Providing Crop Disaster Assistance through a Modified Deficiency Payment Program

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Federal income support programs provide producers with only a limited degree of income protection in the event of a widespread crop failure. As an alternative to supplemental disaster assistance, we propose a modification of the deficiency payments program in which a producer's payment would be based on the difference between a target revenue and the average revenue in the producer's region. A regional target revenue progam would provide improved individual income protection without promoting moral hazard and would limit regional revenue shortfalls, thereby eliminating the demand for supplemental disaster assistance and reducing government costs.

Key words: deficiency payments, disaster assistance, revenue insurance, risk and uncertainty.

Much of the debate surrounding the 1990 farm bill focused on the best means of providing producers with income protection in the event of a widespread crop failure. The debate is not new. Prior to 1980, the U.S. Department of Agriculture (USDA) provided disaster assistance mainly through direct cash payments. Because of strong criticism that the disaster payment program was too expensive, restrictive in scope, and encouraged production in high-risk areas, Congress enacted the Federal Crop Insurance Act of 1980 to replace the disaster payment program with crop insurance as the primary means of providing catastrophic income protection to farmers.

The federal crop insurance program, however, has failed to perform as expected. Although the 1980 act authorized the Federal Crop Insurance Corporation to subsidize producer premium payments and to expand coverage, participation in the program between 1980 and 1988 never exceeded 25% of eligible acreage.[1] Adverse selection and moral hazard problems also seriously undermined the actuarial performance of the program and led to large government outlays (Chambers, Nelson and Loehman, Skees and Reed).[2] Most significantly, however, the federal crop insurance progam failed to eliminate federal disaster assistance. Because of the low rate of participation in the program, the federal government enacted supplemental ad hoc disaster assistance legislation four times between 1980 and 1989 in response to widespread yield shortfalls. The U.S. Government Accounting Office estimates that government disaster payments over that period exceeded $6.9 billion.[3]

The poor performance of the federal crop insurance program has raised serious concerns about whether a fiscally responsible crop insur-

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[1] While estimated participation in 1989 is 44%, much of the increase resulted from a provision of the 1988 Disaster Assistance Act that required producers to purchase crop insurance for 1989 in order to qualify for 1988 disaster payments (Glauber et al.).

[2] The General Accounting Office estimates that over the period 1980–88, government outlays for the federal crop insurance program exceeded $4.2 billion, accounting for over 80% of the total indemnities paid to producers.

[3] Supplemental disaster assistance legislation has significantly undermined participation in the crop insurance program. Many producers forego purchasing crop insurance in the belief that the federal government will provide supplemental disaster relief.

ance program could attract sufficient participation to reduce the demand for supplemental disaster legislation. Citing these concerns, the Bush administration has recommended replacing the federal crop insurance program with a standing disaster assistance program that would indemnify producers for individual crop losses whenever catastrophic losses are experienced at the county level (USDA 1990). Critics, however, have charged that the program would provide producers with insufficient protection at the low coverage levels that would be required to observe federal budgetary constraints. Proposed modifications to the current federal crop insurance program aimed at increasing participation also appear unattractive. Making crop insurance compulsory for loan program participants would be unpopular with producers. Providing free, fully subsidized crop insurance would involve large government outlays and would encourage risky production practices (Glauber, Harwood, and Miranda).

As an alternative to supplemental disaster assistance, we propose a modification of the current deficiency payment program that would provide improved income protection in the event of widespread crop failure. Under the current deficiency payment program, producers receive payments proportional to the difference between a target price and the higher of the market price or the nonrecourse loan rate. Although this method of payments provides protection against price drops, it offers little protection against the adverse effects of catastrophic yield shortfalls: in the event of a widespread crop failure, the market price rises, shrinking if not eliminating, the deficiency payment. Under the modified deficiency payment progam, a producer's payment would be based on the difference between a target revenue and the average revenue in the producer's region. Because yield and price are negatively correlated, deficiency payments would be higher under a target revenue progam than under a target price program when yields are low, thereby providing improved income protection in the event of a crop failure. More significantly, a target revenue program would place a high floor on regional producer revenues, thereby reducing, if not eliminating, the demand for supplemental disaster assistance and lowering overall government costs (Evans).

Because target revenue payments are based on regional rather than individual revenue shortfalls, a target revenue program is not a true individual income insurance program (Arzac, Offut and Lins, U.S. Congressional Budget Office, USDA 1983). A target revenue program, however, can offer effective protection against individual income risk because individual producer yields are generally correlated within a region. A target revenue program, moreover, is not prone to the moral hazard problems that typically undermine individualized insurance schemes. Moral hazard, which occurs when insured individuals alter their behavior in a manner that increases their chances of collecting an indemnity, leads to resource misallocation and actuarial losses for the insurer. Under a target revenue program, however, an individual producer cannot significantly affect aggregate revenue and, thus, the indemnity received. Accordingly, a target revenue program does not distort existing individual incentives to produce efficiently.

In the following sections, a regional simulation model of the U.S. corn market is used to compare producer revenues and federal budget outlays under the current target price deficiency payment program and under national, state, and county target revenue deficiency payment programs. The analysis indicates that for the same cost as the current target price program, a county target revenue progam for corn would substantially reduce county-level revenue variability and would also stabilize total government deficiency payments. The analysis also indicates that a county target revenue program would provide better individual income protection to corn producers than a target price program, even when the latter is implemented in conjunction with individualized crop insurance coverage such as is currently available through the Federal Crop Insurance program.

Regional Model of the U.S. Corn Market

Let Y_j denote the average yield obtained by corn producers in region j at harvest time. Denoting the program acreage planted to corn in region j by A_j^p, the amount of program corn produced in region j is

$$Q_j^p = A_j^p \cdot Y_j. \tag{1}$$

Denoting the nonprogram acreage planted to corn in region j by A_j^n, the amount of nonprogram corn produced in region j is

$$Q_j^n = A_j^n \cdot Y_j. \tag{2}$$

Total program corn production is, thus,

$$Q^p = \sum_j Q_j^p, \tag{3}$$

total nonprogram corn production is

$$Q^n = \sum_j Q_j^n, \tag{4}$$

and total program and nonprogram corn production is

$$Q = Q^p + Q^n. \tag{5}$$

The quantity of corn C that disappears for domestic and foreign consumption and for other private productive uses is a function of the market price for corn P:

$$C = D(P). \tag{6}$$

Quantities of corn released by the government from its stockpile, denoted G^-, and quantities of corn acquired by the government, denoted G^+, alter the market supply-demand equilibrium. The supply of corn available on the market is composed of new production and government stock releases; conversely, available supplies of corn are either consumed or acquired by the government. This leads to a material balance relation:

$$Q + G^- = C + G^+. \tag{7}$$

Government stock acquisitions and releases are governed by the provisions of the nonrecourse loan program. If the market price for corn P exceeds the loan rate for corn P_L, participating corn producers repay their loans and the government acquires no stocks:

$$P > P_L \rightarrow G^+ = 0. \tag{8}$$

If the loan rate exceeds the market price, on the other hand, all participating producers default on their loans and the government acquires their output:

$$P < P_L \rightarrow G^+ = Q^p. \tag{9}$$

If the release price for corn P_R exceeds the market price for corn P, the government releases no stocks from its stockpiles,

$$P < P_R \rightarrow G^- = 0. \tag{10}$$

If the market price exceeds the release price, on the other hand, the government releases its entire corn inventory G,

$$P > P_R \rightarrow G^- = G. \tag{11}$$

Alternative Deficiency Payment Programs

Under the current federal income support program, a participating corn producer receives a per-acre deficiency payment that is calculated by multiplying the national deficiency payment rate times the individual program yield. The deficiency payment rate is the difference, if positive, between the target price P^T and the greater of the market price P and the loan rate P^L. Denoting the program yield of participating corn producer i in region j by Y_{ij}^*, the per-acre payment received by the producer under the current deficiency payment program is given by

$$D_{ij}^P = \max\{0, P^T - \max\{P, P^L\}\} \cdot Y_{ij}^*. \tag{12}$$

Under a regional target revenue program, a participating corn producer in region j would receive a basic per-acre deficiency payment equal to the difference, if positive, between the regional target revenue R_j^T and the participant regional average revenue, which equals the maximum of the market price and the loan rate times the regional average yield Y_j. In order to account for differences in productivity among corn producers, the basic payment is adjusted by a factor equal to the ratio of the individual's program yield and the regional average program yield Y_j^*. The per-acre deficiency payment received by participating producer i in region j under a regional target revenue program is, thus,

$$D_{ij}^R = \max\{0, R_j^T - \max\{P, P^L\} \cdot Y_j\} \cdot \frac{Y_{ij}^*}{Y_j^*}. \tag{13}$$

A regional target revenue program will provide the same expected payment as the target price program, provided that the revenue target R_j^T is chosen so that

$$\mathcal{E} \max\{0, P^T - \max\{P, P^L\}\} = \mathcal{E} \max\{0, R_j^T - \max\{P, P^L\} \cdot Y_j\} \cdot \frac{1}{Y_j^*}, \tag{14}$$

where $\mathcal{E}$ denotes the expectation with respect to the joint distribution of price and yield. A unique revenue target satisfying this condition clearly exists since the expression on the right-hand side of (14) is zero if R_j^T is zero, is strictly and continuously increasing in R_j^T wherever the expectation is positive, and can be made arbitrarily large by raising R_j^T.

Although various regional configurations for a corn target revenue program are possible, only national, state, and county target revenue programs will be examined in this paper. Under a county target revenue program, Y_j and Y_j^* represent the average realized and program county yields, respectively; under a state target revenue

progam, they represent the average realized and program state yields, respectively; and under a national target revenue program, they represent the average realized and program national yields, respectively. Under any of the regional target revenue programs, any two corn producers having the same individual program yield and residing in the same region will, in any year, receive the same deficiency payment, regardless of any differences in their realized individual yields.

Empirical Model Parameterization

The regional simulation model of the U.S. corn market comprises the 1,142 largest corn-producing counties in the United States, which account for over 90% of all corn production nationally, and 137 multicounty regions that account for all the remaining U.S. corn production. The empirical market model was simulated, for the most part, under conditions prevailing during the 1989 marketing year. The national target price was set at $2.84 per bushel, the national loan rate at $1.65 per bushel, and the national release price at $2.84 per bushel, their 1989 values. Initial government corn inventories were set at 1.1 billion bushels, the combined level of Commodity Credit Corporation and Farmer-Owned Reserve holdings at the end of the 1988 marketing year. Because 1989 county-level corn acreage data were unavailable, program and nonprogram corn acreages were set at their 1984–88 average; total U.S. acreage and acreage for the top fifteen states ranked in order of descending program acreage are given in table 1.

In order to preserve the observed covariation among the regional corn yields in the simulations, empirical yield distributions were employed. The empirical yield distributions were constructed by adjusting observed 1972–88 county-level corn yields for secular trends by state to reflect 1989 production levels. Table 2 gives the expectation and the standard deviaton of the trend-adjusted state corn yields, together with the average 1989 corn program yields by state. Table 2 also gives the state yield "beta," a normalized measure of the covariance between the state corn yield Y_j and the national corn yield Y:

$$\beta_j = \frac{\text{Cov}(Y_j, Y)}{\text{Var}(Y)}. \tag{15}$$

Total demand for corn was formulated as the sum of domestic and export demand, both of which were specified in Cobb-Douglas form expressing quantity demanded in billions of bushels in terms of price in 1989 dollars per bushels. The constant term and elasticity for the domestic demand function were 6.615 and −0.3, respectively; the constant term and elasticity for the export demand function were 3.392 and −0.9, respectively.

Table 1. Number of Corn-Producing Counties and Corn Acreage by State

State	Number of Counties	Program Acres	Non-program Acres	Total Acres
		------- (million acres)		-------
Iowa	99	10.9	1.0	11.8
Illinois	100	8.3	2.0	10.3
Nebraska	82	6.2	0.7	6.8
Minnesota	70	5.0	0.6	5.7
Indiana	89	4.4	1.1	5.5
Ohio	74	2.7	0.8	3.5
South Dakota	46	2.6	0.2	2.8
Michigan	46	1.9	0.4	2.3
Wisconsin	56	1.9	1.0	2.9
Missouri	71	1.5	0.7	2.2
Texas	42	1.0	0.4	1.4
Kansas	52	1.0	0.1	1.2
North Carolina	48	0.8	0.5	1.3
Kentucky	50	0.7	0.6	1.4
North Dakota	12	0.5	0.0	0.5
Rest of U.S.[a]	342	3.2	4.0	7.2
U.S. Total	1,279	52.5	14.2	66.7

[a] Number reflects the aggregation of some smaller corn-producing counties into multicounty regions.

Revenue targets for the hypothetical national, state, and county target revenue programs were set so that each participating corn producer's expected deficiency payment was the same under each of the target revenue programs as under the target price program. This was accomplished by solving (14) numerically for the revenue target level for each region and program. It was further assumed, as a first-order approximation, that corn producers maximize expected profits. The constancy of the expected deficiency payment thus implies that corn producer acreage supply decisions will not vary across the four programs. Table 3 gives the state and national revenue targets for corn; county-level revenue targets have been omitted for lack of space.

Regional Revenue and Government Cost Stabilization

Supplemental disaster assistance is provided in response to widespread regional crop failures,

Table 2. Program Yield, Expected Yield, Yield Standard Deviation, and Yield Beta for Corn, by State

State	Program Yield	Expected Yield	Standard Deviation of Yield	Beta
	(Bushels/Acre)			
Iowa	117	120	17.0	1.27
Illinois	117	117	19.2	1.44
Nebraska	109	130	11.3	0.68
Minnesota	103	114	17.3	1.19
Indiana	110	116	16.3	1.17
Ohio	110	119	14.1	0.86
South Dakota	65	78	13.5	0.93
Michigan	97	99	11.5	0.67
Wisconsin	105	109	14.4	0.88
Missouri	93	101	20.2	1.45
Kansas	109	131	12.4	0.71
Texas	94	93	11.5	0.34
North Carolina	78	76	11.9	0.22
Kentucky	95	91	15.1	0.90
North Dakota	64	80	12.2	0.65
Rest of U.S.	88	100	11.6	0.43
U.S. Average	105	112	12.6	1.00

rather than isolated individual crop failures. If a deficiency payment program is to eliminate the demand for supplemental disaster assistance, it must limit revenue shortfalls at the regional level. In this section, we examine how target price and target revenue deficiency payment programs stabilize corn revenues at the county level. We also compare government expenditure variability across programs.

Table 3 gives expected revenues for deficiency payment program participants and nonparticipants by state and nationally. Because the deficiency payment expected by any participating corn producer is, by design, the same under the three target revenue programs as under the target price program, the expected net revenue for any participating producer is the same under all four programs. Regional price discrepancies arising from basis differentials are ignored; therefore, regional differences in market revenues for nonparticipants are exclusively the result of variations in regional corn yields. Re-

Table 3. Mean Expected Revenue for Corn Deficiency Payment Program Participants and Nonparticipants, by State, and Mean-Preserving State and National Revenue Targets

State	Non-participants	Participants	Revenue Target
	($/Acre)		
Iowa	229.5	331.2	331.2
Illinois	223.7	325.4	325.4
Nebraska	253.3	348.1	347.5
Minnesota	218.5	308.0	308.0
Indiana	221.7	317.3	317.3
Ohio	228.9	324.5	324.5
South Dakota	148.0	204.5	204.5
Michigan	192.5	276.8	276.3
Wisconsin	209.6	300.8	300.8
Missouri	191.0	271.9	271.9
Kansas	253.7	348.5	347.9
Texas	181.7	263.4	261.6
North Carolina	147.6	215.5	214.4
Kentucky	175.2	257.8	257.8
North Dakota	154.8	210.4	209.5
Rest of U.S.	194.6	271.2	269.5
U.S. Average	217.3	309.1	306.8

gional differences in market revenues for program participants further reflect the differences among regional program yields and revenue targets. A comparison of participant and nonparticipant expected revenues indicates that, under 1989 conditions, the typical participating U.S. corn producer would expect to receive a deficiency payment of nearly $92 per planted acre.

As shown in table 4, expected government deficiency payments to corn producers under each of the four programs total $4.82 billion annually. Total government expenditures, however, are substantially more stable under the target revenue programs than under the target price program. The standard deviation of government deficiency payment outlays is $2.35 billion under the target price program but $0.98, $0.93, and $0.91 billion under the national, state, and county target revenue programs, respectively. A target revenue program thus reduces government expenditure variability by about 60% relative to a target price program.

Table 5 shows the average variability of county-level per-acre corn revenues for participants under the four alternative deficiency payment programs and also for nonparticipants. A semivariance statistic is used to measure downside revenue variability. Specifically, revenue variability is measured by the standard semideviation, which is defined for any n revenue observations $R_1, R_2, \ldots, R_n$ with mean $\bar{R}$ as

$$(16) \quad s_R = \sqrt{\sum_{i=1}^{n} 2 \cdot (\max\{0, \bar{R} - R_i\})^2}.$$

The double counting of the negative revenue deviations assures that the semivariance measure is compatible with more conventional variability measures; specifically, if the distribution of the revenues is symmetric, the standard semideviation will equal the conventional standard deviation. The standard semideviation provides a measure of the downside revenue loss typically experienced by corn producers county-wide in below-normal years.

As seen in table 5, a target price deficiency payment program destabilizes county-level per-acre corn revenues, on average, in eleven of the top fifteen U.S. corn-producing states. For a typical U.S. corn-producing county, per-acre revenue variability is $29.60 per acre for nonparticipants, but $45.50 per acre for target price program participants. These findings support the view that the value of the current deficiency payment program to corn producers derives from the high level of income transfer it provides, not its ability to stabilize income.

A target price program destabilizes producer revenues by undermining the competitive market's natural revenue stabilization mechanism. In the absence of government price intervention, when aggregate yield falls, prices rise, and vice versa. This natural response of price to yield variations provides a moderating "natural hedge" against the revenue shortfalls that might otherwise result from yield shortfalls. A target price deficiency payment program stabilizes the effective price received by corn producers around the target price but removes the natural price hedge in the process (Grant, Miranda and Helmberger). Because the stabilizing effect of the natural hedge on regional revenues is strongest for regions whose yields are highly correlated with the national yield, it is precisely those regions that suffer the greatest revenue destabilization under a target price program. This assertion is confirmed by comparing the average county-level revenue variability to the state yield beta (table 2).

Target revenue programs do not destroy the natural hedge between price and yield and thus provide better overall revenue stability. Under a national target revenue program, most states exhibit significantly lower county-level revenue variability relative to a target price program. Only Nebraska, Kansas, Texas, and North Carolina fail to show a significant improvement under a national target revenue program. Notably, these are states in which the target price program is revenue stabilizing because of the low correlation between the state and national corn yields and the absence of an appreciable natural price hedge. For a representative U.S. county, corn

Table 4. Mean and Standard Deviation of Total Annual Government Deficiency Payments to Corn Producers Under Alternative Deficiency Payment Programs

	Target Price	National Target Revenue	State Target Revenue	County Target Revenue
	($ billion)			
Expectation	4.82	4.82	4.82	4.82
Standard deviation	2.36	0.98	0.93	0.91

Table 5. Standard Semi-Deviation of County-Level Per-Acre Corn Revenue Under Alternative Deficiency Payment Programs, Average by State

State	Nonparticipants	Target Price	National Target Revenue	State Target Revenue	County Target Revenue
	($/acre)				
Iowa	31.2	54.0	33.0	27.9	0.1
Illinois	27.2	61.0	32.0	21.8	0.0
Nebraska	33.0	27.1	26.5	19.9	1.7
Minnesota	27.1	47.4	28.3	18.0	0.1
Indiana	22.4	50.1	24.9	17.5	0.0
Ohio	31.2	42.7	25.5	18.2	0.1
South Dakota	21.5	32.4	22.9	15.0	0.5
Michigan	28.3	35.7	23.0	16.8	1.1
Wisconsin	27.1	45.4	25.7	17.0	1.0
Missouri	32.6	54.8	37.8	26.5	0.3
Kansas	39.8	33.0	33.4	27.4	2.6
Texas	37.3	31.2	30.7	23.4	4.1
North Carolina	34.4	30.8	30.7	18.0	2.2
Kentucky	28.7	49.9	32.9	18.3	0.2
North Dakota	24.0	26.8	21.9	12.8	1.7
Rest of U.S.	37.2	31.6	31.7	16.7	3.4
U.S. Average	29.6	45.5	29.3	21.0	0.7

revenue variability will be $29.30 per acre under a national target revenue program as compared to $45.50 per acre under a target price program, an improvement of 36%.

As shown in table 5, the amount of downside revenue protection afforded by a target revenue program substantially improves if the program is implemented on a state rather than national level. For the top fifteen corn-producing states, a state target revenue program stabilizes county-level revenues to a greater extent than either a target price or national target revenue program and in no case destabilizes revenues relative to nonparticipation. For a representative U.S. county, corn revenue variability will be $21.00 per acre under a state target revenue program, an improvement of 54% over a target price program.

The greatest stabilization of county-level revenues, however, is obtained through a county target revenue program. A county target revenue program will be more responsive to the effects of local crop failures than either state or national target revenue programs. Because of high levels of support implicit in the corn deficiency payment program in 1989, the equivalent county revenue targets are such that the probability of a county revenue exceeding its target will be negligible for the vast majority of U.S. corn-producing counties. In Iowa, Illinois, Minnesota, Indiana, and Ohio, states which account for over 60% of total U.S. corn production, a county target revenue program will reduce participant county-level revenue variability to less than 15¢ per acre on average. For a representative U.S. county, corn revenue variability will be less than 73¢ per acre, indicating a more than 98% improvement over the target price program.

Table 6 provides an indication of how the findings depend on the assumptions regarding the corn market model parameters. In this table, U.S. average county-level corn revenue variability under different deficiency payment programs are reported for the base case and for five scenarios. In the first four scenarios, the demand elasticities are varied over a wide range; in the remaining scenario, a reduction in the target price is considered. As seen in table 6, the findings regarding the superiority of the county target revenue program are robust with respect to demand elasticity specification. Under all four scenarios in which the elasticities are varied, county-level revenues are 98% more stable under a county target revenue program than under a target price program.

As seen in table 6, the stabilizing effects of a county target revenue program are still substantial, though less dramatic, if the target price is significantly reduced. Specifically, if the target price is lowered by 60¢ per bushel, county-level revenue variability will be $5.30 per acre under the county target price program offering the same level of support. This level of variability, how-

Table 6. Standard Semi-Deviation of County-Level Per-Acre Corn Revenue Under Alternative Deficiency Payment Programs and Alternative Corn Market Model Parameterizations, U.S. Average

Scenario	Nonparticipants	Target Price	National Target Revenue	State Target Revenue	County Target Revenue
	($/acre)				
Base case	29.6	45.5	29.3	21.0	0.7
Domestic elasticity = 0.1	30.4	45.4	29.1	20.9	0.2
Domestic elasticity = 1.0	27.7	42.9	27.9	20.1	0.1
Export elasticity = 0.1	31.0	45.6	29.4	21.1	0.9
Export elasticity = 2.0	27.4	44.5	28.6	20.5	0.5
Target price = $2.25	29.6	33.8	29.3	22.0	5.3

ever, still represents an 84% reduction relative to the target price program. When the target price is reduced, the corresponding revenue targets fall. Because the revenue targets are lower and thus less effective at truncating the revenue distribution, revenues become less stable under the county target revenue program. These results suggest that a county target revenue program may not eliminate the demand for supplemental disaster assistance entirely if the overall level of support provided by the program, and thus the revenue targets, are low.

Individual Revenue Stabilization

We now examine how target revenue deficiency payment programs stabilize revenues of individual corn producers relative to a target price program. We begin by constructing a model of how a representative corn producer's yield is distributed conditional on the surrounding county yield. We then link the individual yield model to the regional corn model developed above and simulate the combined model to estimate the revenue variability experienced by individual corn producers under alternative deficiency payment programs.

An individual corn producer's yield, say yield Y_{ij} of individual i in county j, is related to the county yield Y_j through the identity

$$(17) \qquad Y_{ij} = \bar{Y}_{ij} + \beta_{ij} \cdot (Y_j - \bar{Y}_j) + \tilde{\epsilon}_{ij},$$

where $\bar{Y}_{ij}$ is the producer's expected yield, $\bar{Y}_j$ is the expected county yield, and $\tilde{\epsilon}_{ij}$ is a zero-mean random variable that is uncorrelated with the county yield. Here,

$$(18) \qquad \beta_{ij} = \text{Cov}\,(Y_{ij}, Y_j)/\text{Var}(Y_j)$$

measures the sensitivity of the producer's yield to systemic factors that affect the county yield. The producer's beta coefficient can be equivalently and more conveniently written as the product

$$(19) \qquad \beta_{ij} = \rho_{ij} \cdot \frac{\sigma_{Y_{ij}}}{\sigma_{Y_j}}$$

of the correlation between the producer's yield and the county yield ρ_{ij} and the ratio of the standard deviations of the producer's yield $\sigma_{Y_{ij}}$ and the county yield σ_{Y_j} (Miranda).

Equation (17) is an identity by construction and requires no special assumptions to hold. To construct a complete working model of individual corn yields, however, requires some distributional assumptions. First, the individual yield residual $\tilde{\epsilon}_{ij}$ is assumed conditionally independent of the county yield Y_j. This is a mild assumption given that the two random variables are uncorrelated by construction. Second, the residual yield term $\tilde{\epsilon}_{ij}$ is assumed normally distributed conditional on the county yield. This, too, places only mild restrictions on the shape of the producer's yield distribution since most individual yield variation is captured by the county-systemic terms $\beta_{ij} \cdot (Y_j - \bar{Y}_j)$, whose distribution is specified nonparametrically and empirically. Given these assumptions, an individual corn producer's yield distribution is completely determined by the expected yield, the yield variability, and the correlation between the yield and the county yield.

Table 7 shows individual per-acre revenue variability for representative corn producers under alternative deficiency payment programs. Nine representative producers, classified according to the variability of their individual yield and the correlation of their individual yield to their county yield, are considered. The figures reported in table 7 represent the acreage-weighted averages across all U.S. corn-producing counties of the representative individual revenue variabilities as measured by the standard semide-

Table 7. Standard Semi-Deviation of Per-Acre Revenue for Representative U.S. Corn Producers Classified According to the Correlation between Their Individual Yield and the County Yield and the Variability of Their Individual Yield Relative to the County Yield

Yield Correlation	Program	Relative Yield Variability[a] 120%	140%	160%
		($/acre)		
.5	Target price	46.9	54.9	62.9
	Target price & crop insurance	42.1	47.9	53.6
	National target revenue	41.6	48.2	55.1
	State target revenue	40.3	46.2	52.6
	County target revenue	38.7	43.9	49.8
.7	Target price	49.6	58.1	66.6
	Target price & crop insurance	46.0	53.0	60.0
	National target revenue	39.3	46.4	53.8
	State target revenue	35.6	41.8	48.6
	County target revenue	30.9	36.2	42.4
.9	Target price	53.0	62.1	71.3
	Target price & crop insurance	51.6	60.2	68.8
	National target revenue	37.6	45.4	53.6
	State target revenue	30.4	37.4	45.2
	County target revenue	19.9	26.2	33.7

[a] Standard deviation of the individual yield as a percentage of the standard deviation of the county yield.

viation. Each representative corn producer's expected yield and program yield are assumed to equal the county average.

In addition to the one target price and three target revenue schemes examined thus far, we also consider revenue variability under a target price program assuming that federal crop insurance is purchased by the producer. The producer is assumed to elect yield guarantee of 75% of normal yield and a price guarantee of 90% of expected price, the most common choices under the current crop insurance program. Thus, if the insured individual's corn yield falls below 75% of normal, the individual receives a per-acre indemnity payment equal to the yield shortfall times the price election. The insured producer's premium payment is assumed to be actuarially fair; that is, the premium equals the expected indemnity.

As seen in table 7, crop insurance provides only a modest improvement in the individual revenue risk protection offered by a target price program. This result is not particularly surprising in light of the significant limitation of coverage imposed by the 25% deductible. Suggestions to lower the deductible to improve individual coverage historically have been resisted because doing so would promote substantial moral hazard.

As seen in table 7, state and county target revenue programs consistently outperform the target price program, even when the latter is supplemented with crop insurance. Relative to a target price deficiency payment program with crop insurance, the improvement in individual revenue risk reduction afforded by a county target revenue program ranges from 7% (from \$53.60 to \$49.80 per acre) for the low correlation, high variance producer to 61% (from \$51.60 to \$19.90 per acre) for the high correlation, low variance producer. Although not reported, these patterns persist on a state-by-state basis.

A county target revenue program does not base deficiency payments on individual revenue losses and thus is not, strictly speaking, a revenue insurance program. A target revenue program is more comparable to a free put option in which the county revenue target plays the role of the strike price and the county revenue plays the role of the price of the underlying security (Gardner, Marcus and Modest). Because the county target revenue program offers a hedge rather than pure insurance against individual revenue risk, its effectiveness at reducing individual revenue risk depends mainly on the correlation between the producer's individual revenue and the county revenue.[4] As seen in table 7, the improvement afforded by a county target revenue program is

[4] By addressing price and yield risk simultaneously, the target revenue program may be viewed as a generalization of the area-yield crop insurance scheme, which has recently received renewed attention (Halcrow, Miranda).

substantial if the producer's yield is highly correlated with the county yield but is more modest for lower degrees of correlation.

The concern over individual income risk coverage raises the question whether an individualized target revenue program, in which payments are based on individual revenue shortfalls, might not be more desirable than a county target revenue program. An individualized target revenue program providing the high level of income transfer associated with the current deficiency payment program, however, would give rise to severe moral hazard and thus would not be sustainable. Moral hazard would not only lead to serious resource misallocation, it would also raise overall government direct expenditures on the program. In order to combat moral hazard and to recover the increased costs, the government would ultimately have to lower substantially the revenue targets under an individualized program, thereby reducing the level of income transfer and the revenue risk protection provided by the program. A county target revenue program, in contrast, would not be subject to moral hazard, regardless of the overall level of income transfer provided by the program.

Conclusions

This paper has examined a modification of the current deficiency payment program that would address a pervasive weakness of current federal income support programs: the failure to provide producers with adequate protection in the event of a widespread crop failure. Under the modified deficiency payment program, payments would be based on shortfalls in regional per-acre revenues relative to a specified revenue target rather than on shortfalls in price. Because yield and price are negatively correlated, deficiency payments would be higher under a target revenue program than under a target price program when yields are low, thereby providing improved income protection in the event of a crop failure.

A regional model of the U.S. corn market was used to evaluate national, state, and county target revenue deficiency payment programs. Our analysis indicates that for the same cost as the current target price program, a county target revenue program for corn would dramatically reduce county-level revenue variability and would stabilize government deficiency payment program outlays. A county target revenue program would provide better individual income risk protection to corn producers than the current target price program, even when the latter is supplemented by individualized crop insurance, and would not be subject to the moral hazard problems that have historically undermined the actuarial performance of the federal crop insurance program. More important, however, a county target revenue program providing the same overall level of support as is currently enjoyed by corn producers would place a sufficiently high floor on county-level corn revenues that the demand for supplemental disaster assistance would be significantly reduced if not eliminated.

Sensitivity analysis suggests that our findings are robust to parametric specification and thus should hold for comparable program crops. Care should be taken, however, not to generalize the findings to crops currently not receiving significant income support. A target revenue program for non-program crops would presumably require compensating premium payments from producers to operate on an actuarially sound basis. If premiums are to remain moderate, the associated revenue targets would be low relative to normal revenue expectations and might not provide the high floors on regional revenues that would obtain for program crops. Analysis of target revenue programs for nonprogram crops, as well as for program crops other than corn, must be conducted before generalizations about the cost effectiveness of target revenue programs can safely be made. Our findings suggest that such studies may well be worth while, particularly in light of the high cost of recurring disaster assistance legislation.

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