CR-328
0684

OSU Current Report

Cooperative Extension Service • Division of Agriculture • Oklahoma State University

Crop Decision Risk Analysis

(Includes VisiCalc Template)

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Any decision that can result in a profit also can result in a loss. Profit, in the purest sense, is a return for taking risks. Paid laborers or managers can earn interest with little risk of loss. But, profits represent something more than competitive returns to land, labor, capital, and managment. Profit is the reward that goes to the one who takes the risk of putting management and labor into something without a guaranteed return. Profit goes to capital and land committed without assurance of fixed, positive returns. The potential for profits exist only if there also exists a risk of loss.

Risk may be defined as the chance or probability of a loss or otherwise unfavorable outcome. There are two basic types of risks: business risks and financial risks. Business risk may be thought of as the probability of a loss or adverse outcome from a business decision. Financial risk is the addition to total risks that results from the use of borrowed money to finance a business activity. There are two basic types of business risks: production risks and market risks. Production risk is the probability of loss or adverse outcome resulting from unfavorable yields or production costs. Market risk is the probability of loss or adverse outcome resulting from unfavorable market prices. Total business risk is the sum of production risk and market risk.

Financial risk may be defined as equity risk exposure. Greater use of borrowed capital, ie. higher leverage, increases profits or losses in relation to owned equity. That is, a given level of profit or loss represents a greater percentage of owner equity for a more highly leveraged business activity. From a risk standpoint, higher leverage increases the probability that total owned equity will be lost as a result of any given business decision. Thus, higher leverage implies greater risk.

Risk Rated Decisions

There are an infinite number of possible combinations of probabilities and profits or losses that might result from any decision. A producer might be interested in the chances of making $10,000 or more or of losing $5,000 or more as a result of a decision. One might be interested in how much profit might be expected one-time-out-of-ten in a situation such as the present. Or, risks of loss at the one-out-of-five or 20 percent probability level may be of greater concern. Lack of standard measures of risks tends to make decision making more complex than is necessary.

A producer may choose any risk level as a basis for comparison among alternative courses of action. But, consistent set of standard measures or "risk ratings" may prove useful. A "pessimistic" rating may be assigned to unfavorable outcomes at the one-sixth probability level. Thus, there would be one-chance-in-six of an outcome as bad or worse than the "pessimistic" rated level. An "optimistic" rating may be assigned to favorable outcomes at the one-sixth probability level. There would be one-chance-in-six of an outcome as good or better than the "optimistic" level. An "expected" rating may be assigned to the single most likely outcome. There would be a 50-50 or one-in-two chance of outcomes better or worse than the "expected" level. A producer with a good basic understanding of these three risk levels could make logical risk management decisions.

Decision Risk Analysis

Risk rated decisions follow the same basic guidelines as other decision processes. First, specific risk related objectives should be set by the decision maker. What is the minimum cash flow or net revenue needed at the "pessimistic" probability level? What is the maximum equity exposure at the "pessimistic" level? In other words, how much risk can the operation stand? What is the target or objective net return or cash flow level? What is an acceptable probability of achieving that positive return given the current cost and market situation and outlook? All these are important questions in developing risk rated objectives.

Next, alternative courses of action must be analyzed with respect to their potential for achieving objective returns at acceptable levels of risk. At this point, electronic calculator or computer assistance becomes very useful. Programs are available to combine user estimates of "expected", "optimistic", and "pessimistic" prices and yields to derive risk rated net revenues. Thus, total businesss risks can be expressed as "optimistic", "pessimistic", and "expected" net revenues. The risk ratings of net revenues have the same interpretations as for price and yield risks. There is a one-in-six chance of net revenues higher than "optimistic" levels, one-six-chance of net revenues less than "pessimistic" levels, and so on.

Various financial risk levels are evaluated by calculating total net returns as a percentage of total owner equity. This gives risk rated equity exposure levels. Thus, each alternative can be evaluated in terms of its total business and financial risk dimensions. This process of evaluation facilitates better overall decision making.

*Required Equipment

The following program was designed using a VisiCalc spread sheet program on a micro computer. A similar program is available for use on a TI-59 Texas Instrument programmable calculator with printer. VisiCalc templates are available for Apple IIe and TRS-80 Models II, XII and XVI with Enhanced VisiCalc. A copy of the template can be obtained by contacting the author.

Risk Rated Analysis

The decision maker may input three estimates each for selling price and crop yields to reflect optimistic, expected, and pessimistic situations. This information along with any price-yield correlation, expected production per acre, and number of acres is used to compute risk rated outcomes.

The program will generate estimates of expected, optimistic and pessimistic net returns. Thus, it provides estimates typically shown in "single outcome" planning budgets as well as estimates of outcomes better and worse than those deemed most likely. Probabilities of a profit or loss are calculated also. Profit is defined as a positive return to risk over all costs including opportunity cost of owned equity.

Financial risks are measured in terms of risk rated returns to owner equity. Opportunity costs of owner equity are subtracted from total costs in these calcualtions. The program is capable also of computing probabilities associated with equity outcomes of any level desired by the program user. For example, the user might be interested in outcomes much greater than or less than the optimistic and pessimistic levels generated automatically by the program. However, calculated probabilities are likely to be less accurate for extreme outcomes or for outcomes very near expected values.

Program Input

Risk rated prices and yields make up the first six input entries of each VisiCalc program option. Program users must estimate prices and yields that most accurately represent the predefined probability levels associated with optimistic, expected and pessimistic levels.

Some users may find other ways of expressing the one-in-six levels more helpful. For example, optimistic and pessimistic prices and yields may be thought of as half-way points between most likely outcomes and extreme outcomes that might be expected only one-time-out-of-a-hundred. This definition is consistent with the one-in-six probability level assuming "normally" distributed prices and yields, as used in this program.

Another consistent approach is to divide all possible outcomes into three equal categories: high, average, low. Optimistic then represents the average-high outcome, expected the average-average and pessimistic the average-low outcome. This leaves two-thirds of all outcomes between the average-high and average-low as with the risk rating approach. Regardless of the method, prices and yields entered must be those which seem reasonable to the program user.

Costs per acre of production are assumed to be fixed in this analysis. Thus, all production risks must be reflected in yield risks. This is equivilent to assuming a given amount per acre is committed to production costs at time of planting. Any variation in costs that might be associated with variable pest control measures, irrigation rates, input prices, etc. would have to be estimated as added yield variability for this analysis.

Yield-price correlation entries allow program users to adjust for any expected interrelationship between prices and yields. For example a drought may cause yields to drop toward pessimistic levels. But, poor yields might reduce grain supplies and move prices more toward optimistic levels.

The degree of price-yield correlation will depend on the degree to which program users expect their individual production situation to be correlated with overall market supplies and on sensivity of prices to supply variability. A price-correlation of 0.5 would imply than roughly 25% (0.5x0.5) of price variability would be associated with variability in the program users production crop yields. That would probably be a practical maximum for most producers. A price-yield corr. value of 0.2 might be more reasonable for most situations. And, in many cases a value of 0.0 will be more accurate meaning no measurable correlation between prices and yields for the individual producer.

Risk Rated Analysis--Example

An example risk rated analysis is shown in table 1. Probabilistic estimates of price outcomes indicate a one-in-six chance of an optimistic price as high or higher than $4.20 for wheat at harvest. A most likely or expected price is $3.60. But, there is a one-in-six chance of the pessimistic price of $3.10. Optimistically, there is a one-in-six chance that yields per acre will average as high or higher than 32 bushels. Expected yields are estimated at 28 bu. and pessimistically, yields might run as low or lower than 24 bu. per acre one-out-of-six times.

A price-yield correlation of -.10 assumes only about 1% of price variation is related to yield variation. Expected cost per acre is $90 and 160 acre of wheat are to be planted. Any variability in cost per acre or acres planted must be accounted for in variability of yields.

Financial entries indicate $30,000 of owner equity in this operation with the rest assumed to be borrowed capital. An opportunity interest rate of 14% represents an alternative return on owned equity. Cost of borrowed capital has been included in cost estimates. A 12 month or annual period is used to calculate interest on equity capital.

Intermediate results are shown directly below input values. A $26.25 per acre interest on owner equity figure is subtracted from costs in calculating total returns to equity in the financial analysis section of results. Optimistic and pessimistic standard error figures of 21.01 and 19.05 reflect standard measures of variability in net returns per acre above and below expected net return values.

Risk rated returns are expressed in per acre returns of risk. Expected risk returns , $10.80 per acre, are equal to expected price times expected yields minus expected cost per acre. Optimistic net returns equal expected net returns plus the optimistic standard deviation. There is an estimated one-in-six chance of net returns equal to or greater than $31.81 per acre, based on probabilistic prices and yields entered into the input section of this program. There likewise is an estimated one-in-six chance of net returns equal to or less than a $8.25 loss in this same situation.

Probability estimates of profit and loss are based on assumptions of normally distributed prices, yields and net revenues. There is an estimated 71% chance on a profit, ie. net revenue equal or greater than zero, in this price-yield situation. This leaves a 29% probability of loss. Thus 71 times out of a hundred a producer facing this price, yield and cost situation would expect to show some profit but the other 29 times the outcome would be expected to show a loss.

Financial risks are analyzed in the final section of results. Expected returns to owner equity reflect total costs minus interest on owned equity. Thus, equity returns include returns to both capital and risk. The expected return of $5,928 represents a 20% return on the owner's $30,000 equity commitment for twelve month period. There is an optimistic, one-in-six chance of a $9,289 or 31% return on equity. But pessimistically, there is a one-in-six chance of a $2879 or 10% equity return compared with a 14% opportunity return on equity.

The last section of the program allows users to enter and critical equity return value such as the $10000 and 0 returns shown. Probabilities of such returns are calculated by the program. Example results show an 11% chance of $10,000. This result is a larger return than the optimistic return of $9,289 which would represent a 17% probability. There is a 3% chance of a 0 or negative return to equity from this particular operation. Minimum probabilities shown will be 1% indicating some probability of any reasonable outcome.

Summary

The previous example illustrates only one risk situation. But, the analytical program provides decision makers with the power to analyze numerous alternatives. Some of these alternatives include hedging in the futures market, higher or lower financial leverage, alternative crops and alternative production practices. Reasonable estimates of expected prices and yields as well as variability or risks associated with price and yield estimates are necessary parts of each analysis. Other basic information includes equity capital, interest rates and any yield-price correlation. But, the computer or calculator does all the "pencil pushing" once the appropriate numbers are entered.

There are no guarantees of profitabile decisions. This risk program is designed to deal with the always present possibilities of prices and/or yields less favorable than expected. The best of decisions can result in losses even when risks are taken into consideration. But, the odds of a profitable decision may be improved greatly by evaluation of potential profits and risks among logical alternatives. Programmable calculators and micro computers provide analytical power to make such complex analyses not only possible but practical.

Visicalc Equations

Key equations used in risk rated calculations are provided for those using other computational systems. Spread sheet locations are listed for input and output in column E with the first price data entry in row 34. Calculations for a second column of input, provided in the visicalc program, are identical to those shown for column E.

Equation 1 calculates interest on owner equity on a per acre basis for the appropriate number of months. Equation 2 calculates the standard deviation of net revenue for optimistic outcomes. Differences between optimistic and pessimistic outcomes are used to represent standard deviations of price and yield distributions. Equation 3 repeats the process using differences between pessimistic and expected values to estimate pessimistic net revenue standard deviations. These calculations assume normally distributed prices and costs. The equations used will yield standard deviations of net revenue distributions which approximate normality for normally distributed prices multiplied by normally distributed yields. Standard deviation of revenue per acre equals the square root of expected yield squared times the variance of price plus expected price squared times the variance of yield plus 2 times expected yield times expected price times the covariance of price and yield. Standard deviation of total revenue equals the standard deviation of net revenue assuming cost per acre is a constant.

Equations 4, 5 and 6 calculate optimistic, expected and pessimistic net revenues per acre respectively. Expected net revenue, equation 5, is expected price times expected yiels minus expected cost. Optimistic net revenue equals expected net revenue plus the optimistic standard deviation. Pessimistic net revenues is expected net revenue minus the pessimistic standard deviation.

Equation 7 checks for an expected profit or loss. If the expected return is positive, zero or breakeven will be on the pessimistic side of the distribution and vice versa. Equation 8 calculates a "Z" value of a normal distribution: expected net revenue minus zero divided by the appropriate standard deviation. Maximum "Z" values of 2.5 are used to insure some probability of all reasonable outcomes. The "if" statement in equation 8 selects the appropriate standard deviation. Equations 9 through 11 integrate the area under a normal curve between its mean and the "Z" value calculated in equation 8. Equation 12 checks for a profit or loss and shows the appropriate probability for a profit. The probability of loss is one minus the probability of a profit.

Equations 13 and 14 illustrate the basic methodology used in calculating total returns in the financial risk section. Interest on owner equity is added to net revenue per acre, which is equivilent to reducing costs by that amount. Thus, total returns are returns of owner equity and risk. This adjusted net revenue is multiplied by the number of acres planted to generate an expected total net return. The optimistic standard deviation likewise is multiplied by expected number of acres to calculate the standard deviation of total net revenue.

The optimistic standard deviation is added to expected net revenue to estimate an optimistic total net return to equity, as shown in equation 13. Optimistic total net revenue is divided by owner equity and converted to percentage terms to generate an optimistic equity return, as shown in equation 14. Expected total net revenue is calculated as indicated in the optimistic equation. The pessimistic total net revenue equation is identical to equation 13 except it uses the pessimistic standard deviation.

Probabilities of the last two critical return levels use methodology identical to that used in calculating probabilities of profits. Critical returns are compared

Input Table for Crop Risk Analysis

Description	Input opt#1	Input opt#2
OPTIMISTIC PRICE	4.20	3.65
EXPECTED PRICE	3.60	3.55
PESSIMSITIC PRICE	3.10	3.45
OPTIMISTIC YIELD	32	32
EXPECTED YIELD	28	28
PESSIMISTIC YIELD	24	24
COST PER ACRE:	90.00	90.00
PRICE-YIELD CORR.	-0.10	-0.10
PRODUCTION-ACRES	160	160
OWNER EQUITY-$	30000	30000
INT. RATE-%/100	0.14	0.14
PROD. PERIOD-MOS.	12	12

>A78 Resuts

*** CAUTION DO NOT INPUT VALUES IN POSITIONS BELOW ***

output used in other calculations

INTEREST ON EQUITY	26.25	26.25
OPT. SDT.ERROR	21.01	14.20
PESS. SDT. ERROR	19.05	14.20

Risk Rated Returns

>A31-Input	opt#1	opt#2
OPT. NET RET./ACRE	31.81	23.60
EXP. NET RET./ACRE	10.80	9.40
PESS.NET RET./ACRE	-8.25	-4.80

Risk Return Probabilities

PROB. PROFIT	0.71	0.75
PROB. LOSS	0.29	0.25

Financial Risk Analysis

	opt #1	Opt #2
OPT.TOT. NET.RET.	9289	7975
AS PCT.EQUITY	31	27
EXP.TOT. NET.RET.	5928	5704
AS PCT.EQUITY	20	19
PESS.TOT.NET.RET.	2879	3433
AS PCT.EQUITY	10	11

*** New Critical Values May Be Entered Below *******

CRIT. EQ.RET. #1	10000	10000
PROB. RET.>= #1	0.11	0.03
CRIT. EQ.RET. #2	0	0
PROB. RET.<= #2	0.03	0.01

with expected total net returns to determine whether optimistic or pessimistic standard deviations are appropriate. Normal "Z" values are calculated using the appropriate total net revenue standard deviation. Equations identical to those in equations 9-11 are used to calculate probabilities of returns above critical level #1 and below critical level #2. These basic equations are not shown as a matter of practicality. The whole probability calculation process is a straight forward use of statistical formula associated with normally distributed random variables.

```
1   >E54:((E48*(E49/12)*(E47/E45)

2   >E55:@SQRT(((E39^2)*((E34-E35)^2))+((E35^2)*((E38-E39)^2)
     +(2*E44*E35XE39*(E34-E35)*(E38-E39)))

3   >E56:@SQRT(((E39^2)*((E35-E36)^2))+((E35^2)*((E39-E40)^2)
     +(2*E44*E35*E39*(E35-E36)*(E38-E39)))

4   >E61: ((E39*E35)-E42)+E55

5   >E62: ((E39*E35)=E42)

6   >E63: ((E39*E35)-E42)-E56

7   >J64: (E62<0)

8   >K64: @MIN(2.5,@ABS((E62-0)/@IF(J64,E55,E56)))

9   >L64: 1/(1+(0.2316419*K64)

10  >M64: 0.398942281*((2.71828)^((-(K64^2)/2)))

11  >N64: +M64*((0.31938153*L64)-(0.356563782*(L64^2))
     +(1.781477937*(L64^3))-(1.821255978*(L64^4))
     +(1.330274429*(L64^5)))

12  >E67:@IF(J64,N64,(1-N64))

13  >E73: ((E62+E54)*E45)+(E55*E45)

14  >E74: (E73/E47)*100
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