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ESTIMATING THE COSTS OF REVENUE ASSURANCE

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ABSTRACT

This study estimates the government cost of revenue assurance, one of the many proposals for the 1995 Farm Bill. Under the assumptions of nonnegativity and normality of revenue, a formula for computing the government cost of revenue assurance is derived. This formula is employed to estimate per acre revenue assurance costs at the 70, 75, and 80 percent levels of expected revenue coverage. These costs are compared with results from previous studies and with crop insurance premiums. The relative impacts of changes in yield mean, yield standard deviation, and price-yield correlation are also explored through metamodel analysis. The costs estimated for revenue assurance show that this program would result in substantial budget savings over the current program.

ESTIMATING THE COSTS OF REVENUE ASSURANCE

The U. S. Congress is likely to consider alternative policies ranging from continuation of current farm programs to a complete restructuring of agricultural programs in the 1995 Farm Bill debate. Increasingly vocal criticisms of existing agricultural policies are questioning their survivability, as expressed by Luther Tweeten (1993):

Six decades ago a generous uncle began assistance to an agricultural industry that had fallen on hard times. That assistance is viewed as an entitlement, although agriculture now is financially resilient, dynamic, robust, and capable of adjusting to supply-demand shocks likely in future decades without income support. . . . Agriculture is no longer an industry of low income or low returns on resources nor would it be without commodity programs. Commodity programs transfer income from lower income/wealth taxpayers to higher income/wealth producers. Given the pressing need to promote economic efficiency and to reduce federal outlays and thereby the national debt, a strong case can be made for a transition program to end government intervention in agricultural markets.

A wide range of government programs is used to provide farmers with stable prices and incomes on the basis of the instability of agricultural production and prices. Crop insurance and disaster relief programs seek to protect producers against yield loss. The sum of three agricultural disaster assistance programs (crop insurance, emergency FmHA loans, and ASCS disaster relief payments) amounted to more than \$25 billion between 1985 and 1993 at an annual average cost of \$3.1 billion. Most of these outlays represented payments to compensate farmers for yield shortfalls (Goodwin and Smith 1994).

One proposal, by the Iowa Farm Bill Study Team, would make fundamental changes in the structure of commodity programs by using a revenue protection program as a substitute for the existing target price, crop insurance, and disaster assistance programs. This "Iowa Plan" proposes that producers be provided with catastrophic revenue assurance coverage equal to 70 percent of the "normal" crop revenue. "Normal" crop revenue is defined as the producer's average yield for the past five years times the average county price for the same five years. The

revenue assurance program would replace deficiency payments, crop insurance, and disaster assistance. The acreage reduction program (ARP) and program crop acreage bases would be eliminated and producers would be allowed to plant any crop on any acres on their farms. The U. S. government would continue to provide some price support through the Farmer Owned Reserve. Appendix A provides details on the proposed revenue assurance specifications.

In short, revenue assurance is a guaranteed revenue plan that primarily evens out the fluctuations in farm revenue. The guaranteed revenue is based upon historical crop yields and prices. A farmer commits to a package that might substitute for current crop insurance, disaster payments, fixed target prices, and deficiency payments (Doering 1994; Harrington 1994).

This study provides estimates of the government cost of the revenue assurance program. Sensitivity analysis is also conducted by varying specifications such as the revenue assurance level. Metamodels are estimated to examine the magnitudes of the effects of yield distributions and price-yield correlation on costs.

Agricultural Risks and Statistical Relationships

Agricultural production involves numerous risks. In crop production, three major components of farm income (price, yield, and production cost) involve risk. Risk in production costs is usually relatively small so the major sources of risk are from price and yield. Thus, gross revenue risk (revenue is price times yield) comprises the main component of farm-level risk and understanding farm-level revenue behavior is crucial to analyzing this risk. Because price is usually negatively related to yield, the analysis is complex. Preferably, distributions for yield, price, and revenue (for each crop and farmer) can be established reliably. However, due to lack of farm-level data, it is usually difficult and time-consuming for such an attempt.

For two random variables, price and yield, if they are not independent (Mood, Graybill, and Boes, 1994, p. 180), then

$$E(py) = \mu_p \mu_y + \sigma_{py}, \quad (1)$$

$$V(py) = \mu_y^2 \sigma_p^2 + \mu_p^2 \sigma_y^2 + 2\mu_p \mu_y \sigma_{py} - \sigma_{py}^2 + E\left[(p - \mu_p)^2 (y - \mu_y)^2\right] + 2\mu_p E\left[(p - \mu_p)(y - \mu_y)^2\right] + 2\mu_y E\left[(p - \mu_p)^2 (y - \mu_y)\right]. \quad (2)$$

If they are independent, i.e., $\text{cov}(p, y) = \sigma_{py} = 0$, then

$$E(py) = \mu_p \mu_y, \text{ and } V(py) = \mu_y^2 \sigma_p^2 + \mu_p^2 \sigma_y^2. \quad (3)$$

Specifications proposed by Iowa Farm Bill Study Group are briefly described here. Expected revenue from a crop on a farm (6) is proposed to be estimated using a 5-year moving average yield (4) times a 5-year moving average price (5). The trigger revenue or guaranteed level can be specified as a proportion (α , say 70 percent) of the expected revenue (7).

$$E(y_t) = (1/5) \sum_{i=1}^5 y_{t-i} \quad (4)$$

$$E(p_t) = (1/5) \sum_{i=1}^5 p_{t-i} \quad (5)$$

$$E(p_t y_t) = (1/5) \sum_{i=1}^5 p_{t-i} y_{t-i} \quad (6)$$

$$\bar{R}_t = \alpha E(p_t) E(y_t) \quad (7)$$

Recall that $E(p_t y_t) = E(p_t) E(y_t) + \sigma_{py}$, where σ_{py} is the covariance between p_t and y_t . So $E(p_t y_t) \neq E(p_t) E(y_t)$ when p_t and y_t are correlated. Specifically, $E(p_t y_t) < E(p_t) E(y_t)$ when p_t and y_t are negatively correlated ($\sigma_{py} < 0$). In order to account for negative price-yield correlation, $E(p_t y_t)$ is used in this study for estimating purposes rather than $E(p_t) E(y_t)$. Table 1 shows the average price-yield correlations by crop from 1984 through 1993.

Table 1. Average price-yield correlation, by crop, 1984-1993

Crop	Correlation	Crop	Correlation
Barley	-0.10	Rice	-0.16
Corn	-0.36	Sorghum	-0.32
Cotton	-0.10	Soybeans	-0.34
Oats	-0.13	Wheat	-0.21

Each farmer has a risk profile for each crop on the farm. Different farmers will generally have quite different yield distributions (Goodwin 1994). Also, there are price risks and price tends to be negatively correlated with yield. If yield is low but price is high enough, a farmer may not face any economic hardship. Revenue assurance provides protection only when it is needed; most farmers would seldom need payments under 70 or 80 percent of revenue assurance (Hennessy, Babcock, and Hayes 1995). When payments are needed, farmers with high revenue variability would gain more than farmers with low revenue variability at the same expected revenue. The expected program cost (government cost of revenue assurance) can then be estimated according to the distribution of revenue and the revenue guarantee level. Since revenue assurance is free to producers, the estimates for the expected payment received by farmers would be the same as expected cost to the government less administrative costs. The costs of revenue assurance can be represented as

$$c = \int_y \int_p (\bar{R} - py)f(p, y)dpdy, \quad (8)$$

where \bar{R} is the revenue target and $f(p, y)$ is the joint probability density of yield and price that characterizes the revenue distribution.

Comparative statics indicate that as the revenue guarantee level increases, the cost of revenue assurance will increase (9). As either price or yield variability rises, revenue assurance costs rise (10). Also, revenue assurance costs are lower with more negative price-yield correlations (11):

$$\partial c / \partial \bar{R} > 0 \Rightarrow \partial c / \partial \alpha > 0, \quad (9)$$

$$\partial c / \partial \sigma_p > 0, \quad \partial c / \partial \sigma_y > 0, \quad \text{and} \quad (10)$$

$$\partial c / \partial \sigma_{py} < 0. \quad (11)$$

While it is difficult to estimate a joint probability distribution of yield and price, an alternative method is to directly estimate a revenue distribution. Revenue is calculated by price times yield. Consider equation (12) as a substitute for equation (8):

$$c = \int_r (\bar{R} - r)f(r)dr, \quad (12)$$

where $r = py$ and $f(r)$ is the revenue probability distribution. This form implicitly considers the expected negative price-yield correlation.

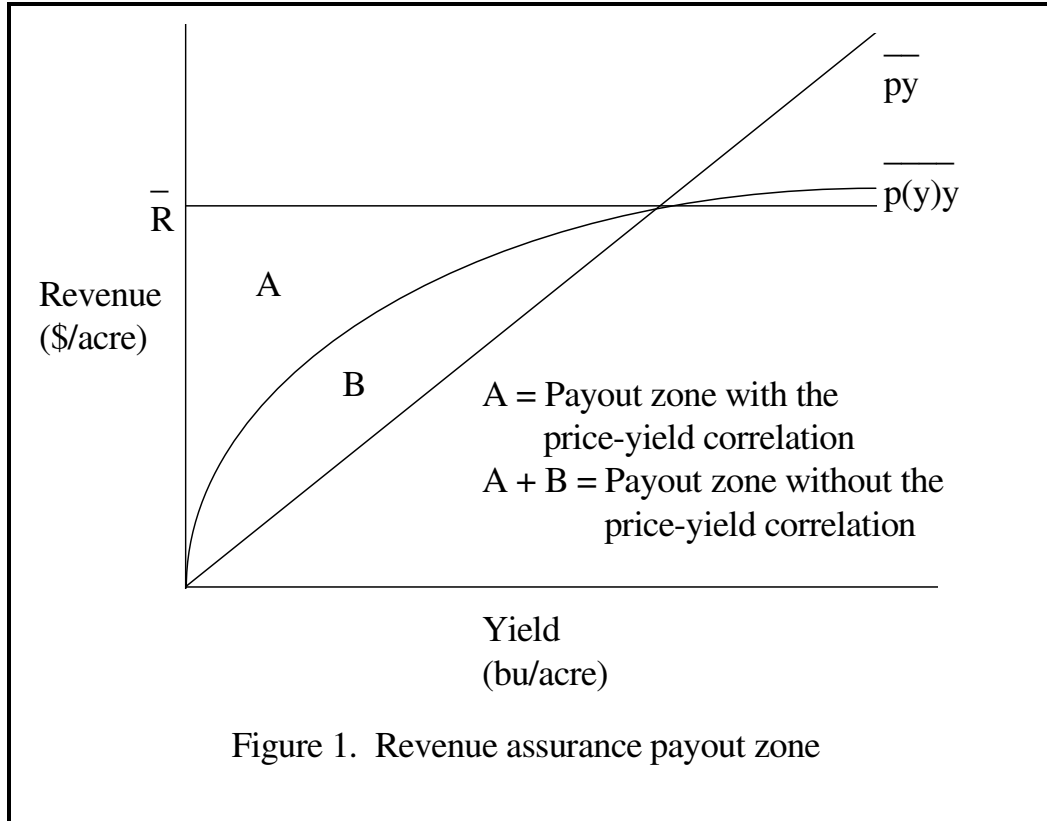
Again, similar results to the previous case can be expected. Higher revenue assurance costs are expected with higher revenue guarantee levels, higher price and/or yield variabilities, and less negative price-yield correlations (13). The impacts of the variabilities and the correlation come through their effects on the variability of revenue,

$$\partial c / \partial \bar{R} > 0; \partial \sigma_r / \partial \sigma_p > 0, \partial \sigma_r / \partial \sigma_y > 0, \partial \sigma_r / \partial \sigma_{py} < 0, \partial c / \partial \sigma_r > 0. \quad (13)$$

Yield, price, and/or revenue variability will change depending on aggregation level. The variability will increase at lower levels of aggregation. For example, farm-level yield variability would be higher than that at the state level. The implication of this variability difference is that the estimated cost for revenue assurance would appear higher at the farm level than at the county or state level. Specifically, we have:

$$\sigma_f \geq \sigma_c \geq \sigma_s \Rightarrow c_f \geq c_c \geq c_s. \quad (14)$$

Assuming price is negatively correlated with yield, cost will be overestimated when price-yield correlation is ignored. This is illustrated in Figure 1. When price is independent on yield, revenue is given by a straight line, such as \overline{py} . When price is negatively correlated with yield, the revenue line is concave, a quadratic, for example, as $\overline{p(y)y}$. For a guaranteed level \bar{R} , revenue assurance payment zone is A when price is negatively correlated with yield, and (A + B) when price is independent on yield. The difference in cost is B.



Yield, price, and/or revenue variability can be compared with and without revenue assurance to examine the effectiveness of the proposed program. The effectiveness of revenue assurance would depend on the assurance guarantee level, and yield, price, and revenue distributions. In estimating yield mean and variability, some previous studies have used detrended yields (Skees and Reed, 1986; Miranda, 1991). Yield variability around a trend yield would be less than that actual yields. Use of actual yields without detrending would increase yield variability estimates and therefore revenue variability. The cost of revenue assurance would be overestimated without detrending yield. Because yield data are available for only a small number of years (10 years, from 1984 to 1993), no obvious trend is observed for this period. Yield is therefore not detrended.

Moral hazard could be a potential problem under revenue assurance. A farmer might have no incentive to seek the highest price when yield is known and price cannot make revenue to exceed the assurance level. For example, when yield is known at y_0 , a farmer would be indifferent among price levels as long as the highest possible price cannot make revenue exceed

the assurance level. In this case, another party can take the advantage by buying at a low price and selling for a profit. Using the market price to establish the guarantee level could mitigate the problem. Similarly, farmers may be encouraged to have a crop failure at low yields rather than harvest additional bushels of the crop at additional harvest expense per bushel as there is a wide range of yield where gross revenue remains the same (Doering 1994).

The Revenue Assurance Cost Formula

Under the assumptions of normality of gross revenue and nonnegativity of revenue, the per acre cost of revenue assurance can be estimated for each analytical unit (say, insurance unit, IU). The normal density function for R , with mean μ and variance σ^2 , is given by

$$f(R) = \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-0.5((R - \mu)/\sigma)^2\right). \quad (15)$$

The truncated density function for R imposing revenue nonnegativity is defined by

$$f(R|R \geq 0) = \frac{f(R)}{\Pr(R \geq 0)} = [\Pr(R \geq 0)]^{-1} \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-0.5((R - \mu)/\sigma)^2\right) \text{ for } R \geq 0. \quad (16)$$

The term $\Pr(R \geq 0)$ is derived as

$$\begin{aligned} \Pr(R \geq 0) &= \int_0^{\infty} f(R) dR = \int_0^{\infty} \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-0.5((R - \mu)/\sigma)^2\right) dR \\ &= \int_{-\mu/\sigma}^{\infty} \frac{1}{\sqrt{2\pi}} \exp(-0.5Z^2) dZ = 1 - \Phi(-\mu/\sigma) = \Phi(\mu/\sigma). \end{aligned} \quad (17)$$

Then we have

$$f(R|R \geq 0) = [\Phi(\mu/\sigma)]^{-1} \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-0.5((R - \mu)/\sigma)^2\right). \quad (18)$$

Let the revenue assurance level be $\lambda\mu$, where $0 \leq \lambda \leq 1$. Government cost for revenue assurance is defined as

$$\begin{aligned} c &= \int_0^{\lambda\mu} (\lambda\mu - R)f(R|R \geq 0)dR = [\Phi(\mu / \sigma)]^{-1} \int_0^{\lambda\mu} (\lambda\mu - R)f(R)dR \\ &= [\Phi(\mu / \sigma)]^{-1} \left[\frac{\sigma}{\sqrt{2\pi}} \exp\left(-0.5((\lambda - 1)\mu / \sigma)^2\right) + (\lambda - 1)\mu\Phi[(\lambda - 1)\mu / \sigma] \right]. \end{aligned} \quad (19)$$

Once the parameter λ is specified and μ and σ are estimated for a unit (a crop on a farm, a county, a state, or the United States), the per acre cost of revenue assurance can then be calculated using the formula in (19).

Let the revenue assurance cost for a farmer in a particular state be c_{sf} . State average cost on revenue assurance (C_s) is calculated as

$$C_s = F^{-1} \sum_{f=1}^F c_{sf}. \quad (20)$$

Let the corn acreage in a state be (A_s). Federal government costs of revenue assurance less administrative costs (GC) is calculated as

$$GC = \sum_{s=1}^S C_s A_s. \quad (21)$$

The Empirical Data

The eight crops included in this study are barley, corn, cotton, oats, rice, sorghum, soybeans, and wheat. Actual Production History (APH) yield data are from the Federal Crop Insurance Corporation (FCIC). The APH data set contains ten years of historical yield data from 1984 through 1993 with records at the insurance unit (IU) level. Only actual yield data are used in the analysis and yield data that are doubtful are deleted. For example, records with yields higher than 400 bushels per acre for corn are deleted. Yield records that are missing for any year

in the ten-year period and duplicate records are also deleted. The number of records for each crop is presented in Table 2.

Table 2. Number of insurance units for the eight crops

Crop	No. Records	Crop	No. Records	Crop	No. Records
Corn	36619	Sorghum	3460	Barley	427
Wheat	16449	Cotton	1689	Oats	66
Soybeans	15071	Rice	567	Total	77348

Price data for each crop and state are used in calculating gross revenue for each IU in a particular year. The mean and standard deviation of gross revenue over time are calculated for each IU. Data at micro-level is limited to perform a reliable statistical test regarding normality of revenue. Instead, a test on normality of revenue is performed using state-level data.

The Shapiro-Wilk test is used for testing 1980-1993 state-level revenue data for normality. In this test, the Shapiro-Wilk statistic, \mathbf{W} , is calculated with small values of \mathbf{W} leading to the rejection of the null hypothesis of normality. \mathbf{W} is the ratio of two variance estimators: the best estimator based upon the square of a linear combination of order statistics and the corrected sum of squares estimator. \mathbf{W} is bound between zero and one and has a highly skewed distribution. To obtain significance levels for \mathbf{W} , Royston's approximate normalizing transformation (22) is applied to convert \mathbf{W} into a standard normal variate, \mathbf{Z} .

$$\mathbf{Z} = \sigma^{-1} \left((1 - \mathbf{W})^\gamma - \mu \right), \quad (22)$$

where σ , γ , and μ are functions of the number of observations and are estimated from simulation results. Large values for \mathbf{Z} indicate departures from normality (SAS 1992, p.627-28). The SAS statistical package provides probabilities for the Shapiro-Wilk statistic in this manner. If the probability level is less than the chosen significance level, then the null hypothesis of normality can be rejected. Several states are tested for each crop. Table 3 reports the results of the Shapiro-Wilk tests. From these results, it appears the assumption of normally distributed revenues is justifiable. Of the 125 crop-state combinations examined, only 8 state crop revenues can reject the assumption of a normal distribution.

Table 3. Results from the Shapiro-Wilk Test for Normality of Revenue, 1980-1993

Crop	Number of states tested	Number of states where normality is not rejected
Barley	14	14
Corn	23	18
Cotton	8	7
Oats	15	15
Rice	6	4
Sorghum	9	9
Soybeans	25	25
Wheat	25	25
Total	125	117

Note: at the 5 percent level of significance.

Based on the FCIC yield data and state-level farm prices, farm revenues are computed over the 1984 to 1993 period. From these revenues, estimates of the farm-level coefficient of variation (standard deviation/mean) of revenue are formed for the eight crops. Forecasted state-level values of farm prices, acres planted, and yields computed from regional FAPRI revenue assurance scenario figures are combined with the estimated farm-level coefficient of variation of revenue from the FCIC data set to complete the needed data for the revenue assurance cost estimates for 1996-2003. Table 4 contains the estimated coefficients of variation for the crops. Corn, rice, and soybeans have the lowest coefficients of revenue variation, while cotton and oats have the highest.

Table 4. Coefficients of revenue variation by crop, 1984-1993

Crop	Coefficient of Variation
Barley	0.3266547
Corn	0.2739777
Cotton	0.3978268
Oats	0.4406353
Rice	0.2782905
Sorghum	0.3413951
Soybeans	0.2460898
Wheat	0.3638209

Revenue Assurance Cost Estimates

The expected per acre cost of revenue assurance is estimated using equation (19). The λ is set at 0.7, 0.75, and 0.8 to estimate revenue assurance costs for coverage levels of 70, 75, and 80 percent of revenue. The μ is computed dynamically as the average revenue for the crop for each state over the previous 5 years and σ is computed as μ multiplied by the farm-level revenue coefficient of variation for the crop. This formulation of σ gives the state-level revenue farm-level revenue variability, a key component of the costs of a revenue assurance program.

Table 5. The 1996-2003 average per acre and total revenue assurance costs and average acreage covered

Crop	Acres (mill.)	Per Acre Cost (\$/acre)			Total Cost (mill. \$)		
		70%	75%	80%	70%	75%	80%
Barley	5.32	3.24	4.26	5.51	17.2	22.6	29.3
Corn	80.41	5.41	7.66	10.60	435.4	616.6	852.9
Cotton	12.40	18.68	23.09	28.24	231.6	286.3	350.2
Oats	4.43	4.95	5.97	7.13	21.9	26.4	31.6
Rice	2.48	8.62	12.12	16.65	21.3	30.0	41.2
Sorghum	11.05	5.11	6.62	8.45	56.5	73.2	93.5
Soybeans	62.49	2.71	4.06	5.90	169.3	253.7	369.0
Wheat	72.52	5.33	6.76	8.47	386.6	490.5	614.4
Total	251.09	5.33	7.16	9.48	1339.9	1799.4	2382.2

The revenue assurance costs are average costs for the 1996-2003 projection period. The cost of revenue assurance differs by crop. The 1996-2003 average per acre and total revenue assurance costs and average total acres covered by crop are given in Table 5. Soybeans has the lowest average per acre costs of revenue assurance at the 70 percent coverage level at \$2.71; cotton has the highest at \$18.68. Overall, average per acre revenue assurance costs at the 70 percent coverage level is \$5.33. Average costs rise to \$5.90, \$28.24, and \$9.48 for soybeans, cotton, and the total for 80 percent coverage. Corn revenue assurance costs per acre are \$5.41, \$7.66, and \$10.60 for the 70, 75, and 80 percent coverage levels. Wheat revenue assurance costs per acre are \$5.33, \$6.76, and \$8.47 for the 70, 75, and 80 percent coverage levels. Average total costs for revenue assurance are \$1.34 billion for 70 percent coverage and \$2.38 billion for 80 percent coverage.

Table 6. The 1996-2003 average per acre revenue assurance costs by state and crop

Crop	State	Per Acre Costs		
		70%	75%	80%
		(\$/acre)		
Corn	Illinois	5.84	8.26	11.43
Corn	Iowa	5.54	7.84	10.85
Cotton	Mississippi	24.91	30.80	37.68
Cotton	Texas	14.67	18.13	22.18
Rice	Arkansas	8.24	11.58	15.91
Rice	California	11.40	16.02	22.01
Rice	Texas	9.89	13.91	19.11
Soybeans	Illinois	3.11	4.66	6.77
Soybeans	Iowa	3.08	4.62	6.72
Wheat	Kansas	4.74	6.01	7.53
Wheat	North Dakota	4.75	6.03	7.55

The cost of revenue assurance differs by state. Table 6 contains the 1996-2003 average per acre revenue assurance costs for selected states and crops. Per acre costs of revenue assurance for corn in Iowa range from \$5.84 for 70 percent coverage to \$11.43 for 80 percent coverage. In Kansas, wheat per acre costs of revenue assurance are \$4.75 for 70 percent coverage and \$7.53 for 80 percent coverage. Cotton shows some of the largest variation in state-level per acre revenue assurance costs. For example, at 70 percent coverage, per acre costs of revenue assurance for Mississippi and Texas differ by more than \$10. This difference increases to more than \$15 at 80 percent coverage.

Analytically, it is logical that the revenue assurance cost should be less than the yield insurance cost (premium) under that same percentage coverage if there is any negative price-yield correlation. Rain and Hail Insurance Services has provided cost estimates for 69 percent yield coverage for corn. Table 7 displays estimated state-level average costs for revenue assurance and yield insurance for corn. For 69 percent yield coverage, per acre costs are \$8.57 in Iowa and \$9.81 in Illinois. These numbers are compared to per acre costs of \$5.54 in Iowa and \$5.84 in Illinois under 70 percent assurance. Average per acre cost is \$9.13 for 69 percent yield coverage versus \$5.41 for 70 percent assurance. Estimates on revenue assurance costs are comparable to

those reported in Harwood et al (1994). However, the estimates here are higher than in Harwood et al. but they follow a similar ranking among states.

Table 7. Comparison of revenue assurance and yield insurance per acre costs for corn

State	70%, FAPRI	70%, Harwood et al. (\$/acre)	69%, RHIS
Illinois	5.84	4.74	9.81
Indiana	6.07	4.17	9.94
Iowa	5.54	2.36	8.57
Minnesota	5.22	4.04	8.90
Nebraska	5.85	4.26	8.01
US Average	5.41	4.06	9.13

There are several differences in estimating costs of revenue assurance. First, state prices rather than the U.S. prices are used here. Second, yield is not detrended here. Third, expected cost of revenue assurance for each IU is estimated assuming a normal distribution for revenue. Fourth, an adjusted distribution is used by imposing a restriction of nonnegative gross revenue. Harwood et al. does not impose distributional assumptions but instead uses the empirical data. Also, different time periods are examined. Therefore, while the differences in costs can not be solely attributed to price effects (different data sets are used), price is certainly one major reason for the difference.

Table 8 reports estimates on government program expenditures of the current program and the revenue assurance program. Average yearly payments under the revenue assurance programs have been computed with and without transitional payments. The transitional payments are computed by taking a fixed percentage of the average total deficiency payments over the period 1991 to 1995 (actual for 1991-94, projected 1995). For example, in 1996 the transitional payment is equal to 80 percent of this average total deficiency payment. In 1997, the transitional payment is 60 percent of this average and so on. The current program payouts are projected deficiency payments over the period. Under the 70 percent coverage level, average revenue assurance payments are over three billion dollars less than average deficiency payments even when transitional payments are included. Even at the 80 percent coverage level, the average budgetary savings from the revenue assurance program is more than \$2 billion.

Table 8. Average yearly payments under the current program and revenue assurance, 1996-2003

	Without Transitional Payments	With Transitional Payments
	(billion \$)	
Current Program	6.07	6.07
70% Revenue Assurance	1.34	2.88
75% Revenue Assurance	1.80	3.34
80% Revenue Assurance	2.38	3.92

Metamodel Analysis

To characterize relationships between the cost of revenue assurance, yield distributions, and price-yield correlations, a metamodel is specified in (23). A metamodel is a model of simulated results or a model of results from various studies. A metamodel represents research findings in a more systematic and statistical way so that systematic relationships are more likely to be discovered if they exist. Analysis using metamodels can be performed across a number of studies, on multiple findings within one study, or both. The basic assumption underlying a metamodel is that each study (simulation) result is an observation that can be thought of as one data point in a larger dataset containing all possible observations, given the true relationship being studied (Marra and Schurle 1994). There are two major questions posed by metamodel analysis: (1) Is the effect of factor x on outcome y significant, and (2) What is the size of the effect of factor x on outcome y (Hunter, Schmidt, and Jackson 1982)? A metamodel is then a useful tool for establishing empirical relationships among variables of interests. It is a simple analytical tool capable of abstracting relationships among interested variables (Bouzaher et al. 1993). A major advantage of a metamodel is that it contains essential information of numerous results in a compressed form. It can therefore be used to “predict” the effects that may not be included in the simulations due to high costs and impracticality of exhausting all simulation possibilities. Metamodel (23) is estimated under various assurance levels. The metamodel is used to examine the effects of distributional parameters of yield and price-yield correlation:

$$c_{sf} = \alpha_s + \beta_s \mu_{sf}^y + \gamma_s \sigma_{sf}^y + \eta_s \rho_{sf}^y + \varepsilon_{sf} \quad \forall s, \quad (23)$$

where $\mu_{sf}^y, \sigma_{sf}^y$ are the mean and standard deviation of yield for each IU, and ρ_{sf}^y is the price-yield correlation. Parameters $\beta, \gamma,$ and η are the effects of yield mean and standard deviation, and price-yield correlation. While the effect of mean yield is expected to be negative, the effects of yield standard deviation and price-yield correlation are expected to be positive.

Table 9. Metamodel results for corn

Revenue Assurance Level	Intercept	Mean Yield Effect	Std. Dev. Yield Effect	Price-Yield Correlation Effect	R ²
70%	2.7632 (39)	-0.0683 (153)	0.4447 (442)	8.1522 (177)	0.88
75%	2.9646 (42)	-0.0709 (160)	0.5237 (523)	9.6752 (212)	0.91
80%	3.1508 (46)	-0.0686 (157)	0.6037 (615)	11.3035 (252)	0.93

Note: Absolute t-values are in parentheses.

Metamodel (23) is estimated for each crop. In Table 9, three metamodels are reported for corn in all states under 70, 75 and 80 percent assurance. All estimates have the correct signs as expected and are statistically significant at the 1 percent probability level. The metamodels appear robust and adequately characterize the effects of distributional parameters of yield and revenue on expected costs.

These metamodels are used to examine the effects of yield distribution on cost. Results indicate that the relative effect of mean level is small (-6.83 to -7.09 cents) but the relative effect of standard deviation is large (44.47 to 60.37 cents). Correlation between price and yield affects cost in a way that the larger the negative correlation, the lower the cost. It has a relatively large effect on cost. For example, the per acre cost difference between farmers with a weak price-yield correlation (for example, -0.10) and with a strong correlation (for example, -0.40) can be high at \$2.45, \$2.90, and \$3.40 under 70, 75 and 80 percent assurance levels. Negative price-yield correlation exists and this correlation has a large effect on cost. Similar results are found for other crops that are not reported here.

The implications of these results are important. Regional difference in cost of revenue assurance can be attributed to regional differences in yield variability and price-yield correlation. First, states and production regions with high yield variability would benefit more than those with low yield variability. For example, average farm-level corn yield variability has 27 percent of coefficient of variation (mean of 126 and standard deviation of 34) in the Corn Belt, and 37 percent of coefficient of variation (mean of 89 and standard deviation of 33) in the Southeast. This would result in a \$2.08 per acre higher benefit in the Southeast than in the Corn Belt. Second, major production states and regions affect the market more than minor production regions and major production regions would benefit less than minor production regions. For example, average price-yield correlation is -0.40 in the Corn Belt and -0.19 in the Northeast. This would result in a \$1.71 per acre higher benefit in the Northeast than in the Corn Belt. Third, any estimation procedure that ignores price-yield correlation effect or assumes an unreasonable correlation value in estimating revenue assurance cost would certainly bias results.

Summary and Concluding Comments

This study employs an expected cost approach to estimate government cost for the proposed revenue assurance program. Per acre costs by state and crop, together with estimated state acreages for each crop, are used to estimate government cost for each crop in each state. Total government cost is then summed over crop and state. The cost of revenue assurance is then compared with the costs of the current programs, yield insurance, and other revenue assurance cost estimates.

Budgetary savings would depend on specifications of transitional payments from the current programs to a revenue assurance program. Government cost is estimated to be \$1.34 billion to ensure a 70 percent gross revenue for eight crops. Deficiency payments averaged \$5.4 billion between fiscal years 1985 and 1992 and peaked at \$6.3 billion in 1985 (Harwood et al. 1994). Projected costs for current (1992/93) deficiency and disaster payments are \$6.9 billion (\$4.3 billion for deficiency and \$2.6 billion for disaster payments) (Doering 1994). The sum of three agricultural disaster assistance programs (crop insurance, emergency FmHA loans, and ASCS disaster relief payments) amounted to more than \$25 billion between 1985 and 1993 at an annual average cost of \$3.1 billion (Goodwin and Smith 1994). The estimated revenue assurance

costs show substantial savings over these current programs. Both national- and state-level revenue assurance costs are provided here. The costs of revenue assurance differ both by state and crop. Metamodel analysis indicates the price-yield correlation has a major impact on the per acre costs of revenue assurance.

**APPENDIX A: DESCRIPTION AND SPECIFICATION FOR THE PROPOSED
REVENUE ASSURANCE PROGRAM**

- Crops Covered

Program crops, soybeans, alfalfa, and other hay

Hay is harvested forage only, not grazing: uses existing grazing rules

- Base Acres

No base acres

- Set Asides and 0/50/85 programs are eliminated.

- Target Prices and Deficiency Payments

Revenue assurance eliminates target prices and deficiency payments.

However, during the phase-in period, a declining proportion of a fixed/frozen expected deficiency payment would be made. Base deficiency payments would be calculated as a 5 year average of historical payments. The base would be multiplied by .8, .6, .4, and .2, respectively over a four year period and 0, thereafter.

- Flex: Revenue assurance allows 100 percent flex, at least conceptually.

- Nine Month Recourse loans exist under Revenue Assurance; non-recourse loans are eliminated.

- Marketing Loans are eliminated.

- No CCC Stocks

- Farmer Owned Reserve is continued under revenue assurance. No Rule changes were planned.

- EEP, Deip, MPP, etc. are retained.

- CRP: Use Baseline Assumption on CRP expiration/continuation.

- Conservation Compliance - No Green Payments

Conservation compliance is required to be eligible for Revenue Assurance payments.

No additional green payment programs in initial scenarios.

- Revenue Assurance Rate (70-80% of expected revenue) - initially 70% in analysis

- Revenue Assurance Price (5 year moving average of posted county price, annual)

- Revenue Assurance Yield (5 year moving average of proven yield)

- Time Periods: Begins in 1996 or as soon as implementable. Would have a five year phase in period during which the proportional deficiency payment would be phase down.

- Added funding for research and market development -- a high proportion (yet to be determined) of budgetary savings would be allocated to agricultural research, product and market development.

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