The Budgetary and Resource Allocation Effects of Revenue Assurance

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ABSTRACT

The efficiency of redistribution and the level of government costs of revenue assurance are compared with current farm programs. The results suggest that a revenue assurance program that uses a fixed base acreage and actual or county average yields to assure whole farm revenues could provide a significant improvement over existing policies. The result derives in large part because revenue assurance works only when needed and it works on the component of the objective function (revenue) that is of greatest relevance to producers. Also a fixed base revenue assurance scheme would eliminate resource misallocation costs associated with current programs. A revenue assurance scheme that guaranteed 100 percent of base revenues would provide almost as much benefit to producers as existing programs at less than half the cost. Revenue assurance at the 80 or 70 percent level would result in a significant drop in producer welfare, but an even greater drop in government expenditures.

THE BUDGETARY AND RESOURCE ALLOCATION EFFECTS OF REVENUE ASSURANCE

Introduction

Some of the distinguishing features of agriculture are the uncertainty of supply, the inelasticity of demand for products, and a lack of adequate producer training in financial markets. Together, these result in high income uncertainty and low access to risk management tools such as futures markets. In response, the federal government has operated deficiency payment and subsidized crop insurance schemes, and an ad-hoc disaster relief program.

These federal interventions have proven to be expensive. For example, over the four year period 1989-1992, average net Commodity Credit Corporation outlays were $8.94 billion. There is also concern about the efficacy of the expenditures. For example in 1994, when yields for many crops were high, deficiency payments were also high. Likewise in the drought years of 1990 and 1991 both yields and deficiency payments were low. Widely reported moral hazard problems in the disaster assistance and crop insurance programs have also brought pressure to bear on existing approaches to agricultural income support (Wall Street Journal, 10/31/1994). A further problem is the distortionary effect of existing programs. For example, it is widely believed (and is supported by the results below) that excess corn is grown in the Midwest in response to attractive corn deficiency payments. Also the land taken out of production to meet acreage reduction rules is land that would otherwise have been used to increase national production.

In 1991, Canada, adopted the Gross Revenue Insurance Program (GRIP). While the details of the GRIP program vary across the provinces, the underlying principle is to insure revenue rather than price or output. In the U.S., while the concept was considered as far back as 1983 (Congressional Budget Office), it has been receiving increasing attention in recent years. The approach was proposed by the Iowa Farm Bill Study Team in 1993. Following up on that report, Gray, Richardson, and McClasky conducted simulations to compare the present situation with alternative revenue assurance schemes for cropping systems in Texas and Iowa[1]. The limitations of their work is that they did not look at the implications for production decisions. They found that current farm income support programs were expensive and not very effective in supporting income relative to revenue assurance alternatives. These results concur with Harwood et al. who conducted a similar analysis for corn, soybeans, and wheat. And Turvey (1992a) found that the Canadian revenue insurance program is less costly than combined price and crop insurance.

Because revenue insurance would involve a restructuring of existing U.S. farm programs we know little about how government costs, producer welfare, and output would respond under various contract specifications. We see a need for research that evaluates the likely impact of revenue assurance at the farm level. The advantage of this approach is that we can examine optimal response to changes in the way contracts are written. The obvious disadvantage of a farm specific analysis is that results may not be generalizable. However, we cannot conduct a macroeconomic analysis until we know the details of the contract, and policymakers cannot decide on which contract details make most sense until they have some idea about what these alternative specifications mean at the farm level.

We chose for our example from a 500 acre corn/soybean farm in Sioux County in Northwest Iowa. This farm was chosen (a) because we could get 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 assurance without the complications that exist with multiple enterprises, (c) the farm is loosely representative of other Cornbelt farms and as such the results (to the extent that they are generalizable) apply to a significant component of U.S. agriculture, (d) the farm grows both a program crop (corn) and a nonprogram crop (soybeans) allowing us to examine the distributionary effect of both current programs and of revenue assurance.

Some of the individual farm results are generalizable and these appear first. We then describe

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[1] Assurance is used to denote an insurance program where no premium is required. It is this type of program that the Iowa Farm Bill Team proposed.

the data and the simulation procedure and present the farm specific results. Two of these farm specific results are of importance. First it would appear that the government could offer an 80 percent revenue insurance program at only a fraction of the cost of current programs. Second, the revenue assurance provides a greater benefit to producers than it costs the government. This is not, in general, true of current programs.

Contract Details

The government seeks to assure the income of farmers against the occasional occurrence of low income levels. The problem facing a risk-neutral government is to design an insurance policy to increase producer welfare while incorporating producer decisions, and placing a maximum limit on expected government cost. Revenue assurance is commonly assumed to provide payouts of the form

$$\mathrm{Max}[0, \bar{R} - \text{Gross Revenue}], \tag{1}$$

where $\bar{R}$ is a constant, guaranteed revenue floor (Gray, Richardson, and McClasky, Harwood et al., Barnaby). It is also the form of revenue assurance currently implemented in Canada (Turvey 1992a, 1992b), and is the specification used to define the results presented below.

Several additional details must be supplied before equation (1) can be used to evaluate farm level decisions. First, we must specify whether the revenue assured is the whole farm revenue or the revenue of individual crops. Following Turvey (1992b) we refer to the former as portfolio revenue assurance, and to the latter as crop specific revenue assurance. Both are considered below. Second, we must decide whether the yield level used is that for the individual producer or some area average. The more specific the contract on yield the better will be the program at assuring 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 so as to evaluate the change in producer welfare and government cash 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. At first glance a program based on current land use patterns makes the most sense, because producers who change cropping patterns and move into alternative crops, would want an assurance policy that reflected their decisions. However, this advantage could cripple the program in the long run, as producers would have nonmarket incentives to move into high risk crops that require little up-front expenditures. In the results presented below we base revenue on historic production patterns and pay revenue assurance on these acres regardless of actual plantings. As a consequence, we know that the changes in land use patterns that we report are not caused by the program itself.

Revenue Assurance versus Price and Crop Assurance

The federal government currently provides price assurance for most of the main crops produced in the U.S. through deficiency payment programs.[2] It also provides crop assurance through subsidized premiums on crop insurance contracts and through congressionally authorized disaster assistance payments. In figure 1 below, revenue assurance is contrasted with price and crop assurance. For a single crop denote price 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, respectively. Price assurance is paid on Q_0 units of output, while crop shortfalls are compensated at price P_0. The vertical 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 assurance 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*, respectively.*

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[2] The principal crops covered are corn, wheat, barley, sorghum, cotton, oats, and rice.

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 below, outcomes in section I require both price and quantity assurance payments. For all these outcomes, the cost of price and crop assurance is* $Q_0(P_0 - P) + P_0(Q_0 - Q)$. *The price of revenue assurance is* $P_0Q_0 - PQ$. *Subtract the second expression from the first and rearrange to get* $(P_0 - P)(Q_0 - Q) > 0$. *Thus, for any outcome occurring in section I, revenue assurance is less costly for the assurer. Outcomes in section III require no assurance payments of any form. Outcomes in section II always require crop assurance payments but never require price assurance payments. In section IIa, revenue assurance payments would be required because revenue does not exceed* $\bar{R}$. *In this section revenue assurance costs the assurer* $\bar{R} - PQ$, *while combined crop and price assurance costs* $P_0(Q_0 - Q) = \bar{R} - P_0Q > \bar{R} - PQ$. *In section IIb, no revenue assurance payments occur, while combined crop and price assurance costs* $\bar{R} - P_0Q > 0$. *Therefore, in this section also, revenue assurance is less costly to the assurer. As section IV is symmetrical to section II, revenue assurance saves money for the assurer in this section also. Therefore, the inequality holds in all states.*

The result may also be stated as

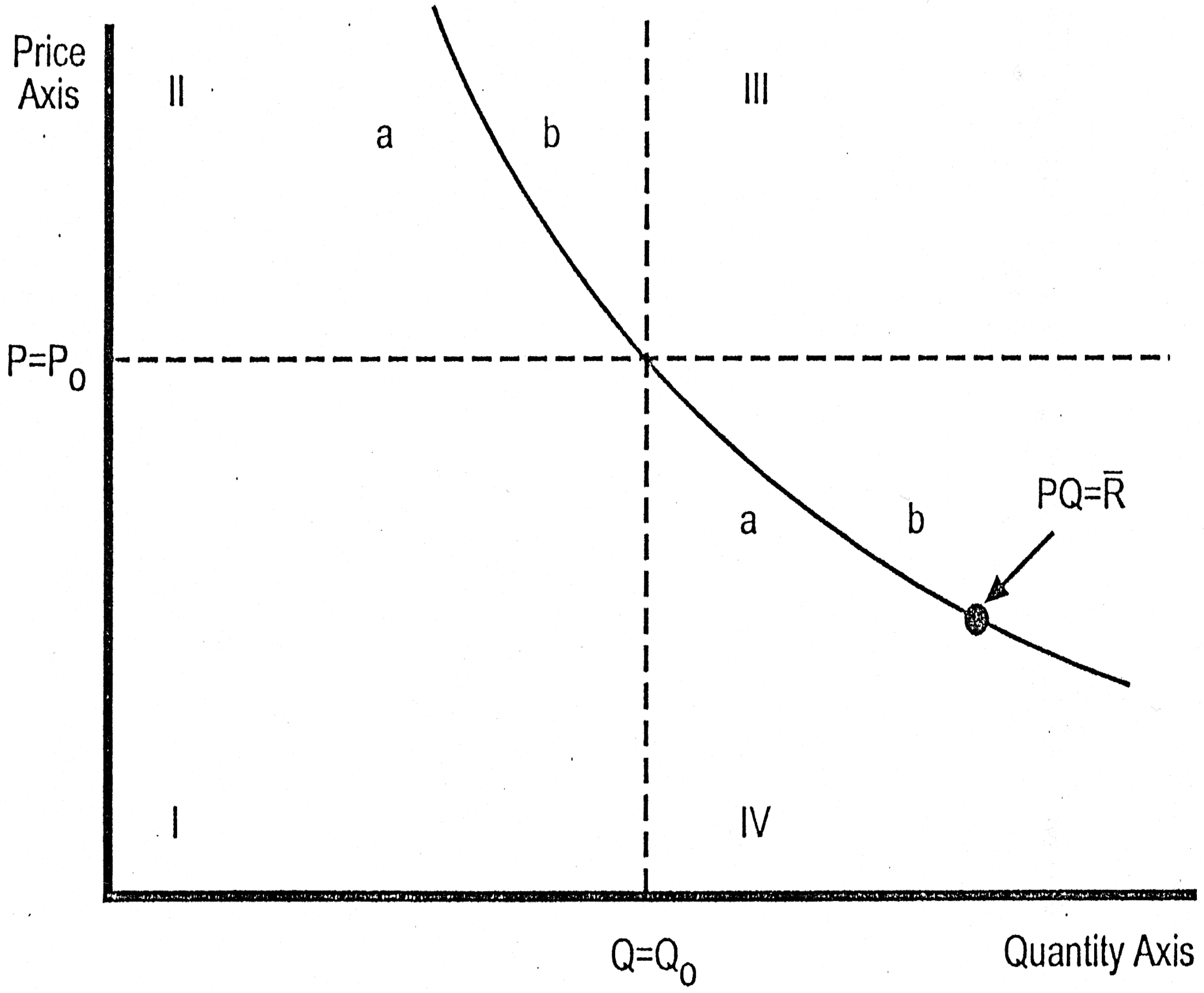
$$Q_0\mathrm{Max}[0, P_0 - P] + P_0\mathrm{Max}[0, Q_0 - Q] \geq \mathrm{Max}[0, \bar{R} - PQ]. \tag{2}$$

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 Assurance

Just as the assurer can benefit from coordinating price and crop assurance through the use of revenue assurance, there are gains to be made from coordinating assurances given to the revenues of different crops. Portfolio assurance can be less costly to the assurer than crop specific assurance, and the savings occur regardless of the correlation between contemporaneous crop revenues. To

Figure 1: Comparison of Revenue Assurance with Price and Crop Assurance



illustrate, 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 $C_1(A_1)$, i.e., a function of 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 $\bar{R}_2$, respectively. Let B_1 be the number of acres upon which the farmer can receive crop 1 revenue assurance, i.e., the number of crop 1 base acres. Let L - B_1 acres be eligible for crop 2 revenue assurance. The following result can now be stated:

Result 2: *Portfolio revenue assurance is less costly to the assurer than crop specific revenue assurance over the same base acres, and at the same per acre assurance levels.*

Proof: *Consider figure 2 below. Let* $\Delta = B_1(\bar{R}_1 - \tilde{R}_1) + (L-B_1)(\bar{R}_2 - \tilde{R}_2)$. *The horizontal axis represents the value of* $\tilde{R}_2$, *while the vertical axis represents that of* $\tilde{R}_1$. *The downward sloping line is the equation* $\Delta = 0$. *The cost to the government of portfolio assurance is Max[0,* Δ*]. It can be seen that* $\Delta = 0$ *represents the boundary that partitions the region where portfolio assurance payouts are required and where they are not required. The vertical dotted line is the equation* $\bar{R}_2 = \tilde{R}_2$, *while the horizontal dotted line is the equation* $\bar{R}_1 = \tilde{R}_1$. *Outcomes in section I require payouts for each crop if crop specific assurance is used, and a payout if portfolio assurance is used. Outcomes in section III do not require payouts regardless of the assurance policy used. Outcomes in section II require a crop specific assurance payout on crop 2 base acres, never require crop specific assurance payouts on crop 1 base acres, and may or may not require portfolio assurance payouts. Section IV is symmetrical to section II. The total payout for portfolio and crop specific assurance schemes are*

Table 1: State Contingent Assurance Costs for Different Fixed Acreage Base Assurance Schemes.

Section and Conditions	Portfolio Assurance	Crop Specific Assurance
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	$(L - B_1)(\bar{R}_2 - \tilde{R}_2)$
Section IIb: $\tilde{R}_1 > \bar{R}_1$, $\tilde{R}_2 < \bar{R}_2$, $\Delta < 0$	0	$(L - B_1)(\bar{R}_2 - \tilde{R}_2)$
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	$B_1(\bar{R}_1 - \tilde{R}_1)$
Section IVb: $\tilde{R}_1 < \bar{R}_1$, $\tilde{R}_2 > \bar{R}_2$, $\Delta < 0$	0	$B_1(\bar{R}_1 - \tilde{R}_1)$

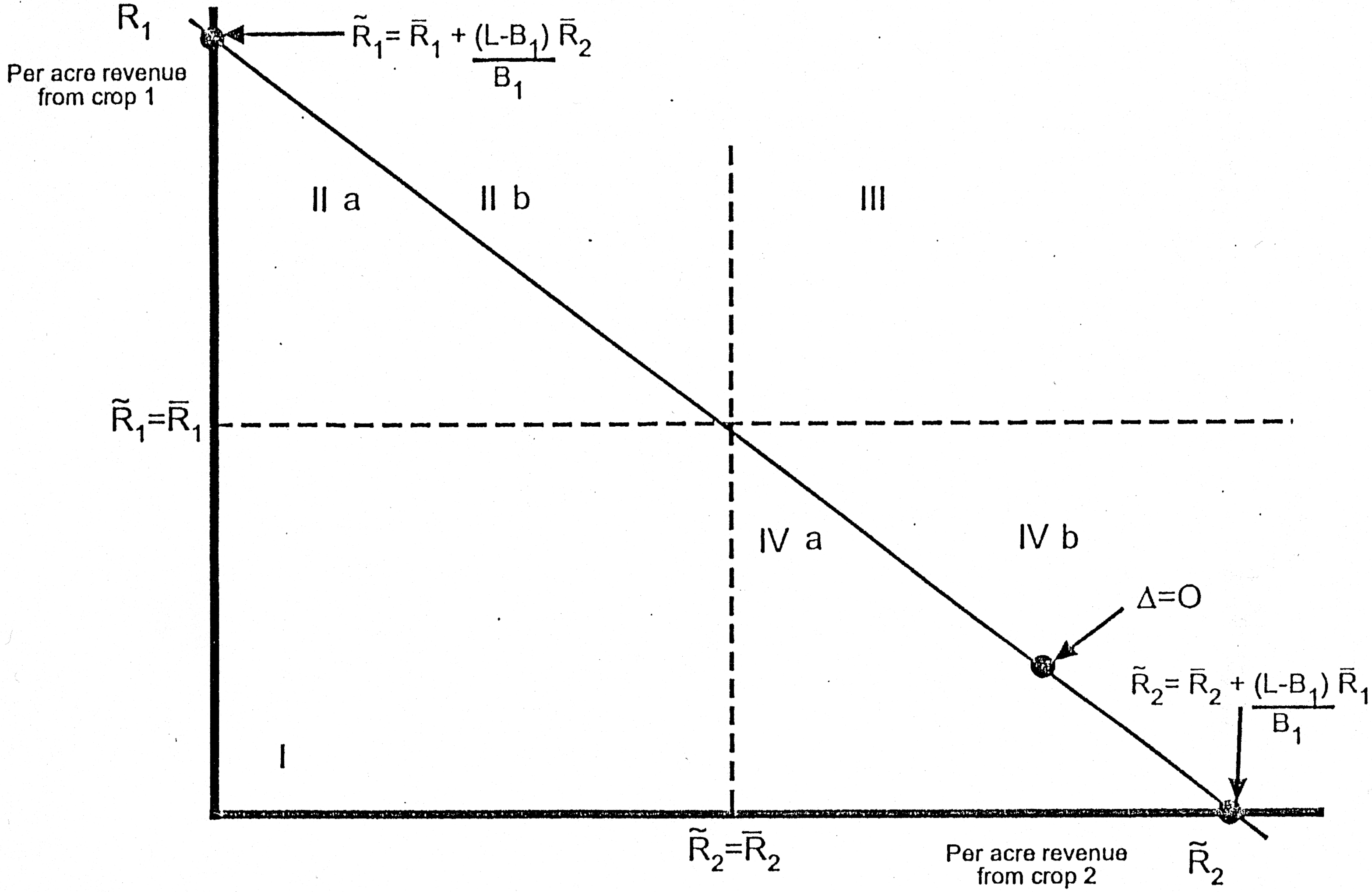
contrasted in table 1. For outcomes in sections I and III both schemes cost the same, while for all other outcomes crop specific assurance is more costly. Therefore, the inequality holds in all states.

The situation is illustrated in figure 2 below, where $\Delta = B_1(\bar{R}_1 - \tilde{R}_1) + (L - B_1)(\bar{R}_2 - \tilde{R}_2)$. The result may be stated as

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

where $\mathbf{CG_{CSpec}}$ and $\mathbf{CG_{Port}}$ 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

Figure 2: Comparison of Portfolio Revenue Assurance with Crop Specific Revenue Assurance



sides is taken with respect to $(\tilde{R}_1, \tilde{R}_2)$. This inequality can easily be extended to the case of a multiple output farm. It can also be demonstrated that

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 assurance be paid on $Q_{i,0}$ units per acre, on B_i base acre, and for price shortfalls below $P_{i,0}$. Let crop i crop assurance be paid at the indemnity $P_{i,0}$ per unit on B_i base acre, and for yield shortfalls below $Q_{i,0}$. Then portfolio revenue assurance is less costly than the sum of price and quantity assurances.*

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

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

where $\sum_{i=1}^{n} B_i = L$. *For a multi-product farm, result 2 may be stated as*

$$\sum_{i=1}^{n} B_i \mathrm{Max}[0, \bar{R}_i - \tilde{R}_1] \geq \mathrm{Max}\left[0, \sum_{i=1}^{n} B_i (\bar{R}_i - \tilde{R}_i)\right]. \qquad \textbf{(6)}$$

Associating the inequalities demonstrates the result.

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 $(\{P_i\}_{i=1}^{n}, \{Q_i\}_{i=1}^{n})$.

A Farm Level Comparison of Revenue Assurance with Deficiency Payments and Crop Insurance Programs

In this section, a representative Cornbelt farmer is studied to infer the revenue, profit, welfare, and resource allocation implications of different revenue assurance regimes. Moral hazard and market price effects are not explicitly considered. That is, we assume that the farm which produces corn and soybeans under current government programs continues to produce corn and soybean under revenue assurance. We limit our analysis to how acreage is allocated between these two crop under the two programs assuming that the distribution of prices is unaffected by the program change. Our typical farm is a 500 acre corn and soybeans farm in Sioux county of Northwest Iowa. County yield data was available for the years 1973-1989. To relate county yield to national yield, the following OLS sensitivity regressions were run,

$$cy_{c,t} = b_{c,0} + b_{c,1}USY_{c,t} + u_{c,t}, \tag{7}$$

$$cy_{s,t} = b_{s,0} + b_{s,1}USY_{s,t} + u_{s,t}, \tag{8}$$

where $cy_{i,t}$ are county yields (bushels per acre) for crop i at time t, $USY_{i,t}$ are national bushels per acre yields at time t, $u_{i,t}$ are stochastic error terms, and $b_{i,j}$ are parameters (j = 0 or 1). National yields are trended over time,

$$USY_{c,t} = d_{c,0} + d_{c,1}t + \epsilon_{c,t}, \tag{9}$$

$$USY_{s,t} = d_{s,0} + d_{s,1}t + \epsilon_{s,t}, \tag{10}$$

where t is a time index initiated at time = 0 in 1980, $\epsilon_{i,t}$ are stochastic error terms, and $d_{i,j}$ are parameters. The results of these four regressions are presented in appendix A.

The estimated contemporaneous correlation between the error terms in equations (7) and (8), (which captures the correlation between national yields), was calculated and found to be 0.6526.

To identify the effect of yield on market prices, inverse demand functions were estimated for corn and soybeans,

$$n(DP_{c,t}) = f_{c,0} + f_{c,1}t + f_{c,2}D_t + f_{c,3}Ln(Q_{c,t}) + \phi_{c,t} \tag{11}$$

$$n(DP_{s,t}) = f_{s,0} + f_{s,1}t + f_{s,2}D_t + f_{s,3}Ln(Q_{s,t}) + \phi_{s,t} \tag{12}$$

where $DP_{i,t}$ is the CPI deflated farm price of crop i, $\phi_{i,t}$ is a stochastic error term for crop i at time t, $Q_{i,t}$ is the national output of crop i at time t, and D_t is a dummy variable to account for extreme exchange rate movements in the mid-1980's: D_t is 0 before 1985, and 1 thereafter. The results are presented in Appendix A.

To account for the averaging effect of county yield data, correlated normal error terms with standard deviations equal to 100 percent of the county residuals (i.e., $u_{c,t}$ and $u_{s,t}$) were added to the county yield data regression for simulation purposes.[3] The correlation coefficient between $u_{c,t}$ and $u_{s,t}$ was calculated from historic data to be 0.338. Denote these correlated error terms as $\theta_{c,t}$ and $\theta_{s,t}$, and denote the farm level corn and soybeans yield variables as $fy_{c,t}$ and $fy_{s,t}$, respectively. Thus, eight sources of error are specified to enter the farm profit function. These are $\{u_{c,t}, u_{s,t}, \theta_{c,t}, \theta_{s,t}, \epsilon_{c,t}, \epsilon_{s,t}, \phi_{c,t}, \phi_{s,t}\}$, and are correlated by the knock-on effects of national yield correlations and county yield correlations. The mean vector and covariance matrix of the stochastic variables $\{fy_{c,t}, fy_{s,t}, cy_{c,t}, cy_{s,t}, P_{c,t}, P_{s,t}\}$ evaluated for 1994 are presented in table 2 below. Here $P_{c,t}$ and $P_{s,t}$ are farm-level corn and soybeans prices, and are inferred from the estimated inverse demand functions.

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 and uses the subsidized Group Risk Plan crop insurance policy available through the Federal Crop Insurance Corporation (FCIC) (Schraufnagel, 1994). The coverage level chosen for both corn and

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[3] In other words, we assume that the averaging effect as we go from individual yields to county yields is the same as from county yields to national yields. Given that we do not know what area the insurer would actually use for area based yields this halfway point seems reasonable.

soybeans is 70 percent of predicted yield. The per bushel crop insured price is $2.21 for corn and $6.17 for soybeans, the regression estimated expected price levels for 1994. Farmers were levied the actuarially fair premia less 30 percent. This reduction captures premium subsidies currently provided by the FCIC.

Table 2: Means and Covariances of Stochastic Yields and Prices

Variable	Mean	$fy_{c,94}$	$fy_{s,94}$	$cy_{c,94}$	$cy_{s,94}$	$P_{c,94}$	$P_{s,94}$
$fy_{c,94}$	131.07 Bu	570.5	37.66	394.0	26.36	- 1.17	- 5.73
$fy_{s,94}$	44.04 Bu	---	37.34	37.45	15.38	- 0.15	- 1.68
$cy_{c,94}$	131.07 Bu	---	---	392.3	26.55	- 1.15	- 5.79
$cy_{s,94}$	44.04 Bu	---	---	---	15.74	- 0.15	- 1.68
$P_{c,94}$	$2.21	---	---	---	---	0.12	0.031
$P_{s,94}$	$6.17	---	---	---	---	---	0.574

For the deficiency payments scheme, the target price for corn is $2.75/bu as specified in the 1990 Farm Bill. Base per acre yield is set at 112.1 bu. This is the mean of county yields over the five years preceding the 1985 Farm Bill, the year when base 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 1990-1994 period.

Cost data was obtained from 1994 Iowa State University Extension budgets (Iowa State University, 1994). 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, the predicted 1994 corn yield of 131.07 bu/Acre was augmented by 5 percent to 137.6 bu/Acre when planted in a corn-soybean rotation, and diminished by 5 percent to 124.52 bu/Acre when planted in a corn-corn-soybean rotation (Henning). Soybeans yield was augmented by 7.5 percent when planted in this rotation. To allow for the possibility of soybeans after soybeans, and to accommodate for the associated tilth and pest problems, mean predicted soybeans yield of 44.07 bu/Acre was diminished by 12.5 percent to 38.56 bu/Acre when planted in continuous soybeans. Linearly interpolating between the yields used in the budgets, the total variable costs incurred in a two acre corn-soybean rotation is found to be \$310.1. Linearly interpolating between yields used in the budgets, the total costs incurred in a two acre corn-corn sequence is \$335.84. Though not reported in the budgets, the variable cost of a soybeans-soybeans sequence was obtained by extrapolating towards soybeans the costs of growing the corn-corn and corn-soybeans sequences, and the variable cost of a corn-corn-soybeans rotation was obtained by a similar linear interpolation. The resulting two acre cost is \$273.25.

Currently, target price program payments are not made on 15 percent of land enrolled in the target price program. These acres are called flex acres, and can be planted to any crop (in this case either corn or soybeans). The present program scenario stochastic profit function is for the current program.

$$
\begin{aligned}
&P_{c,94} fy_{c,94} K_c - costc) A_c^P (1-\alpha) + (P_{s,94} fy_{s,94} K_s - \\
&{}_4 fy_{c,94} K_c - costc) A_c^{NP} + Max[P^T - P_{c,94}, 0] y_0 (1 \\
&\qquad + TA_c [P_c^I G_c^{70} - w_c^{70}] + A_s [P_s^I G_s^{70} - w_s^{70}] .
\end{aligned}
\tag{13}
$$

Here, K_c and K_s are the rotation adjustment coefficients, and α is the set-aside rate, *costc* and *costs* are the per acre costs of growing corn and soybeans, respectively, and vary with the crop mix. A_c^p is the corn acreage that the farmer grows inside the program, A_c^{NP} is the flex acreage that the farmer allocates to corn, and A_s is the soybean acreage. Y_o is the historic corn base yield and P^T is the target price, \$2.75/bu. $TA_c = A_c^P (1\alpha) + A_c^{NP}$ is the total acreage allocated to corn, while P_c^I = \$2.21 and P_s^r = \$6.17 are the prices at which yields are insured, i.e., 1994 expected prices. W_c^{70} and W_s^{70} are the per acre actuarially fair costs of fully insuring corn and soybean yield losses below 70 percent of expected yield, whereas $G_e^{70} = \text{Max}[0.7E[cy_{c,94}] - Y_{c,94}, 0]$ and

$G_s^{70} = \text{Max}[0.7E[cy_{s,94} - Y_{s,94}, 0]$ are the yields upon which payouts are made. It should be noted that acreage allocations are constrained to obey $A_c^P + A_c^{NP} + A_s = 500.$

Crop specific revenue assurance could be calculated using either average county level yields or actual farm level yields. The crop specific revenue assurance scenario stochastic profit function is

$$= (P_{c,94} fy_{c,94} K_c - cost\, c) A_c = (P_{s,94} fy_{s,94} k_s - cost \\ + B_c \text{Max}[\beta \bar{R}_c - P_{c,94} Y_{c,94}^P, 0] + \text{Max}[\beta \bar{R}_s - P_{s,94} Y_{s,}^D \tag{14}$$

where $Y_{c,94}^D$ and $Y_{s,94}^D$ are average 1994 corn and soybean county yields when crop specific assurance payments are made, and are actual 1994 corn and soybean farm yields (including rotation effects) when crop specific assurance payments are made. β is the level of revenue assurance considered. The levels considered are 1.0 or 100 percent, and 0.8, or 80 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. B_c and B_s are respectively, corn and soybean fixed base acres eligible for crop assurance payments. Their values are assigned from the acres allocated to each crop in simulations for each risk aversion level under the present program scenario. In the case of corn, set-aside acres are considered to be allocated to that crop. All other variables have been defined previously.

The portfolio revenue assurance scenario stochastic profit function is

$$= (P_{c,94} fy_{c,94} K_c - cost\, c) A_c + (P_{s,94} fy_{s,94} K_s - cos \\ - \text{Max}[B_c (\beta \overline{R_c} - Ps_{194} Y_{c,94}^D + B_s (\beta \overline{R_s} - P_{s,94} Y_{s,94}^D), (\tag{15}$$

where A_c and A_s, sum to 500 acres.

Risk preferences are held 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 suggest low, and high risk aversion coefficients (RACs) of 0.00001, and 0.00006, respectively. To complete the model for simulation purposes, national corn and soybeans acres planted figures must be assumed. The figures chosen were 75.14 million acres for corn and 58.54 million acres for soybeans. These are the five year average national plantings for the years 1989-1993.

Simulation Results for Target Price/Crop Insurance

Optimum acreage allocation for the present situation, with participation in the corn target price program and 70 percent crop insurance coverage for both crops, was found by Monte Carlo simulations of (13) using GAUSS software. Optimal acreage levels maximize the expected utility of profits as represented by equation (13). For each trial acreage value 100,000 random draws of the eight random variables were used to estimated expected utility. The trial acreage value obtained from a grid search routine that resulted in the highest level of expected utility was taken to be the solution to the maximization problem. Corn program base acres are set equal to optimal corn plantings adjusted for set-aside. This is done because equilibrium can exist only when corn plantings adjusted for set-aside equals base acres.

The target price/crop insurance results are presented in table 3 below. Most noteworthy is that corn acreage decreases with increased risk aversion. Thus, while the target price program is intended to manage risk, other factors outweigh the price support's risk reducing effect as risk aversion increases. One reason may be the lack of diversification when only 167 of 500 acres are planted to soybeans. Compounding this diversification impact is that per acre revenue from variability of soybeans is less than from corn. The standard deviation of corn revenue is \$67/acre while that of soybeans is \$45.6/acre. In addition, the negative correlation between price and farm level yield, at - 0.141, mitigates somewhat the risk impact of low corn prices for corn grown outside the target price program.

Table 3: Acreage Allocations, Costs, and Welfare for Present and Free Market Scenarios

Policy	RAC	A_s	A_c	CER[a]	E[Y][b]	E[C][c]
Present Situation	0.00001	167	311	76,461	78,369	25,141
	0.00006	239	244	70,668	76,924	15,728
Free Market Situation	0.00001	250	250	62,490	64,127	0
	0.00006	250	250	55,199	64,176	0

[a] CER stands for certainty equivalent return.
[b] E[Y] denotes expected income inclusive of support payments.
[c] E[C] denotes expected cost to the government of support payments.

In the target price/crop insurance simulations, non-program acreage planted to corn, (A_c^{NP}) is zero at both risk aversion levels. This is because the target price program induces extra corn plantings relative to the free market situation, and because these extra plantings depress corn yields and elevate soybean yields through rotation effects. For this reason, flex acres are always planted to soybeans.

The CERs (certainty equivalent returns)[4] for the target price/crop insurance program reported in column 5 of table 3 are some $6,000 lower at the higher risk aversion level than at the lower risk aversion level. In the lower section of table 3, the target price program and crop insurance contracts are not used. In this "free market" scenario, all acres are in the corn-soybeans rotation. This result occurs mainly because of the yield enhancing effects of the rotation. These effects imply that expected market income increases with land devoted to soybeans. It peaks at the 50 percent-50 percent rotation, and decreases as soybeans acreage increases from 250 acres to 500 acres. There is a kink in this expected revenue profile at the 50 percent-50 percent allocation, and this allocation is the solution for a range of simulations.

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[4] For details on how CERs were calculated see appendix 2.

With no target price program transfers, expected income and CER decreases relative to the results in table 3. Notice that the difference between columns 6 and 5 for the free market situation in table 3 is less than that for the present situation at the low risk aversion level but greater for the high risk aversion level. For example, when RAC = 0.00001 the difference is $1,908 for the existing situation but $1,637 for the free market situation, while when RAC = 0.00006 the gap is $6,256 for the present situation but $8,977 for the free market situation. Thus, the target price program and insurance contracts are most effective in improving producer welfare at lower risk aversion levels. Thus, the current program does provide assurance. Also, the existence of the present programs increases the CER of the more risk-averse producer by $15,469, slightly higher than the $13,971 increase accruing to the less risk-averse producer. This is true despite the fact that the less risk-averse producer plants more corn and, therefore, gets larger deficiency payment transfers than the more risk-averse producers.

The cost of the deficiency payment program is, however, quite large. In pursuit of revenue from the target price program, acres shift from the more free market profitable soybeans crop to corn. This means that the expected cost of the target price program exceeds by some $11,000 the improvement in the CERs at the low risk aversion level. The difference would remain, but would be smaller, if corn and soybeans prices responded to large movements out of corn. For the highly risk-averse producer, where little acreage shifting occurs, the increase in CER is only some $300 less than program cost. Thus, while the target price program, together with crop insurance, does provide a degree of assurance, the revenue impact of acreage diversion due to the target price program means that the government could enhance producer welfare at lower budgetary and resource misallocation costs by giving decoupled lump sum payments to producers. For example, for risk aversion equal to 0.00001, the transfer of $25,141 to the producer operating under a free market would provide a CER of $87,631, far in excess of the $76,461 resulting from the existence of the target price program and subsidized crop insurance contracts. This is true even after foregone profits from set-aside land are accounted for.[5]

Results for Revenue Assurance Schemes

In table 4, farm level revenue assurance simulations are reported. These results are from Monte Carlo optimization of 14 and 15. Fixed base crop specific and portfolio assurance results are reported for coverage at 100 percent and 80 percent of expected revenue. We assume that the size of the base is based on historical planting data, therefore the base acres and revenue floors used are extracted from the current policy situation in table 3. Acres planted to corn, i.e., gross of set-aside, are 333 for the low RAC producer and 261 for the high RAC producer. These are used as the corn base acres, while the remainder is all related to the soybeans base acreage, (i.e., 167 acres and 239 acres for low and high RAC producers, respectively. The 100 percent revenue floor is the present situation expected revenue per acre. Because per acre revenues depend on acres planted, the expected per acre revenue changes with the RAC level. These results are presented on the far right of table 4. The 100 percent portfolio assurance floor is the sum across crops of the product of base acres and 100 percent revenue per acre assurance floors. The 80 percent portfolio and per acre revenue assurance floors are 80 percent of the per acre assurance floors.

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[5] Under CARA, free market acreage allocations would not be altered by such a transfer (Just and Pope, Proposition 3).

Table 4: Acreage Allocations, Costs, and Welfare for Farm Level Revenue Assurance

Policy	RAC	A_c	CER	E[Y]	E[C]	Assurance Floor	
						Corn	Soya
100%	0.00001	250	74,813	75,349	11,178	$289.6/Ac	$270.2/Ac
Crop Specific	0.00006	250	70,038	72,955	8,768	$302.4/Ac	$253.3/Ac
						Total	
100%	0.00001	250	73,247	73,767	9,498	$141,547	
Portfolio	0.00006	250	67,378	70,407	6,188	$139,460	
						Corn	Soya
80%	0.00001	250	65,001	66,225	2,024	$231.7/Ac	$216.2/Ac
Crop Specific	0.00006	250	59,584	65,884	1,679	$241.9/Ac	$202.6/Ac
						Total	
80%	0.00001	250	63,618	65,009	850	$113,238	
Portfolio	0.00006	250	56,440	64,376	239	$111,568	

The most apparent result in table 4 is that in all cases the acreage allocation is 50 percent-50 percent, the kink point in the expected revenue profile. The motivation for this result is that the yield and cost effects of moving from this allocation are considerable. Only significant, and crop biased, interventions such as the present corn target price program are likely to induce production in this area of Iowa away from the 50:50 corn-soybean rotation. Note that, at 100 percent and 80 percent assurance levels, the crop specific assurance policy is more costly to the government than the portfolio policy. The additional expected cost is in the order of $3-$5/Ac for 100% assurance and about $2-$3/Ac for 80% assurance. At both assurance levels, and for both schemes, the less risk averse producer is more costly to the government. The principal reason for this additional cost is that this producer has more of the risky corn base acres in his vector of base acres. Further, his vector of base acres is less diversified than that of the very risk average producer.

For the less risk average producer, 100 percent portfolio assurance gives a CER of $3,200 less than the target price program and crop insurance scenario, but at a cost of $15,600 less. For risk average producer, 100 percent portfolio assurance gives a CER of $3,300 lower than the present situation but costs $9,500 less. These results suggest that the acreage distortions caused by the present policies, together with the assurance inefficiencies identified in result 3, make the present policy quite inefficient relative to the revenue assurance alternative.

To avoid moral hazard problems, a revenue assurance scheme may alternatively be based on area averages. For this reason, the simulations presented in table 4 above are replicated for the case where the yield on which payouts are calculated are county average yields. Expected government costs are somewhat smaller in these scenarios because county average yield is 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).

Table 5: Acreage Allocations, Costs, and Welfare for County Level Revenue Assurance

Policy	RAC	A_c	CER	E[Y]	E[C]	Assurance Floor	
						Corn	Soybean
100% $270.2/Ac	0.00001	250	73,666	74,428	10,236	$289.6/Ac	
Crop Specific $253.3/Ac	0.00006	250	66,550	71,117	6,965	$302.4/Ac	
						Total	
100%	0.00001	250	70,858	71,685	7,522	$141,547	
Portfolio	0.00006	250	64,797	69,255	5,133	$139,460	
						Corn	Soybean
80% $216.2/Ac	0.00001	250	64,258	65,621	1,400	$231.7/Ac	
Crop Specific $202.6/Ac	0.00006	250	57,650	65,109	919	$241.9/Ac	
						Total	
80%	0.00001	250	62,717	64,318	91	$113,238	
Portfolio	0.00006	250	55,708	64,306	64	$111,568	

A Comparison of the Dollar Cost Effectiveness of Current Programs with Revenue Assurance

Comparisons of columns 4 and 6 in table 5 with those in table 3, show the low effectiveness (per dollar government spending) of the present policies in increasing producer welfare. A measure of just how ineffective the current program is provided in figure 3 below. The cost effectiveness of target price/crop insurance programs relative to a county level revenue assurance program for the more risk adverse producer. Simulations were run for fixed base portfolio assurance, with the assurance floor ranging from 70% to 100% of expected revenue. Simulations were also run to measure the effectiveness of present policy instruments using the target price along the range [$2.05/Bu, $2.75/Bu].

The CER for the more risk-averse producer under the free market scenario, $55,199, 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 assurance is very effective at low assurance levels and even at high assurance levels it provides a $2/$1 welfare return on expected government cost. The target price program is not very effective at low price guarantee levels because of the reduced welfare due to set-aside. Its effectiveness levels off at higher price guarantee levels to provide a $1/$1 to $1.1/$1 welfare return on expected government cost. This is not impressive because a pure non-stochastic cash transfer provides a $1/$1 return when preferences are CARA.

Discussion of the Results

Two results stand out. First, a 70 percent reserve assurance scheme (as requested by producers under the Iowa Plan) would result in a very large reduction in government outlays. This would be particularly true if government assured whole farm revenue, used a county base for yields, and used a fixed acreage base in calculating revenues. Second, revenue assurance makes possible an efficient redistribution of government farm spending. Even if we assume that the marginal opportunity cost of government spending is 1.5 or greater (see Alston and Hurd), revenue assurance defined here could return more to society than it costs. This result occurs because revenue assurance 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 producers welfare function, the product of price times quantity.

Revenue assurance has some other advantages as described here. It is nondistorting and would not lead to resource misallocation (set aside land, excess planting of program crops). However, this paper does not consider the national price impact of such a program nor have we directly considered moral hazard. A full consideration of these effects would likely require some qualification of the results discussed above. We also need to emphasize that all of the simulation results are specific to the particular farm we model. Further work will be required on other types of farms, and on both the moral hazard and national price effects before any farm policy guidelines can be established.

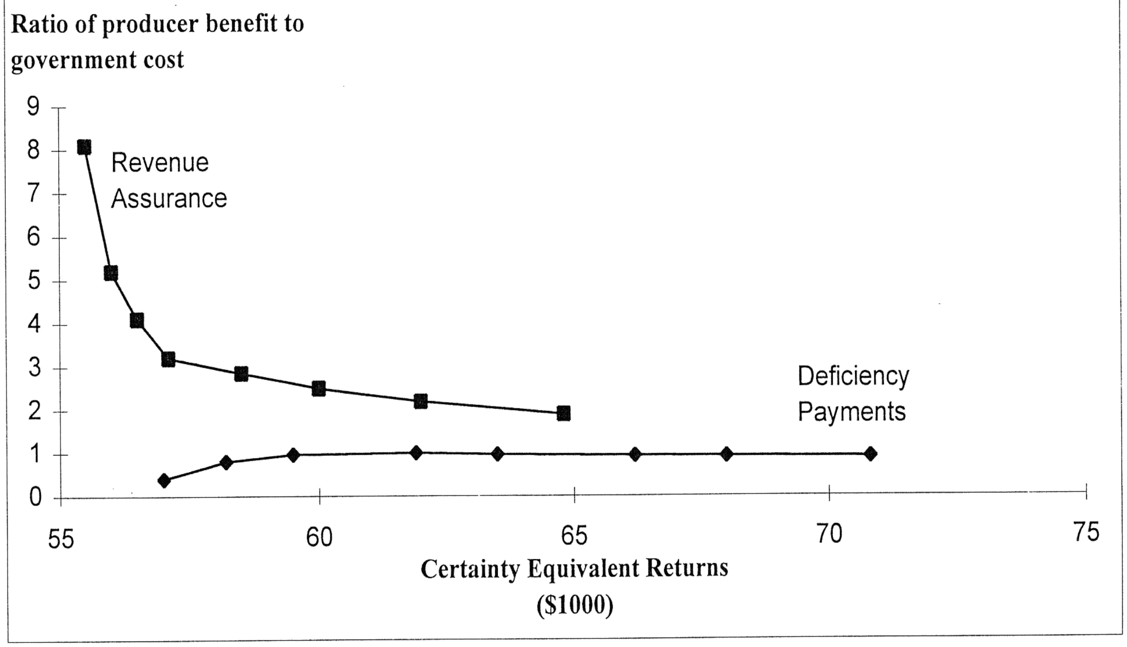
Summary and Conclusions

In this paper, revenue assurance is compared with price and crop assurance, and is found to be less costly in achieving the goal of guaranteeing income from a single crop. It is also shown that fixed base schemes which treat crops separately cost more to the assurer than fixed base portfolio type schemes.

To confirm the directions and understand the magnitudes of the effects, policy simulations were conducted on two Midwestern corn and soybeans producers who possess the same resources and technology, but have different levels of risk aversion. It is found that, under present circumstances, both producers allocate more land to corn than soybeans. Under a free market scenario, both producers allocate land equally to corn and soybeans. The free market 50%-50% allocation is also expected profit maximizing because of the yield enhancing rotation effects. The comparison of the two scenarios suggests that the present deficiency payment policy encourages resource misallocation. Fixed base revenue assurance schemes are shown to provide good assurance with no resource misallocation, and at lower budgetary cost than the present policy.

Simulations were also conducted for county level revenue assurance, where yield used was obtained at a county level. This approach might be used to safeguard the scheme against moral hazard. Here assurance was less costly and somewhat less effective than farm level revenue assurance. Of the schemes considered, county level portfolio fixed base assurance seems most appropriate. It is non-distortionary, is cost efficient for the assurer, and may be free of moral hazard problems. The welfare return, measured in CERs per unit of expected budgetary cost, is about three times as high for this scheme as for the present set of policies.

Figure 3. Efficiency of Government Redistribution.



Note: Producer welfare is increasing in the target price, which is varied from \$2.05/bu to \$2.75/bu, and in the percentage of expected revenue assured, which is varied from 70% to 100%.

Appendix A

Regression results for equations (5) through (10) are reported below. Bracketed terms are t statistics.

$$cy_{c,t} = -10.917 + 1.1664\,USY_{c,t} + u_{c,t}, \quad R^2 = 0.6479,$$

$$(-0.4908) \quad (5.254) \qquad\qquad \sigma^2 = 177.67$$

$$cy_{s,t} = 11.260 + 0.97284\,USY_{s,t} + u_{s,t}, \quad R^2 = 0.5617,$$

$$(1.711) \quad (4.384) \qquad\qquad \sigma^2 = 8.028$$

$$USY_{c,t} = 97.387 + 1.7365\,t_{c,t} + \epsilon_{c,t}, \quad R^2 = 0.3413,$$

$$(31.27) \quad (2.788) \qquad\qquad \sigma^2 = 158.27$$

$$USY_{s,t} = 29.488 + 0.31838\,t + \epsilon_{s,t}, \quad R^2 = 0.2536,$$

$$(41.37) \quad (2.258) \qquad\qquad \sigma^2 = 8.1133$$

$$Ln(DP_{c,t}) = 4.28 - 0.033\,t - 0.22\,D_t - 0.35\,Ln(Q_{c,t}) + \phi_{c,t},\ R^2 = 0.78,$$

$$(2.24) \quad (-1.72) \quad (-1.37) \quad (-1.61) \qquad\qquad \sigma^2 = 0.0229$$

$$Ln(DP_{s,t}) = 10.83 - 0.024\,t - 0.231\,D_t - 1.162\,Ln(Q_{c,t}) + \phi_{c,t},\ R^2 = 0.9243,$$

$$(6.26) \quad (-2.56) \quad (-3.10) \quad (-5.07) \qquad\qquad \sigma^2 = 0.0055$$

Appendix B

This appendix reviews how certainty equivalent returns (CER) are calculated for a CARA utility function. Calculating certainty equivalent returns. Consider the curve that traces out points of indifference between risk and return, with return measured on the y axis and risk measured on the x axis. Now specify a CARA utility function of the type

$$U[Y(R)] = 1 - EXP[-\lambda Y(R)] \qquad \textbf{A1}$$

where Y income depends on revenue R, and λ is the risk aversion coefficient. Choose any risk/return bundle and draw the indifference curve that cuts the range this point. The CER is the point at which this indifference curve intersects the y axis, i.e., it is the certainty equivalent of the risky investment.

To find this point of intersection integrate the utility function with respect to the revenue density function

$$\int_0^\infty (1 - Exp[-\lambda Y(R)])\, f(R)\, dR = E[U] \qquad \textbf{A2}$$

By definition CER is the certain income that generates the same utility as the risky alternative.

$$\int_0^\infty (1 - Exp[-\lambda Y(R)])\, f(R)\, dR = 1 - Exp[-\lambda CER] \qquad \textbf{A3}$$

$$=)\ CER = \frac{LN(1 - E[U]}{(-\lambda)} \qquad \textbf{A4}$$

To find this value we numerically integrate A2 using GAUSS and insert the solution into A4.

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