ASSESSMENT OF RISK WHEN CONTRACT CROPS ARE INCLUDED AMONG OTHER CROP ALTERNATIVES*

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All those who have worked closely with farmers know that uncertainties in farming are great.[1] They stem from many sources — natural forces such as weather, disease, variation in market prices, etc. Some uncertainties, e.g., weather hazards such as hail, can be insured against; others can be reduced by increased wealth. Farmers can also reduce uncertainty through contracting, as these may specify price and quantity.

Most crops grown in the U.S. Central Corn-belt are sold on highly developed public markets with daily prices and offerings. While target prices for soybeans and corn exist, price uncertainty still remains at the time farmers make decisions. Futures markets have long been available. However, few farmers use futures markets to predetermine prices in their crop planning process. One reason for this is that while use of futures markets can remove price risks, biological weather risks remain.

As long as there are well-organized free public markets with a relatively large volume of standardized and homogeneous crops, there is little incentive on the part of the buyer to contract for a crop unless there is a precondition for some advantage either in quality, price, or in time of delivery and method of handling. Likewise, the producer has little or no incentive to contract for future delivery of such a crop unless some price, volume, handling or associated advantage can be gained.

Recently, there has been increased interest in producing crops for which poorly developed public markets exist. These include some of the specialty corns, high starch corn (amylopectin or amylose), high lysine corn, white corn, popcorn and of course, seed corn itself. Some farmers near wet corn millers can now contract to produce high starch corn generally known as waxy-maize. These contracts usually require that the corn be drived and stored on the farm until delivered through the local elevator to the processor. The Japanese are contracting for a special type of soybean that is a more desirable product for direct food consumption on the Japanese market. It may be advantageous for the buyer and seller to contract for certain specialty crops as markets are usually small, special handling may be required and specialized trasportation routes are needed.

The purpose of this study is to develop a way of assessing the risk of contracting specialty crops, along with other normal crop alternatives, on a typical farm. A cornbelt farm is used as an empirical example. However, the method could be used for other production situations where input-output coefficients are known and expected revenue distributions can be estimated.

Use of this model is not limited to micro models. It can be expanded to be regional or national in scope, provided that appropriate information is available, e.g., the effect of selected policy decisions on national production. An example study could analyze expected acreage diverted for selected plans along with confidence intervals for the expected acreage diverted. Armed with this information, policy makers may be better able to choose a plan that will minimize diverted acreage deviations around a

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[1]This paper will not attempt the Knightian differentiation [6] between risk and uncertainty. In this paper risk and uncertainty will be used synonomously.

preselected goal.

THEORETICAL APPROACH TO RISK ASSESSMENT

Much of the work involving assessment of risky alternatives has involved an hypothesized distribution of outcomes and how outcomes of different activities are related. Farm management work on diversification among crops was based partly on negative correlation coefficients observed in the variation of returns among some farm activities [3, 4].

The portfolio selection model, using the income variance efficient frontier, was developed during the 1950s [1, 2, 5, 7]. A basic assumption of this model is that the investor makes decisions based on some expected income and variance of income utility function.

Freund has shown that Markowitz's mean-variability approach to financial assets can be extended to include real production activities as well [2]. The model determines the optimal production combination for a set of resources available to a farmer, given a farmers utility function U(E,V) consisting of mean income and variance of income for the production activities.

The objective function to be maximized is:[2]

$$E\ (U) = u - \alpha\sigma^2$$

where E(U) is expected utility, u is expected income,

σ^2 is the variance of expected income or a measure of the variability of expected income, and

α is a positive coefficient indicating a linear relationship between expected utility and variability of income.[3]

It has been shown that the quadratic programming risk aversion model (QP) incorporates income variances and co-variances with the ordinary production model to describe the variance efficient frontier [2]. A risk aversion coefficient has been incorporated into the quadratic part of the objective function, or rather, a coefficient which has been suggested as the risk aversion coefficient. To our knowledge, no one has yet been able to associate any particular value of this risk aversion coefficient in the QP model with a person's actual disutility for risk. Therefore, only recently has this model been very useful empirically. Computer programs have been developed which parameterize the risk aversion coefficient from zero to unbounded while generating a set of efficient farm plans.

Since the quadratic programming model does account for variation in expected returns from each activity, along with covariance relationships among activities, it has much theoretic appeal if it can be adapted in a practical way to help production decision-making.[4] Adaptation also means that outcomes must be well understood by economists developing the model and actual decision-makers involved with the farming operation.

This study follows the approach taken by Scott and Baker [8]. They proposed to graph the QP model results with respect to expected income and expected variation in income for different production allocations. This method singles out expected income and variation in expected income for different levels of production combinations. The production combination which suits individual preferences with regard to introspective risk aversion and income attainment goals can then be selected (Figure 1).

Minimum to maximum expected income for different activity combinations is graphed on both the Y and X axis. Farm plans or activity combinations are identified on the X axis and can be explicitly detailed in accompanying tabular form. The maximum income level reached is the linear programming outcome and

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[2]An implied relationship is that as expected income (u) is increasing, (σ^2) or the variance in income is also increasing.

[3]The two following conditions are satisfied by the above objective function.

$$\frac{\partial E(U)}{\partial u} = 1 > 0 \quad \text{and} \quad \frac{\partial E(U)}{\partial \sigma} = -2\alpha\sigma < 0$$

Assuming other things being the same these conditions mean:
  (1) a larger expected income would be preferred to a lower one; and
 (2) a lower level of risk would be preferred to a higher level.

Therefore, the objective function permits selection of efficient production combinations only.

Paraphrasing from Markowitz [7] a production combination is efficient if "it is impossible to obtain a greater expected return without incurring greater standard deviation; it is impossible to obtain a smaller standard deviation without giving up income on the average."

[4]For a mathematical interpretation of quadratic programming check with the following reference sources [2, 7, 8,].

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is given by point D in Figure 1. Curves are also plotted for expected income variation at one standard error and 1.96 standard errors below the expected income path. These paths describe a probability lower bound of expected incomes, assuming variation in incomes approximately normally distributed about the expected income. Thus, while the line designated by U'X gives expected income attained from various farm plans designated on the X axis, a farmer could be at least 82 percent confident that income would not fall below the level indicated by the lower bound S path, or at least 97 percent confident that income would not fall below the 1.96S lower bound income path.

Figure 1. VARIANCE EFFICIENT EXPECTED MEAN INCOME AND STANDARD ERROR PATHS
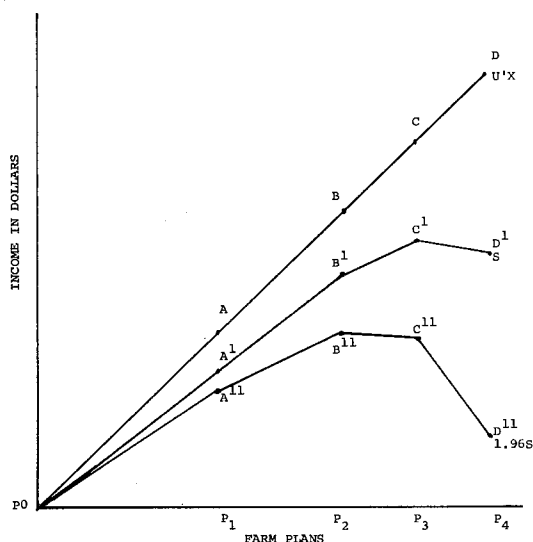
In all cases, most farmers would want to at least reach the income level of plan P_2; at this point not only is expected income (point B) greater, but income is always likely to be better for P_2 than P_1, even with possible income variation. There might be some farmers however, who would not seek a higher expected income (point C) at farm plan P_3; under poor circumstances, for example, drought, disease, etc., income might fall below that received under similar probabilities at farm plan P_2. In figure 1 this is shown by comparing points C^{11} and B^{11}.

Other farmers, willing to accept greater risks, would likely move at least to farm plan P_3 where expected income would be better than the previous two plans at least 82 percent of the time.

Some of these same farmers might not select the maximum expected income with farm plan P_4, since at this risk level there is a greater probability of income falling below that received with farm plan P_3. Still others, with either a very low aversion to risk or a liking for high risk, would choose farm plan P_4 with expected income at D.

The quadratic program calculates the expected income path (U'X$_i$) for each of the different farm plans (P$_i$) determined by parameterizing the risk aversion coefficient in the objective function. The one standard error lower income bound path (labeled S in Figure 1) is calculated as follows: $U'X_i - (X'_i, WX_i)^{1/2}$. The probability path labeled 1.96S is $U'X_i - 1.96 (X'_i WX_i)^{1/2}$.

PROCEDURE, DATA, ASSUMPTIONS

Various alternatives examined were seed corn and waxy-maize as contracted crops, along with commercial grain crops typically grown in Central Illinois — corn, soybean, oats and wheat.

Returns were estimated by yield and price data collected over the ten year period 1962-1971, inclusive, from Illinois Crop Reporting Service Publications. Input-output coefficients and costs were calculated, using Illinois Farm Business Association Record Summaries for the same years. Expected net return variances for each production activity — and co-variances among non-contracted production activities — were estimated by using variances and co-variances calculated from past net revenues of the alternative activities. Past net revenues for contracted crops were calculated using limited experimental data and the few farms where records could be obtained.

The variance and co-variance of expected return, as calculated herein, shows activity performance during the period 1962-71. This approach assumes the past is a good predictor of the future, and that prices and price relationships do not behave randomly.

The quadratic program contained usual resource constraints, transfers, and activities found in farm production linear programming models. It also contained the estimated variance-co-variance matrix of expected net revenues for all production activities included. Risk aversion quadratic programs were developed and calculated for 250, 400, 800 and 1,280 acre cornbelt grain farms from both the whole farm and tenant's viewpoint, assuming a fairly typical 50-

50 crop share lease arrangement. Only details for the whole 400 acre farm, assuming an owner-operator decision maker are reported here.

Table 1 summarizes recommended production activities, net revenue expected, standard error or expected net revenue and lower probability net revenue bounds for the example farm. Numbers not in parentheses are solutions when seed corn is not a contracted alternative. Figure 2 is a graphic representation of these results.

Table 1. SOLUTIONS FOR 400 ACRE OWNER OPERATED FARM

Solution Number	Commercial Corn (Acres)	Soybeans (Acres)	Wheat (Acres)	Oats (Acres)	Seed Corn (Acres)	Idle Land (Acres)	Expected Income U'X (Dollars)	Standard Error (X'WX)$^{\frac{1}{2}}$ (Dollars)	S (Dollars)	1.96S (Dollars)
1	----	----	----	----	----	400	----	----	----	----
	----	----	----	----	----	400	----	----	----	----
2	90.4[a] (99)[c]	28.9 (31.3)	----	236.9 (222.2)	29.9 ----	13.9 (47.6)	18,476[b] (16,296)	934 (842)	17,542 (15,454)	16,645 (14,646)
3	106.9 (119.3)	36.3 (159.5)	----	206.1 (121.3)	40.7 ----	---- ----	21,566 (26,618)	1,120 (1,837)	20,446 (24,781)	19,370 (23,017)
4	152.2 (142.2)	59.9 (176.0)	----	85.6 (74.4)	102.0 ----	---- (7.5)	29,021 (29,219)	1,802 (2,165)	27,219 (27,054)	25,489 (24,977)
5	140.2 (153.6)	118.2 (171.3)	----	64.7 (57.7)	76.9 ----	---- (17.5)	31,313 (29,746)	2,132 (2,270)	29,181 (27,476)	27,135 (25,296)
6	118.6 (190.1)	138.1 (164.6)	----	60.2 ----	83.2 ----	---- (45.3)	32,288 (30,636)	2,326 (2,517)	29,962 (28,119)	27,729 (25,704)
7	105.0 (191.4)	123.2 (160.8)	31.4 ----	32.6 ----	107.8 ----	---- (47.8)	33,131 (30,925)	2,580 (2,619)	30,551 (28,306)	28,073 (25,791)
8	62.4 (192.3)	107.8 (157.4)	71.2 ----	---- ----	158.7 ----	---- (50.3)	33,918 (31,452)	2,927 (3,042)	30,991 (28,410)	28,181 (25,489)
9	10.1 (193.1)	112.3 (154.7)	76.3 ----	---- ----	201.4 ----	---- (52.2)	34,289 (31,577)	3,257 (3,231)	31,032 (28,346)	27,905 (25,244)

[a]Numbers not in parenthesis represent production combinations when seed corn is a contracted alternative.

[b]Returns above variable costs.

[c]Numbers in parenthesis represent production combinations when seed corn is not a production alternative.

RESULTS

Solutions shown in Table 1 begin with all land unused, zero expected income and zero variance of expected income. As income increases so does risk, as measured by the estimated standard error of expected income.

Production activities when contracted seed corn is an alternative are represented by numbers not in parentheses. To generate income and minimize risk at successively higher income steps, the program first indicates oats as the major crop; the more commercial corn, soybeans and seed corn are recommended with fewer oats; followed by less commercial corn, no oats, increased seed corn and the addition of wheat; and finally further reduction in commercial corn and soybeans, and still more seed corn and wheat.

Note that the high point on the 1.96 standard error lower income bound occurs at solution number 8. Most farm owner operators would want to select at least this combination or one which produces an even higher expected income. Solution number 8 includes soybeans, some commercial corn and wheat, no oats, and contracted seed corn.

Production combinations when contracted seed corn is not an alternative are shown in Table 1 by numbers in parentheses. Oats is the primary crop at the low risk level but is phased out as expected income and risk levels increase. At higher risk levels, soybeans and commercial corn are recommended. As the expected income level increases, acres of commercial corn increase and

soybean acres decrease.

The maximum point on the 1.96 standard error lower income bound is reached at solution 7 and at solution 8 on the one standard error lower income bound. A farmer extremely adverse to risk would stop at solution 7, or possibly a lower expected income level, whereas a farmer with a lower level of risk aversion might possibly select solution 8. Farmers willing to accept still more risk would select the maximum expected income at solution 9.

These results show that larger acreages of commercial corn and soybeans are recommended when contract seed corn production is not an alternative.

For a given level of income risk is lower, or for a given level of risk income is higher, when contract seed corn production is included as an alternative. These results are shown in Table 1 by comparing expected income and respective risk or standard error $(X'WX)^{1/2}$ levels. For example, farm plan 8 for contracted seed corn has a higher expected income ($33,918) and a lower standard error level ($2,927) than for plan 9 without contracted seed corn, $31,577 and $3,231, respectively. These same results are shown in Figure 2. For a given level of expected income respective standard error levels are greater when seed corn is not a production alternative. Thus, contract production of seed corn helps reduce risk when compared to no contract production alternatives, which implies the premise that contract production helps eliminate some risks involved in the production process.

CONCLUSION

An attempt was made in this paper to illustrate how alternatives can be assessed and ideal production combinations for individual farmers delineated, considering the farmers income goals and aversion for risk. These represent very practical problems faced by a growing number of American farmers with regard to contract crops.

For a given level of income, risk was lower where seed corn production was a contract alternative. Thus risk for the example farmer could be lowered by producing seed corn.

While risk reductions gained through contracting may not be large, they may be great enough for some farmers. Individual farmers must weigh the level of reduced risk against provisions stipulated in the contract. Additional effort, storage requirements, etc., may be needed to produce a contract crop.

Figure 2. MEAN INCOME AND STANDARD ERROR PATHS; 400 ACRE OWNER OPERATED FARM
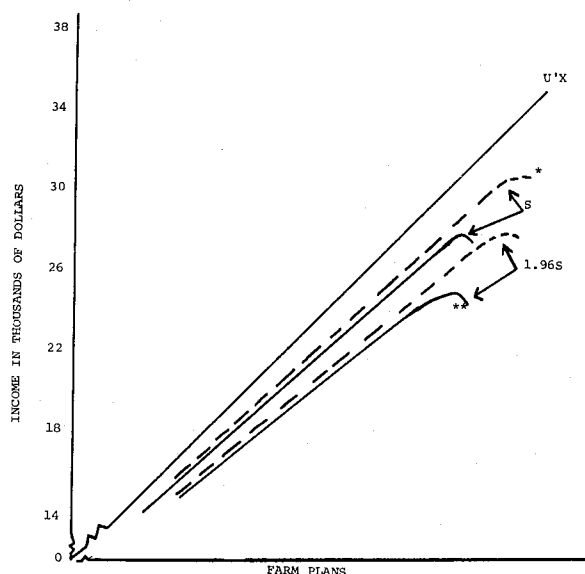
*The dashed lines represent standard error paths with contracted seed corn as a production alternative.

**The two lower solid lines represent standard error paths with contracted seed corn not a production alternative.

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