the earning potential of farmland enrolled in the CRP and eligible land not enrolled is the government payments p^*_{n+1}, which are earned over a 10-year period [3]

$$V^{crp} = \int_0^9 P^*_{n+1}e^{-\delta t}dt + \int_{10}^\infty \hat{p}_{n+1}e^{-\delta t}dt \tag{7a}$$

$$V = \int_0^9 \hat{P}^*_{n+1}e^{-\delta t}dt + \int_{10}^\infty \hat{p}_{n+1}e^{-\delta t}dt \tag{7b}$$

Subtracting 7b from 7a and multiplying by enrolled acreage shows

$$q_{n+1} \times (V^{crp} - V) = \left[\int_0^9 (p^*_{n+1} - \hat{p}_{n+1})e^{-\delta t}q_{n+1}dt\right] + C$$

$$= \left[\sum_{t=0}^{9} \int_{\hat{p}_{n+1}}^{p^*_{n+1}} q_{n+1}e^{-\delta t}dp_{n+1}\right] + C \tag{8}$$

[3]If the land in 7a and 7b truly are similar, then termination of the program should lead to resuming similar land use patterns However, there may be environmental benefits that are capitalized in equation 7a beginning in period 10 which do not affect equation 7b

Calculating equation 8 for contracts across all seven signup periods captures the welfare effects in equation 5 There may also be a residual difference between the last expression in equations 7a and 7b not depicted in equation 5 For example, producers benefit from reduced soil erosion, which can lead to benefits by enhancing the soil's ability to produce in the future (see *12*, p 15) Since this benefit is not perpetual, it is depicted in equation 8 as a lump sum benefit equal to a constant, C The total welfare effect in market n+1 can be directly measured as the difference between the weighted average value of farmland enrolled in the CRP and program-eligible land not enrolled across all seven signup periods

The Data

USDA's Farmland Market Survey polls brokers, appraisers, bankers, and both public and private officials who deal with the agricultural real estate market (*10*) The 1988 survey data included information specifically concerning value of farmland enrolled in the CRP and land eligible for enrollment but not enrolled Although coverage includes all 10 farm production regions of the continental United States, the Pacific and Northeast regions have limited coverage, so are not considered separately for this study (responses from these two regions, however are incorporated into the 48-State estimate) Estimates of the percentage effect of program enrollment on CRP-enrolled farmland values (the ratio of CRP-enrolled farmland value to the value of program-eligible land not enrolled) is developed for 10 farm production regions The 1988 survey was conducted in February 1988, so coincides with the beginning of signup period 6 The survey responses will most likely reflect program effects through five signup periods

Results and Implications

The national average value of CRP-enrolled farmland is 7 percent greater than program-eligible land not enrolled Each of the estimated regions also shows significantly greater values for enrolled farmland, ranging from 3 percent in the Lake States region to 12 percent in the Mountain region (table 1) To convert these percentage figures into dollars, assumptions about the characteristics of the farmland sample are necessary In particular, farmland productivity for erodible farmland is assumed to be similar to nonerodible farmland This assumption is substantiated by a considerable literature that focuses on land productivity issues [4] The observed contract rents for the CRP are generally above or rapidly approaching published cash rental rates for cropland (*11*) as shown in table 2 Comparable rental rates between regional farmland enrolled in the CRP and all farmland within each

[4]See (*2*) for analysis and further references

Table 1—Comparison of survey results to capitalization of initial and subsequent contract bids

Region	Change in value of CRP-enrolled farmland[1]		Equation 9 results through five signups at discount rate of		Equation 9 results through seven signups at discount rate of	
			8%	4%	8%	4%
	Percent	*Dollars per acre*				
Northeast	NA	NA	48	57	57	67
Appalachia	5	52	36	42	36	43
Southeast	8	90	67	79	73	86
Delta States	7	55	63	74	66	78
Corn Belt	8	80	74	87	81	95
Lake States	3	24	57	68	57	68
Northern Plains	11	40	18	22	14	19
Southern Plains	7	37	38	44	38	45
Mountain	12	31	36	42	36	43
Pacific	NA	NA	31	36	32	38
48 States	7	44	41	48	42	38

NA = not available

[1]Column 2 is calculated as the product of column 1 and regional land values based on the 1987 Census of Agriculture (9)

Table 2—Average regional contract payments by signup period, and average cash rental rates for cropland

Region	Average payment by signup period							Cash rent, February 1990
	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	
	Dollars per acre							
Northeast	49	56	58	57	57	58	63	46
Appalachia	48	52	54	55	53	53	55	48
Southeast	31	39	42	43	44	44	45	49
Delta States	33	40	44	44	45	45	45	49
Corn Belt	58	63	70	71	69	70	81	83
Lake States	49	52	57	60	59	57	59	54
Northern Plains	44	45	47	48	46	45	44	38
Southern Plains	34	38	40	40	41	40	41	26
Mountain	34	38	40	40	41	40	40	45
Pacific	44	48	49	49	51	51	51	105
48 States	42	44	47	51	48	48	50	NA

NA = not available

region suggest comparable farmland values,[5] thus providing a basis for converting the regional percentage estimates to dollar figures (table 1)

A variation of the CRP welfare evaluation approach used by Shoemaker (7) was employed to test the hypothesis that the average gains per acre of CRP-enrolled farmland did not significantly change after signup period 5 Shoemaker estimated direct welfare gains from participation in the CRP by assuming that signup period 1 bids represented approximate opportunity costs of the average farmland parcel enrolled in the program Observing subsequent signup period bids asymptotically approaching previously established government bid caps (table 2), Shoemaker assumed that these increased bids reflected farmers' learning established bid caps The total income effect was calculated by capitalizing the difference between final and initial bids Shoemaker used final signup period and initial signup period average regional contract payments (table 2) as proxies for p_i^* and $\hat{p}_i$ More precise estimates are possible by weighting the average effect across each signup period

$$\sum_{i=1}^{5}\left(\frac{a_i}{A}\right)\int_0^9 (p_i^* - \hat{p})e^{-\delta t}dt, \qquad (9)$$

where

a_i = total acreage enrolled in period i, and
A = total acreage enrolled through five signups

This procedure produces a better representation of the average gain to participants throughout the life of the program Equation 9 results are presented in table 1 The range represents a discount rate range of 4-8 percent, which is what Shoemaker used

[5]This is true only under the assumption that farmland's current earning potential can be maintained, in real value, through perpetuity Because investors in erodible farmland may incorporate an expected long-term loss in productivity this assumption may overstate the value of CRP-eligible farmland

For the 48-State estimate, this range is \$41-\$48 per acre, which is consistent with the survey results in column 2 The regional results do not correspond as closely to the survey regional results, yet an ordering of the regions by the magnitude of their estimates shows a close correspondence of the two estimating procedures Overall average producer gains after seven signup periods correspond to average gains through five signups, not surprising because the average accepted contract bids leveled off after five signups (table 2)

The hypothesis that the survey data effectively represent the present value of average gains to program participants in all seven signup periods cannot be rejected Although the survey was conducted after signup period 5, the average per acre gain to program participants in the final two signup periods appears to have remained constant If that is so, the direct program welfare effects can be quantified as the product of the average per-acre effect (\$44) and total enrolled acreage (28 1 million) which comes to \$1 24 billion This value represents the total capitalized value to participants from contract payments above the opportunity cost of program participation, plus all environmental benefits that can be capitalized into the value of the enrolled farmland

Aggregation of Effects in All Markets

Because decreased production will cause upward pressure on prices in affected markets, the land that remains in production will earn higher rents, thus causing further welfare effects to producers participating in these markets The empirical results of the previous section account for welfare effects beyond the price effects that may have occurred This is so because farmland owners will have anticipated the supply effects, which would be reflected in the value of farmland not enrolled in the program

The welfare effects across all n+1 output markets are measured by the area below the derived demand for farmland Markets 1 through n+1 all clearly require a positive amount of farmland to produce output q_i There exists some positive price for farmland, $\hat{w}_j$, which will lead to a shutdown of demand for farmland x_j This price is observed at the farm level by the conversion of farmland at the urban fringe to residential or commercial development At more aggregated levels, this price will likely not be reached However, short of a global shutdown, large regions can become entirely dependent on an outside supply of agricultural products When a shutdown occurs in the market for land, the entire agricultural sector will shut down, reducing rents to zero Using this notion of a shutdown price, plus equations 3 and 4, the change in welfare across markets 1 through n+1, resulting from a change in price p_{n-1} from $\hat{p}_{n+1}$ to p^*_{n+1} is measured by the change in area below the demand for farmland and between the price for farmland with and without the CRP

Equation 10c establishes that the difference in area below the derived demand for farmland and between $\hat{w}_j$ and w^*_j is equivalent to the change in welfare for the farm sector due to introduction of the CRP

Denote C_1 total welfare in sector with the CRP, C_2 total welfare in sector before the CRP, and w_j the price of farmland

$$C_1 = \int_{w_j}^{w_j} x_j \,(P(p^*_{n+1}),\ w^k_i,\ w_j)\, dw_j$$

$$= -\int_{w_j}^{w_j} \frac{\partial R\,(P(p^*_{n+1}),\ w^k_i,\ w_j)}{\partial w_j}\, dw_j$$

$$= R\,(P(p^*_{n+1}),\ W^*) \qquad (10a)$$

$$C_2 = \int_{w_j}^{w_j} x_j \,(P(\hat{p}_{n+1}),\ w^k_i,\ w_j)\, dw_j$$

$$= -\int_{w_j}^{w_j} \frac{\partial R\,(P(\hat{p}_{n+1}),\ w^k_i,\ w_j)}{\partial w_j}\, dw_j$$

$$= R\,(P(\hat{p}_{n+1}),\ W^*), \qquad (10b)$$

where

$w^k_i = (w^k_1, \ldots, w^k_{j-1}, w^k_{j+1}, \ldots, w^k_m)$,

$k = 0, 1$, e g , before or during CRP,

$P(p^*_{n+1}) = (p^*_1, \ldots, p^*_n, p^*_{n+1})$,

$P(\hat{p}_{n+1}) = (p^*_1, \ldots, p^*_n, \hat{p}_{n+1})$

$$C_1 - C_2 = R(P(p^*_{n+1}), W^*) - R(P(\hat{p}_{n+1}), W^*) \qquad (10c)$$

Observed changes in farmland values are general equilibrium changes that reflect conditions throughout the sector as well as any outside sector effects such as the influence of urbanization To isolate the effect on farmland value attributed solely to the CRP, note that the program payments, environmental benefits to program-enrolled farmland, and a risk premium from contract payments are all (or primarily) in the \$1 24-billion welfare gains captured in market n+1 The remainder of the program effects on producer welfare are in the affected commodity markets

There are three possible price effects in the commodity markets affected by the CRP If all program-enrolled cropland were used for crops that were at or near unitary price elasticity for output demand, then the welfare effect for markets 1 to n would be 0, since unitary price elasticity implies price changes are revenue neutral Under unitary elasticity, equation 10c is the observational equivalent to equation 8, and the survey results in table 1 represent the total producer welfare effect of the CRP If these crops are instead generally elastic, then markets 1 to n will have a negative net welfare effect since price elastic demand for agricultural products implies price increases are revenue-decreasing The amount of lost revenue under this scenario should not exceed the gains in market n+1, as this would make the program a net loser for producers If net losses were even remotely possible, farmers would most likely anticipate losses, and program participation would be very low For this scenario, total CRP welfare effects would range between 0 and the amount defined in table 1 The scenario most likely to represent the majority of markets affected by the program will be that of an inelastic demand for producer output [6] A price inelastic demand for agricultural output will result in adjustments in demand that do not offset price increases, thus enhancing producer revenue For this reason, the survey results in table 1 most likely are a lower bound of the total welfare effects from the CRP To measure all effects, a general equilibrium solution must be solved simultaneously That solution may be empirically intractable

A partial equilibrium approach to measuring the total welfare change, outlined in Just, Hueth, and Schmitz (*4*, p 211) identifies a subset of markets that are significantly affected by the policy considered If the number of markets significantly represents the scope of affected markets, yet is not too large to manage, then this subset can be treated as a market, and welfare effects can be measured by simultaneously solving for the new equilibrium In terms of a regional analysis, this approach has empirical possibilities in the more homogeneous areas of the country For example, in the Corn Belt States, corn and soybeans dominate the market for cropland throughout the region Modeling the effects of the CRP could be achieved by considering these two markets plus some set of related markets that could be considered jointly In contrast to the Corn Belt, the Pacific is a very diverse production region and a large number of markets must be considered to capture a majority of the program effects Tractability may be a problem in the Pacific region

A recent study by Young and Osborn (*12*) in effect identifies the U S agricultural sector as a tractable subset of markets affected by the CRP They estimated the net present value of producer income effects from the CRP to range between $9 2 billion and $20 3 billion These results are from an agricultural sector partial equilibrium model and correspond to total income effects in markets 1 through n The wide range in their income effect estimates reflects the tractability problem and is based on alternative policy and price effect assumptions

Total producer welfare gains from the CRP, using the partial equilibrium approach of Young and Osborn and the survey results of table 1, are the sum of these two effects, or between $10 44 billion and $21 54 billion The present discounted value of all producer welfare effects from the CRP thus increases the average value of U S farmland between $11 and $22 per acre [7] The equality of this sum and total producer welfare gains from the CRP is evidenced by noting that land value represents the capitalized value of expected rent (equation 6), and adjustments in the value of farmland represent the sum of all producer adjustments in total welfare (equation 10c)

Conclusions

The empirical results presented are observed program effects through five signup periods of the Conservation Reserve Program Indications from the average bids in the final two signups suggest that the empirical results probably represent the average effect across all signup periods These results represent the average effects of program payments, which include marginal (payments equal opportunity costs) and inframarginal (payments in excess of opportunity costs) farmland enrollment The regions analyzed unanimously indicate a net positive effect in land value due to program enrollment A null hypothesis that program payments are not greater than opportunity costs is refuted by the paradoxical implications of such an assertion If the null hypothesis were true, the empirical results would indicate that the most productive farmland has been taken out of production in favor of highly erodible, unproductive farmland This would be contrary to program objectives, and would be highly unlikely

Although comparisons are made with results from recent studies measuring CRP program effects, the survey results, unlike the simulated results, are independent of any underlying model They are consistent with assumptions of contract prices in excess of expected rents, yet would not contradict a scenario where contract prices are identical to expected rents, such that welfare gains are attributed to a risk premium The empirical results also capture investor expectations of environmental benefits that can be capitalized into the value of farmland This is significant because it establishes a lower bound for measuring program benefits in the farm sector The curtailed supply of crops affected by the program increases the welfare of all producers considerably more than direct welfare effects to program participants

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