The Budgetary and Producer Welfare Effects of Revenue Insurance

David A. Hennessy, Bruce A. Babcock, and Dermot J. Hayes

Working Paper 97-WP 180
June 1997

The Budgetary and Producer Welfare Effects of Revenue Insurance

David A. Hennessy, Bruce A. Babcock, and Dermot J. Hayes

Working Paper 97-WP 180
Revision of 95-WP 130
June 1997

Center for Agricultural and Rural Development
Iowa State University
Ames, IA 50011-1070

David Hennessy is an assistant professor of economics, Iowa State University; Bruce Babcock is an associate professor of economics, Iowa State University, and head of the Resource and Environmental Policy Division, CARD; and Dermot Hayes is a professor of economics, Iowa State University, and head of the Trade and Agricultural Policy Division, CARD.

Contact author: Bruce Babcock, (515)294-5764; e-mail, bbabcoc@iastate.edu.

ABSTRACT

The efficiency of redistribution of a government provided revenue insurance program is compared with the 1990 farm program. The results indicate that revenue insurance would be more efficient because it would provide subsidies when and only when revenue is low and marginal utility is high, and it works on the component of the objective function (revenue) that is of greatest relevance to producers. Simulation results indicate that a revenue insurance scheme that guarantees 75 percent of expected revenue to risk-averse producers could provide approximately the same level of benefits as the 1990 program, at as little as one-fourth the cost.

Key Words: deficiency payments, government costs, producer welfare, revenue insurance.

THE BUDGETARY AND PRODUCER WELFARE EFFECTS OF REVENUE INSURANCE

Recent legislation has changed the way in which the U.S. federal government acts to reduce risks faced by U.S. crop producers. The Federal Agriculture Improvement Act of 1996 replaced deficiency payments, which increased as prices decreased, with a series of fixed annual transition payments. The Federal Crop Insurance Reform Act of 1994 repealed the Ad Hoc Disaster Assistance Program and replaced it with catastrophic coverage. The 1994 act also mandated that the Federal Crop Insurance Corporation (FCIC) develop a pilot revenue insurance program. This act also provided for federal subsidizing of producer premiums, federal reinsurance, and the use of federal funds to cover the costs of administering private revenue insurance pilot programs.

In response to the 1994 act, the FCIC developed a pilot revenue insurance program known as Income Protection. And the FCIC has approved two private sector pilot programs. These are Crop Revenue Coverage (CRC), developed by American Agrisurance, and Revenue Assurance (RA), developed by Iowa Farm Bureau Mutual Insurance Company. CRC first became available in Iowa and Nebraska in 1995, and in the 1995/96 crop year about 10 percent of the national crop was insured under this program (Barnaby 1996). In December 1996 CRC was extended to grain sorghum, cotton and wheat on a pilot basis, and RA was approved for corn and soybeans in all 99 counties. Future growth in the number of commodities and counties covered by these programs seems likely as producer groups in areas not covered by one of the revenue insurance products lobby for inclusion.

The demand by producer groups for these new revenue insurance products has forced U.S. policymakers to grapple with the perplexing issue of what future commodity policy will look like. Should government provide or subsidize a revenue "safety net" for farmers instead of providing fixed payments?

This paper provides insight into this policy issue by comparing alternative forms of revenue insurance to the 1990 deficiency payment program and to a "no-program" alternative. We estimate the effects of the alternative policies on the acreage allocations of a representative farm, expected government cost (assuming the government paid all insurance premiums), and producer welfare. And because we assume that our representative farmer has constant absolute risk aversion, our no program alternative can be used to estimate the welfare effects of fixed transition payments.

We chose a 500-acre corn/soybean farm in Sioux County in northwest Iowa as our representative farm. This farm was selected because (a) we could obtain high-quality data on county yields, rotation effects, and price yield correlations; (b) the farm has sufficient crops (two) to allow an evaluation of whole-farm revenue insurance without the complications that exist with multiple enterprises; (c) the farm is loosely representative of other Corn Belt farms, and as such, the results (to the extent that they are generalizable) apply to a significant component of U.S. agriculture; and (d) the farm grows both a program crop (corn) and a nonprogram crop (soybeans), allowing us to examine possible distortionary effects of both the 1990 farm program and of revenue insurance.

Some of the individual farm results are generalizable and these are presented first. We then describe the data and the simulation procedure and present the farm-specific results. Two of these farm-specific results are of importance. First, we find that the government could offer a 75 percent revenue insurance program at only a fraction of the cost of the 1990 farm program. Second, revenue insurance provides a considerably greater benefit to producers than it costs. This was not, in general, true of the 1990 farm program.

Previous Work

Revenue insurance initially was considered in the United States as far back as 1983 (CBO 1983). In preparation for the 1995 Farm Bill debate, a revenue insurance program was proposed by farmer interest groups in Iowa (Iowa Farm Bill Study Team 1994). In response to this proposal Gray, Richardson, and McClasky (1994) conducted simulations to compare the present situation with alternative revenue insurance schemes for cropping systems in Texas and Iowa (Barnaby 1996). A limitation of this work is that the implications for production decisions were not considered. They found that current farm income support programs were expensive and not very effective in supporting income relative to revenue insurance alternatives. These results concur with those of Harwood et al. (1994), who conducted a similar analysis for corn, soybeans, and wheat. Turvey (1992a) found that the Canadian revenue insurance program is less costly than combined price and crop insurance. Babcock and Hennessy (1996) examined moral hazard problems that could arise from revenue insurance. They concluded that farmers' input decisions are not likely to be altered greatly if coverage levels are kept below 8 percent. However, it is likely that farmers would move into riskier crops if revenue insurance is widely available (*Wall Street Journal* 1994).

Contract Details

The government seeks to assure the income of farmers against the occasional occurrence of low revenue levels. The problem facing a risk-neutral government is to design an insurance policy to increase producer welfare while incorporating producer decisions. Revenue insurance is commonly assumed to provide payouts of the form

$$(1) \qquad \max[0, \bar{R} - \textit{Gross Revenue}],$$

where $\bar{R}$ is a constant, guaranteed revenue floor (Gray, Richardson, and McClasky 1994; Harwood et al. 1994; Barnaby 1994). It is also a generic form of the revenue insurance implemented for many crops in Canadian Provinces (Turvey 1992a, 1992b), and is the specification used for RA.[1]

Several additional details must be supplied before equation (1) can be used to evaluate farm-level decisions. First, we must specify whether the revenue insured is the whole-farm revenue or the revenue of individual crops. Following Turvey (1992b), we refer to the former as portfolio revenue insurance, and to the latter as crop-specific revenue insurance. Both are considered here. Second, we must decide whether the yield level used is that for the individual producer, or some area average. The more specific the contract is on yield, the better the program will be at insuring individual revenue. However, the cost of acquiring information required to implement an individual yield program may be high. Also, because producers have some control over yield, moral hazard problems might emerge with an individual yield program. We present results for both methods to evaluate the change in producer welfare and government cost associated with the way yield is defined.

One final contract detail is whether revenue should be based on historic plantings or in proportion to actual plantings. A program based on current land use patterns would be preferred by producers because producers who change cropping patterns and move into alternative crops would want an insurance policy that reflected these decisions. However, this advantage could cripple the program in the long run, because producers would have nonmarket incentives to move into high-risk crops that require less up-front expenditures. In the results presented here, we restrict the choice of crop to those grown under the 1990 farm program, but revenue insurance payouts are based on actual acreage allocations.

[1]The specification used by CRC is similar to that given in equation (1) except that $\bar{R}$ increases if harvest-time price is greater than spring-time price.

Revenue Insurance versus Price and Crop Insurance

In Figure 1, revenue insurance is contrasted with price and crop insurance for a single crop. Price is denoted by P, output by Q, and guaranteed revenue by $\bar{R}$. The curve denotes the iso-revenue hyperbola, $PQ = \bar{R}$. Let price and output be assured at $P = P_0$ and $Q = Q_0$, respectively, where $P_0Q_0 = \bar{R}$. These are represented by the horizontal and vertical lines in Figure 1. Price insurance is paid on Q_0 units of output, while crop shortfalls are compensated at price P_0. The vertical

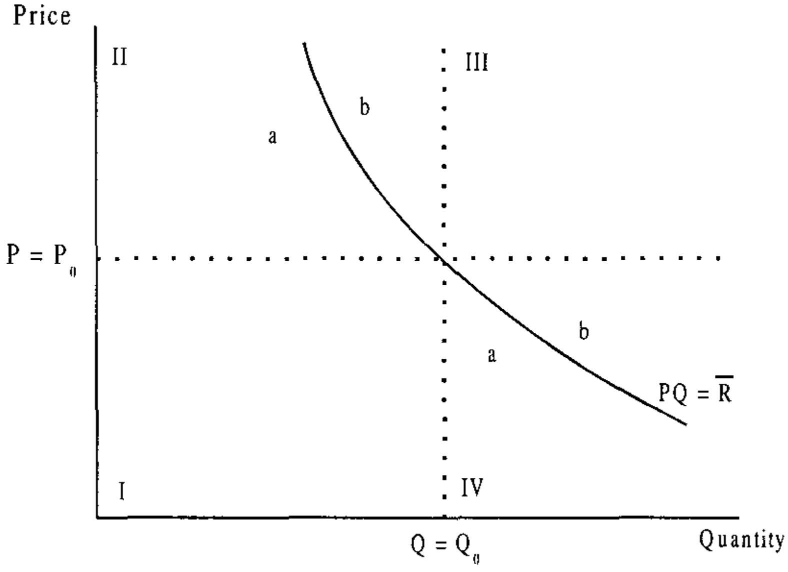

Figure 1. Comparison of revenue insurance with price and crop insurance

and horizontal lines divide the positive quadrant into four sections, while the iso-revenue hyperbola further partitions two of these sections. The following result can now be stated:

Result 1. *Revenue insurance at any level less than or equal to* $\bar{R}$ *is less costly than price and crop insurance at levels* P_0 *and* Q_0.

Proof. The result will be shown for level $\bar{R}$. It will follow for any level less than $\bar{R}$ because of the monotonicity of cost in $\bar{R}$. In Figure 1, outcomes in section I require both price and quantity insurance payments. For all of these outcomes, the cost of price and crop insurance is $Q_0(P_0 - P) + P_0(Q_0 - Q)$.

The price of revenue insurance is $P_0Q_0 - PQ$. Subtract the second expression from the first and rearrange to obtain $(P_0 - P)(Q_0 - Q) > 0$. Thus, for any outcome occurring in section I, revenue insurance is less costly for the insurer. Outcomes in section III require no insurance payments of any form. Outcomes in section II always require crop insurance payments, but never require price insurance payments. In section IIa, revenue insurance payments would be required because revenue does not exceed $\bar{R}$. In this section, revenue insurance costs the insurer $\bar{R} - PQ$, while costs for combined crop and price insurance are $P_0(Q_0 - Q) = \bar{R} - P_0Q > \bar{R} - PQ$. In section IIb, no revenue insurance payments occur, while costs for combined crop and price insurance are $\bar{R} - P_0Q > 0$.. Therefore, in this section also, revenue insurance is less costly. Because section IV is symmetrical to section II, revenue insurance similarly saves money in this section also. Therefore, the inequality holds in all states. Q.E.D.

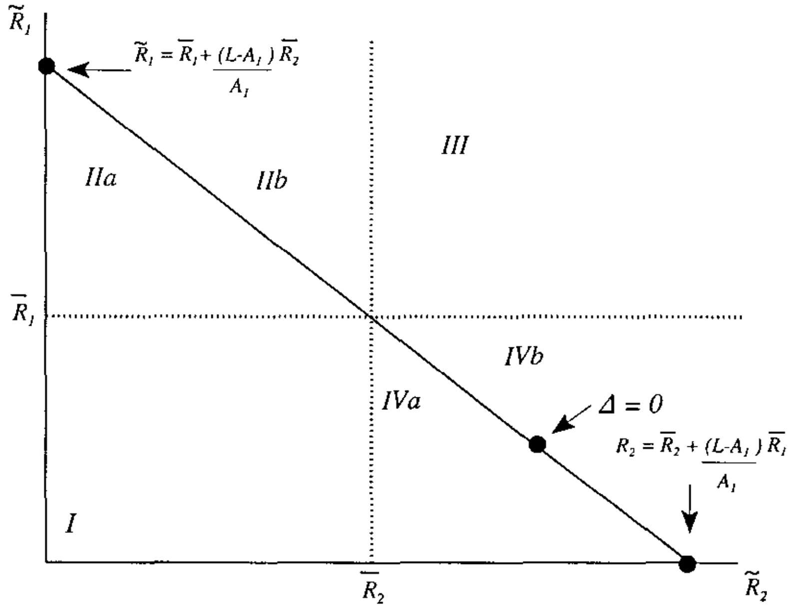

Figure 2. Comparison of portfolio revenue insurance with crop-specific reveue insurance

The result may also be stated as

$$Q_0 \max[0, P_0 - P] + P_0 \max[0, Q_0 - Q] \geq \max[0, \bar{R} - PQ]. \quad (2)$$

Because the inequality is true in every state, it is true when the expectation of both sides is taken with respect to (P, Q). The inequality can be extended to the case of a multiproduct farm by summing inequalities for each crop.

Crop-Specific versus Portfolio Insurance

Just as the insurer can benefit from coordinating price and crop insurance through the use of revenue insurance, there are gains from coordinating insurance given to the revenues of different crops. It is shown here that portfolio insurance is less costly to the insurer than rop-specific insurance, and the savings occur regardless of the correlation between contemporaneous crop revenues. This is not to say that correlation is unimportant; it affects the magnitude of the cost saving and the choice decision variables. To illustrate these points, consider a farm that produces two crops and is L acres in size. It devotes A_1 acres to crop 1, which provides stochastic per acre revenue of $\tilde{R}_1$. The remaining $L - A_1$ acres are devoted to crop 2, which provides stochastic per acre revenue of $\tilde{R}_2$. The cost of producing crop 1 is $C_1(A_1)$, while the cost of producing crop 2 is $C_2(L - A_1)$. Market-based stochastic profit is

$$\pi = A_1\tilde{R}_1 + (L - A_1)\tilde{R}_2 - C_1(A_1) - C_2(L - A_1). \tag{3}$$

Let the guaranteed revenue floors for crops 1 and 2 be $\bar{R}_1$ and $\bar{R}_2$. The following result can now be stated.

Result 2. *Portfolio revenue insurance is less costly to the insurer than crop-specific revenue insurance holding acreage allocations constant.*

Proof. Consider Figure 2. Let $\Delta = A_1(\bar{R}_1 - \tilde{R}_1) + (L - A_1)(\bar{R}_2 - \tilde{R}_2)$. The horizontal axis represents the value of $\tilde{R}_2$, while the vertical axis represents that of $\tilde{R}_2$. The downward sloping line is the equation $\Delta = 0$. The cost to the government of portfolio insurance is Max[0, Δ]. It can be seen that $\Delta = 0$ represents the boundary that partitions the region where portfolio insurance payouts are required and where they are not required. The vertical dashed line represents the equation $\tilde{R}_2 = \bar{R}_2$, while the horizontal dashed line represents the equation $\tilde{R}_1 = \bar{R}_1$. Outcomes in section I require payouts for each crop if crop-specific insurance is used, and a payout if portfolio insurance is used. Outcomes in section III do not require payouts, regardless of the insurance policy used.

Outcomes in section II require a crop-specific insurance payout on crop 2 base acres, never require crop-specific insurance payouts on crop 1 base acres, and may or may not require portfolio insurance payouts. Section IV is symmetrical to section II. The total payouts for portfolio and crop-specific insurance schemes are contrasted in Table 1. For outcomes in sections I and III of Figure 2, costs for both schemes are the same; for all other outcomes, crop-specific insurance is more costly. Therefore, the inequality holds in all states. The result may be stated as

$$
\begin{aligned}
(4) \qquad CG_{CSpec} &= B_1 \max[0, \bar{R}_1 - \tilde{R}_1] + (L - A_1)\max[0, \bar{R}_2 - \tilde{R}_2] \\
&\geq \max[0, A_1(\bar{R}_1 - \tilde{R}_1) + (L - A_1)(\bar{R}_2 - \tilde{R}_2)] = CG_{Port,}
\end{aligned}
$$

where CG_{CSpec} and CG_{Port} are the crop-specific scheme and portfolio scheme costs to government, respectively. Because the inequality is true in every state, it is true when the expectation of both sides is taken with respect to $\tilde{R}_1, \tilde{R}_2$. Q.E.D.

This inequality can be extended easily to the case of a multiple output farm. Again, because the inequality is true in every state, it is true when the expectation of both sides is taken with respect to the $2n$ variate density function $\{P_i\}_{i=1}^{n}$, $\{Q_i\}_{i=}^{n}$.

Result 3. *For an n-product farm, let the stochastic realizations of crop i price and yield be P_i and Q_i, respectively, giving stochastic crop revenue $\tilde{R}_i = P_i Q_i$. Let crop i price insurance be paid on* $Q_{i,0}$ *units per acre, on A_i acre, and for price shortfalls below $P_{i,0}$. Let crop i crop insurance be paid at the indemnity $P_{i,0}$ per unit on A_i base acres, and for yield shortfalls below $Q_{i,0}$. Set $\bar{R}_i = P_{i,0} Q_{i,0}$. Then portfolio revenue insurance on revenue below $\sum_{i=1}^{n} A_i \bar{R}_i$ is less costly than the sum of price and quantity insurances when acreage allocations are held constant.*

Proof. For a multiproduct farm (e.g., n-product farm), result 1 may be stated as

$$
\begin{aligned}
(5) \qquad &\sum_{i=1}^{n} A_i Q_{i,0} \max[0, P_{i,0} - P_i] + \sum_{i=1}^{n} A_i P_{i,0} \max[0, Q_{i,0} - Q_i] \\
&\geq \sum_{i=1}^{n} A_i \max[0, \bar{R}_i - \tilde{R}_i],
\end{aligned}
$$

where $\sum_{i=1}^{n} A_i = L$. For a multiproduct farm, result 2 may be stated as

$$
(6) \qquad \sum_{i=1}^{n} A_i \max[0, \bar{R}_i - \tilde{R}_i] \geq \max\left[0, \sum_{i=1}^{n} A_i(\bar{R}_i - \tilde{R}_i)\right].
$$

Associating the inequalities demonstrates the result. Q.E.D.

Table 1. State contingent insurance costs for different fixed acreage base insurance schemes (from Figure 2)

Section and Conditions	Portfolio Insurance	Crop-Specific Insurance
Section I $\tilde{R}_1 < \bar{R}_1, \tilde{R}_2 < \bar{R}_2$	Δ	Δ
Section IIa $\tilde{R}_1 > \bar{R}_1, \tilde{R}_2 < \bar{R}_2, \Delta > 0$	Δ	$(L - A_1)(\bar{R}_2 - \tilde{R}_2)$
Section IIb $\tilde{R}_1 > \bar{R}_1, \tilde{R}_2 < \bar{R}_2, \Delta < 0$	0	$(L - A_1)(\bar{R}_2 - \tilde{R}_2)$
Section III $\tilde{R}_1 > \bar{R}_1, \tilde{R}_2 > \bar{R}_2$	0	0
Section IVa $\tilde{R}_1 < \bar{R}_1, \tilde{R}_2 > \bar{R}_2, \Delta > 0$	Δ	$A_1(\bar{R}_1 - \tilde{R}_1)$
Section IVb $\tilde{R}_1 < \bar{R}_1, \tilde{R}_2 > \bar{R}_2, \Delta < 0$	0	$A_1(\bar{R}_1 - \tilde{R}_1)$

A Farm-Level Comparison of Revenue Insurance with the 1990 Farm Program

In this section, we conduct a Monte Carlo analysis of the acreage decisions of a representative Corn Belt farmer to infer the revenue, profit, welfare, and resource allocation implications of different revenue insurance regimes. Moral hazard and market price effects are not explicitly considered. We limit our analysis to how acreage is allocated between corn and soybeans under the two programs, assuming that the distribution of prices is unaffected by the program change. Our representative farm is the 500-acre corn/soybean farm in Sioux County, Iowa (see page 2).

Table 2 presents the means and covariance matrix of the random variables needed to simulate the effects of alternative programs. The average yield of this farm was set equal to the expected county average yield for 1994, where the expectations are taken with respect to a beta distribution with parameters that include a time trend. Yield variances were set equal to the average farm variance of yield calculated from a sample of 10 corn and 10 soybean farms in Sioux County and drawn from the FCIC data set that measures yields from farmers who participated in crop insurance from 1983 to 1992.

Confidentiality restrictions precluded the drawing of corn and soybean yield data from the same farms. Therefore, farm-level yield correlation coefficients could not be estimated. We set the correlation coefficient for yields of corn and soybeans equal to 0.68, which is the verage correlation coefficient from the sample of 10 corn farms and 10 soybean farms in Sioux County. The correlation coefficient between county corn and soybean yields was set equal to 0.65, which is the sample correlation coefficient from 1982 to 1993. The correlation between farm corn yield and county corn

Table 2. Means and covariances of stochastic yields and prices

		Farm Yields		County Yields		Prices	
Variable	Mean	Corn	Soybeans	Corn	Soybeans	Corn	Soybeans
Farm Yields							
Corn	119	1220	216.2[a]	696.0[a]	129.0	-6.49[a]	-9.30
Soybeans	43	--	83.7	126.0	22.8	-1.19	-1.67
County Yields							
Corn	119	--	--	625.9	114.6[a]	-3.86	-5.44
Soybeans	43	--	--	--	49.3	-0.74	-1.04
Prices							
Corn	2.30	--	--	--	--	0.14	0.20[a]
Soybeans	6.00	--	--	--	--	--	0.51

Note: Yields are measured in bu/ac, while prices are measured in $/bu.
[a]Correlations imposed on Monte Carlo deviates.

yield was set equal to 0.8, which is the average of sample correlations from the 10 Sioux County corn farms. The correlation between the corn price and the farm corn yield was set equal to −0.4, which is the average correlation from the sample of Sioux County farms. Expected price and price volatility were set at representative levels for Sioux County. The correlation between corn and soybean prices was set equal to 0.75. The remaining covariances reported in Table 1 were not imposed, but were rather the sample covariances obtained from the Monte Carlo simulations.

Monte Carlo simulations were conducted by assuming that prices follow log-normal distributions and yields follow beta distributions. The correlation coefficients discussed here were imposed on random price and yield deviates using a variation of the Johnson and Tenebein method discussed in Babcock and Hennessy (1996). The number of deviates used was 5,000.

Profit depends on the allocation of resources and the particular risk management alternatives available to the farmer. It is assumed that, initially, the farmer participates in the target price program that operated under the 1990 Farm Bill and uses the subsidized Group Risk Plan crop insurance policy available through FCIC (Schraufnagel 1994). The coverage level chosen for both corn and soybeans is

70 percent of expected yield. The per bushel crop insured price was $2.30 for corn and $6.00 for soybeans. Farmers were levied the actuarially fair premiums less 30 percent. This reduction captures premium subsidies currently provided by the FCIC. For the deficiency payments scheme, the target price for corn is $2.75/bushel, as specified in the 1990 Farm Bill. Program yield is set at 112.1 bushels. This is the mean of county yields over the five years preceding the 1985 Farm Bill, the year when program yields were frozen according to the five-year moving average rule. The set-aside rate is fixed at 6.35 percent, the mean over the 1990-94 period. Corn base acres were fixed at 320 acres, which represents the average ratio of planted corn acres to soybean acres in Sioux County in 1992 (IDALS 1993).

Cost data were obtained from 1995 Iowa State University Cooperative Extension Service budgets (1995). Three budgets were available: corn after corn, corn after soybeans, and soybeans after corn. To account for the rotation effect of having corn after soybeans, expected corn yield was augmented by 5 percent when planted in a corn-soybean rotation, and diminished by 5 percent when planted in a corn-corn-soybean rotation (Henning). Soybean yield was diminished by 3.75 percent when planted in a corn-soybean rotation and augmented by 3.75 percent when planted in a corn-corn-soybean rotation. To allow for the possibility of soybeans after soybeans, and to compensate for the associated tilth and pest problems, expected soybean yields were decreased by 12.5 percent when planted in continuous soybeans. Standard deviations of yields were not altered when mean yields were adjusted to accommodate rotation effects because it was not clear what impacts the rotation effects would have on the variance of yields. The variable cost of growing corn after soybeans was set equal to $144/acre. The cost was set to $158/acre for corn after corn. The variable cost of growing soybeans was set at $90/acre, which was increased to $100 for soybeans after soybeans.

Target price payments were not made on 15 percent of land enrolled in the target price program. These acres were called flex acres, and could be planted to any crop (in this case either corn or soybeans). It is assumed that the producer stores output and uses the loan rate corn and soybean programs when prices fall sufficiently. The announced loan rate for corn in 1994/95, denoted by P_c^{LR}, was $1.89/bushel, while for soybean (P_s^{LR}) it was $4.92/bushel. The loan rate is paid on all stored output, and not just on that covered by the target price program.

Risk preferences are assumed to be constant absolute risk-averse (CARA) in form, and two levels of aversion are chosen. The variability of revenue, together with the results of Babcock, Choi, and

Feinerman (1993), suggest low and high risk aversion coefficients of 0.00001 and 0.00005, respectively. These two levels of risk aversion imply a risk premium of between 10 percent and 50 percent of the standard deviation of farm revenue at the free market acreage allocation. Profit under the 1990 program scenario is

$$\begin{aligned}\pi_{90} = {} & (P_c fy_c K_c - costc)\Omega + (P_s fy_s K_s - costs)A_s \\ & + \max[P^T - \max(P_c, P_c^{LR}), 0]\, y_0 \min[BASE(1 - \alpha - NFA), \Omega] \\ & + \Omega(P_c G_c - W_c) + A_s(P_s G_s - W_s) \\ & + fy_c K_c \Omega \max(P_c^{LR} - P_c, 0) + fy_s K_s A_s \max(P_s^{LR} - P_s, 0),\end{aligned} \tag{7}$$

where K_c and K_s are the rotation adjustment coefficients; α is the set-aside rate; *costc* and *costs* are the per acre costs of growing corn and soybeans; $\Omega = A_c - \alpha$ BASE, where A_c is the number of acres planted or considered planted to corn and BASE is the fixed number of base acres also; NFA is percent net flex acres; y_0 is the historic corn base yield; and P^T is the target price ($2.75/bushel). The per acre actuarially fair costs of fully insuring corn and soybean yield losses below 70 percent of expected yield are denoted by W_c and W_s, respectively, where $G_c^{70} = \max[0.7E[cy_c] - y_c, 0]$ and $G_c^{70} = \max[0.7E[cy_s] - y_s, 0]$ are the yields upon which payouts are made. The price increment over the storage period was assumed to just recompense the costs of storage. This approach was considered preferable to explicitly modeling post-harvest price movements and storage costs because profit opportunities can be locked in by use of futures markets, and because competition will ensure that there is zero economic profit. Acreage allocations are constrained to obey $A_c + A_s = 500$.

Crop-specific revenue insurance could be calculated using either county-average yields or farm-level yields. Stochastic profits for crop-specific revenue insurance are

$$\begin{aligned}\pi^{CSpec} = {} & (P_c fy_c K_c - costc)A_c + (P_s fy_s K_s - costs)A_s \\ & + A_c \max[\beta\bar{R}_c - P_c Y_c^D, 0] + A_s \max[\beta\bar{R}_s - P_s Y_s^D, 0],\end{aligned} \tag{8}$$

where Y_c^D and Y_c^D are either county-average corn and soybean yields when payouts are based on county yields, or farm yields (including rotation effects) when crop-specific insurance payments are made. β denotes the level of revenue insurance considered (1.0 or 100 percent, and 0.75 or 75 percent). $\bar{R}_c$ and $\bar{R}_s$

are expected per acre corn and soybean revenues, respectively, as evaluated for simulations for each risk-aversion level under the present program. Average allocation A_c and A_s sum to 500 acres. All other variables have been defined previously.

Profit for portfolio revenue insurance is

$$\pi^{Port} = (P_c fy_c K_c - cost\,c)A_c + (P_s fy_s K_s - costs)A_s + max[A_c(\beta\bar{R}_c - P_c Y_c^D) + A_s(\beta\bar{R}_s - P_s Y_s^D), 0] \quad (9)$$

where A_c and A_s sum to 500 acres, and all other variables have been defined previously.

Results for the 1990 Program and the No-Program Alternative

The target price/crop insurance results (the 1990 farm program) are the first set of results presented in Table 3. Most noteworthy is that the optimal corn/soybean rotation is a 50 percent acreage allocation to each crop. The yield benefits of rotating corn with soybeans on corn yields and the risk-reducing effects of greater diversification are enough to ensure that the 50-50 rotation is both the profit maximizing solution and the expected utility maximizing solution.

Expected government cost with the 1990 program is $13,741. Government payments arise from five different sources: the corn target price program, corn and soybean crop insurance premium subsidies, and corn and soybean loan rate programs. The most important source is the target price program, which accounts for about 90 percent of expected total cost. The loan rate programs account for about 5.6 percent of cost, while area-level crop insurance premium subsidies account for the remainder. It should be noted that if crop insurance programs were based on farm yields, then the insurance component of government costs would be substantially higher. Certainty equivalent returns (CER) under the 1990 farm program for the more risk-averse producer are $15,474 less than for the less risk-averse producer.

The second set of results presented in Table 3 are for a producer who did not participate in the 1990 farm program. And, because we assume no price effects from the program, this set of results represents what happens when the 1990-96 farm program mix is eliminated in favor of free markets. The no-program scenario results in decreased expected revenue, CER and government costs. The decline in CER, for the less risk-averse producer is $2,786 less than the drop in government payments. That is, the

Table 3. Acreage allocations, government cost, and producer welfare from alternative farm policies on a 500 acre Iowa corn and soybean farm

Policy Option	Ratio of Corn Acreage Soybean Acreage	Expected Producer Income ($)[a]	Certainty Equivalent Returns ($)		Expected Government Cost ($)[a]
			Low risk aversion[b]	High risk aversion[c]	
1990 Farm Program	1.0	83,839 (27,843)	79,885	64,411	13,741 (8,973)
No Program	1.0	73,067 (28,759)	68,930	53,489	0 (0)
Farm-Level Revenue Insurance					
Crop-Specific					
100 percent	1.0	87,218 (15,383)	86,122	83,058	14,150 (17,229)
75 percent	1.0	76,105 (24,490)	73,226	64,273	3,038 (6,955)
Portfolio					
100 percent	1.0	85,777 (15,683)	84,646	81,605	12,709 (17,648)
75 percent	1.0	75,200 (25,364)	72,105	62,516	2,132 (6,409)
County-Level Revenue Insurance					
Crop-Specific					
100 percent	1.0	84,131 (23,809)	81,295	70,261	11,064 (13,140)
75 percent	1.0	73,067 (28,759)	70,855	57,202	1,160 (3,497)
Portfolio					
100 percent	1.0	82,941 (24,000)	80,056	68,736	9,873 (13,501)
75 percent	1.0	73,796 (27,928)	69,915	55,678	728 (3,148)

[a]The standard deviations of producer income and government costs are shown in parentheses.

[b]Absolute risk aversion coefficient equals 0.00001.
[c]Absolute risk aversion coefficient equals 0.00005.

1990 farm program increases this producer's welfare by about $0.80 for each dollar of government cost. The 1990 farm program is equally efficient for the more risk-averse producer. Thus, the target price program together with crop insurance does not provide a large degree of risk protection. In fact, the government could have enhanced producer welfare at lower budget cost by giving decoupled lump-sum payments to producers. For example, the transfer of $13,741 to the low risk-averse producer operating under a free market would provide a CER of $82,671, substantially in excess of the $79,885 resulting from the existence of the target price program and subsidized crop insurance contracts. Under CARA, free market acreage allocations would not be altered by such a transfer (Pope and Just 1991, proposition 3).

Results for Revenue Insurance Schemes

The next set of results presented in Table 3 are the simulation results for the farm-level revenue insurance programs. These results are from Monte Carlo optimization of equations (8) and (9). Results are presented for both crop-specific and portfolio revenue insurance at 100 percent and 75 percent of equilibrium per acre market revenue insurance levels. The corresponding crop-specific dollar insurance levels are $287.27/acre and $215.45/acre for corn and $247.20/acre and $185.40/acre for soybeans. The portfolio insurance levels are $267.23 for 100 percent revenue insurance and $200.43 for 75 percent revenue insurance.

Farm-level revenue insurance results in the same 50-50 acreage allocation as the no-program scenario. The motivation for this result is that the yield and cost effects of moving away from this allocation are considerable. Only significant and crop-biased interventions, such as a coupled deficiency payment corn target price program, are likely to induce production on this farm away from the 50-50 corn-soybean rotation. Note that at 100 percent and 75 percent insurance levels, the crop-specific insurance policy is more costly to the government than the portfolio policy. The additional expected cost is $2.88/acre for 100 percent insurance and $1.81/acre for 75 percent insurance.

For the less risk-averse producer, CER under 100 percent crop-specific revenue insurance are $6,237 more than under the 1990 farm program. But government costs increase by only $409. For the more risk-averse producer, CER under 100 percent crop-specific insurance increase by $18,647. These results indicate that the inefficiencies identified in result 3, combined with the acreage set-asides, make the old policy mix inferior to the revenue insurance alternative. The inefficiency of the 1990 program is also apparent with 100 percent farm-level portfolio insurance. Here, CER for both levels of risk aversion greatly exceed corresponding levels under the 1990 program but expected government costs are $1,032 less than under the old policy.

CER at a 75 percent insurance level for farm-level portfolio insurance is lower than under the 1990 farm program for both levels of risk aversion. However, the decrease in government payments is much greater than the decrease in producer welfare. CER under farm-level portfolio revenue insurance at the 75 percent level decreases by $7,780 for the less risk-averse producer and by $1,895 for the more risk-averse producer, while expected government costs decline by $11,609 in each case. But CER is still greater than under the no-program option by $3,175 for the less risk-averse producer and $9,027 for the more risk-averse producer. It is interesting to note that both expected producer income and CER are always lower for portfolio insurance than for a comparable level of crop-specific insurance. Though this may seem at variance to the claim that portfolio insurance is more efficient than crop-specific insurance, in fact it is not. Because crop-specific insurance incurs a higher expected government cost than portfolio insurance at the same level (result 2), the comparison between approaches at the same level of insurance is not valid. Crop-specific insurance gives higher expected income and CER because of the higher government costs that are incurred. Put another way, if the same expected government cost were distributed according to portfolio insurance, the resulting CER would dominate that achieved by crop-specific insurance.

To avoid possible moral hazard problems, revenue insurance alternatively may be based on area averages. The last set of results in Table 3 is the simulation results for revenue insurance for the situation where payouts are based upon county average yields. One difference between area-based revenue insurance and farm-level revenue insurance is that expected government costs are somewhat lower in these latter results because county average yields are less variable than farm yields. This is true because the payout functions CG_{Port} and CG_{CSpec} in inequality (4) are convex in the stochastic variables, and because reductions in variability reduce the expected value of convex functions (Rothschild and Stiglitz 1990). The other significant difference is that CER under area-based revenue insurance is substantially below the corresponding CER for farm-level revenue insurance, particularly for the more risk-averse farmer. The reason for this is that the correlation between county yields and farm yields is not perfect.

An Efficiency Comparison of the 1990 Program with Revenue Insurance

The efficiency with which government programs redistribute income can be measured by the increase in producer welfare per dollar of government spending. Farm-level portfolio insurance at the 75 percent level increases producer welfare over the no-program level by only $3,175 for the less risk-averse producer and by $9,027 for the more risk-averse producer. But the expected cost of providing this benefit is only $2,132, which implies that the dollar increase in producer welfare (CER) per dollar cost is $1.49 and $4.23, respectively. This efficiency ratio is 1.24 for the less risk-averse producer and 2.21 for the more risk-averse producer for 100 percent farm-level portfolio insurance. In general, efficiency of revenue insurance increases as the insurance level decreases and as risk aversion increases. And the efficiency of portfolio insurance is somewhat greater than the efficiency of crop-specific revenue insurance, particularly for the more risk-averse producer.

Figure 3 compares the efficiency of portfolio revenue insurance relative to the efficiency of the 1990 farm program mix for the more risk-averse producer. Simulations were run for county-level portfolio insurance, with the insurance floor ranging from 65 percent to 100 percent of expected revenue. Portfolio insurance was chosen for the efficiency comparison because it is more efficient than crop-specific insurance. The county level was chosen rather than farm level because the crop insurance modeled in the 1990 mix is county level and it is only fair to compare like with like, and also because moral hazard is less of an issue with county-level revenue insurance programs than farm-level ones. Simulations also were run to measure the effectiveness of present policy instruments using the target price along the range [$1.95/bushel, $3.00/bushel].

CER for the more risk-averse producer under the free market scenario, $53,489, is used as the basis for comparing policy effectiveness. This amount was subtracted from the CER series generated by the two sets of simulations, and the difference was divided by the expected government cost.

The resulting series are graphed in Figure 3. The results show that revenue insurance is very efficient at low insurance levels. At high insurance levels, revenue insurance provides between $1.50 and $2.00 of an increase in producer welfare for each dollar of expected government cost. The target price program is not very efficient at low price guarantee levels because of reduced welfare due to set-aside. Its effectiveness levels off at higher price guarantee levels to provide an $0.82 welfare increase for each $1.00 of expected government cost. This is not impressive since a pure nonstochastic cash transfer provides a $1.00 increase for each $1.00 transferred.

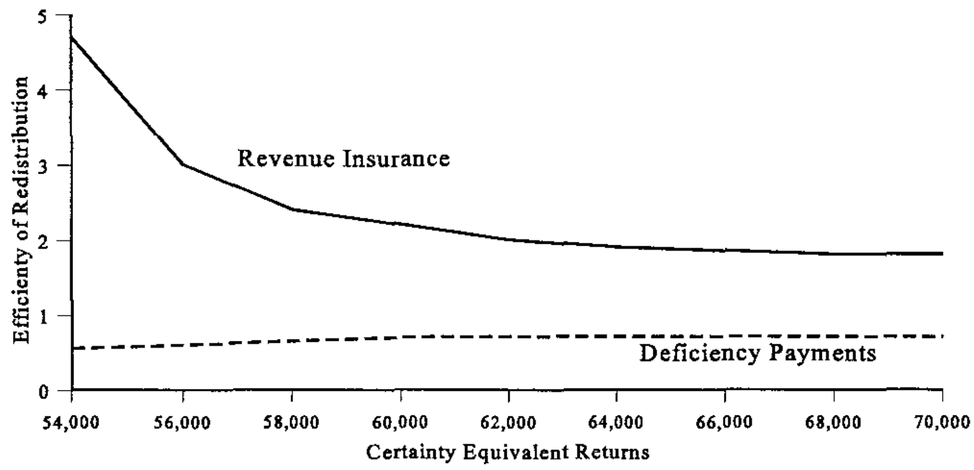

Figure 3. Efficiency of 1990 farm programs and revenue insurance

Concluding Remarks

Two results of this study are particularly important. First, a 75 percent revenue insurance scheme would result in a very large reduction in government outlays when compared to the 1990 farm program mix. Producer welfare for producers with low risk aversion would also decrease substantially, but producer welfare for more risk-averse producers would actually increase. Second, revenue insurance increases the efficiency of redistribution. Even if we assume that the marginal opportunity cost of government spending is 1.5 or greater (see Alston and Hurd 1990), revenue insurance, as defined here, could return more to society than it costs—because revenue insurance provides protection only when it is needed, and because most farmers would seldom need such payments. Also, revenue insurance (unlike futures or options contracts on prices and yields) focuses on the term that actually enters the producer's welfare function (the product of price and quantity).

One issue that we did not consider in this study is the justification for government involvement in providing revenue insurance. Should government continue to subsidize producer insurance premiums, selling expenses, and provide reinsurance? As noted by Vukina, Li, and Holthausen (1996), development of state yield contracts on the Chicago Board of Trade raises the possibility that speculators could provide private reinsurance. And the large producer welfare gains of revenue insurance demonstrated here raises the possibility that farmers would purchase insurance even without federal subsidies.

REFERENCES

Alston, J. M., and B. H. Hurd. 1990. "Some Neglected Social Costs of Government Spending in Farm Programs." *Amer. J. Agr. Econ.* 72(February): 149-56.

Babcock, B.A., and D.A. Hennessy. 1996. "Input Demand Under Yield and Revenue Insurance." *Amer. J. Agr. Econ.* 78(May): 416-27.

Babcock, B. A., E. K. Choi, and E. Feinerman. 1996. "Risk and Probability Premiums for CARA Utility Functions." *J. Agr. and Resour. Econ.* 18(July):17-24.

Barnaby, G.A., Jr. 1996. "CRC Grain Sorghum Approved for Selected Counties." Cooperative Extension Service, Kansas State University, Manhattan.

Barnaby, G. A., Jr. 1994. "Using Private Markets to Achieve Revenue Insurance." Paper presented at Risk Management Preconference, AAEA 1994 annual meetings, San Diego.

Gray, A. W., J. W. Richardson, and J. McClasky. 1994. "Farm-Level Impacts of Revenue Insurance." Unpublished manuscript, Department of Agricultural Economics, Texas A&M University, College Station.

Harwood, J. L., K. H. Coble, R. G. Heifner, and J. W. Glauber. 1994. "Revenue Insurance in the U.S.: A Framework, Economic Impacts, and Implementation Issues." Paper presented at Risk Management Preconference, AAEA 1994 annual meetings, San Diego.

Henning, S. 1992. "Annual Progress Reports, 1991: Northeast Research Farm, Nashua, Iowa." Pub. No. ORS91-13, Northeast Iowa Agricultural Experimental Association, Iowa State University Agriculture and Home Economics Experiment Station. March.

Iowa Department of Agriculture and Land Stewardship. 1993. *Iowa Agricultural Statistics.* Des Moines: IDALS.

Iowa Farm Bill Study Team. 1994. "Findings of the 1995 Farm Bill Study Team." Unpublished report, December.

Iowa State University, Cooperative Extension Service. 1995. "Estimated Costs of Crop Production in Iowa, 1995." CES Staff Publication, Ames IA, January.

Johnson, M.E., and A. Tenebein. 1981. "A Bivariate Distribution Family with Specified Marginals." *Journal of the American Statistical Association* 76(March): 198-201.

Pope, R. D., and R. E. Just. 1991. "On Testing the Structure of Risk Preferences in Agricultural Supply Analysis." *Amer. J. Agr. Econ.* 73(August):743-48.

Rothschild, M., and J. E. Stiglitz. 1970. "Increasing Risk I: A Definition." *J. Econ. Theory* 2(September):225-43.

Schraufnagel, S. A. 1994. "Group Risk Plan Crop Insurance." *Managing the Farm Series*, vol. 27, no. 1. Department of Agricultural Economics, University of Wisconsin, Madison. February.

Turvey, C. G. 1992a. "Contingent Claim Pricing Models Implied by Agricultural Stabilization and Insurance Policies." *Can. J. Agr. Econ.* 40(July):183-98.

________. 1992b. "An Economic Analysis of Alternative Farm Revenue Insurance Policies." *Can. J. Agr. Econ.* 40(November):403-26.

U.S. Congress, Congressional Budget Office (CBO). 1983. "Farm Revenue Insurance: An Alternative Risk-Management Option for Crop Farmer." CBO Staff Report. Washington, D.C.: U.S. Government Printing Office.

Vukina, T., D. Li, and D.M. Holthausen. 1996. "Hedging with Crop Yield Futures: A Mean-Variance Analysis." *American J. Agr. Econ.* 78(November): 1015-25.

Wall Street Journal, The. 1994. "Crop Disaster Program has Georgia Farmers Raising Lots of Squash." Unsigned article. October 31, A1.