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Sources and Measurement of Risk in Agriculture–A Review

Shashi Kiran, A.S.[1], K.B. Umesh [2], K.S. Somashekar[3] and L. Harish[4]

[1,2]Department of Agricultural Economics, UAS, GKVK, Bangalore-65
[3]Department of Agronomy, UAS, GKVK, Bangalore-65
[4]Department of Agricultural Extension, UAS, GKVK, Bangalore-65
E-mail: [1]shashikiran4089@gmail.com

Abstract—*Agriculture production is confronted with risk and uncertainty conditions. As agriculture production being biological and seasonal in nature, we don't know the nature of agricultural decisions and their possible outcomes. It is a highly difficult proposition to make right decisions about making investments in agriculture. Though there is not much difference between risk and uncertainty, according to recent view, risk is measurable, while uncertainty is not measurable. In the present paper different sources of risk are discussed which are to be considered in assessing risk before making any investments. The risk associated can be estimated from behavioral view by using sensitivity analysis and probability and statistically by standard deviation and coefficient of variation. A hypothetical example where two projects of same economic life requiring same initial investment but with different cash flows is considered for better understanding. Among four methods discussed in this paper coefficient of variation is a better measure of the risk as it adjusts for the size of the cash flow.*

1. INTRODUCTION

Agriculture production is confronted with risk and uncertainty conditions. As agriculture production being biological and seasonal in nature, we don't know the nature of agricultural decisions and their possible outcomes. It is a highly difficult proposition to make right decisions when the production environment is risky and uncertain. Farmers are generally concerned with decisions on crops to be planted, seed rates, fertilizer application, application of other crucial inputs, etc. These decisions are subjected to change depending on the nature of weather risk and other associated risks. A livestock farmer has to take a number of decisions to expand his dairy cattle herd and he has to wait for several years to get back the investment and also income from investment. Changes in the weather, price, and other socio-economic factors occur between time period in which investment decisions are made and the final outcome. Due to this the farmers have to consider various management strategies relevant to the risk and uncertainty conditions. If everything in farming goes with certainty then every farmer becomes a better manager, but this is not the case with real farming situation. Only a few farmers can become efficient, particularly those who could understand risk and uncertainty situation in farming and follow the relevant risk management strategies.

2. RISK AND UNCERTAINTY

Earlier economists did not make any difference between risk and uncertainty. Only about three decades ago, economists made a clear cut distinction between these two terms. According to recent view, risk is measurable, while uncertainty is not measurable.

Risk is defined as a situation when all possible outcomes are known for a given management decision and probability associated with each possible outcome is known. Risk is measured through probability concepts. Probabilities are based on judgement and experience of individuals and these may vary from individual to individual. Uncertainty is a situation where all possible outcomes of events are unknown and then neither the possibilities nor the outcomes are known. A pure risk situation is not seen in real world, because the true probabilities are not estimated for the events.

Knight (1971) brought out the difference between risk and uncertainties. He indicated that in case of risk the distribution of outcome in a group of instance is known while in case of uncertainty this is not true. Ray (1960) in his paper reviewed the need and importance of crop insurance in minimizing risk and also examined the countries operating crop insurance programmes. Rajagopalan and Varadarajan (1978) in an attempt to study the impact of risk and uncertainties on farm production and income in the hilly areas indicated that diffusion of technology helps in minimizing risk and also protects the farmers in general. Singh and Sharma (1988) attempted to highlight the risk element in farm business on unirrigated farms. The magnitude of risk in yields, product prices, variable cost and gross margins per farm were determined by computing the coefficients of variation.

3. MAJOR SOURCES OF RISKS

- Production risk or technical risk

- Price risk or marketing risk
- Financial risk
- Institutional risk
- Human or personal risk

4. PRODUCTION RISK

In industrial business there is a technical input-output relationship with known quantity of output for given input i.e., the production practices are standardised in industrial production. Such type of relation does not exist in agricultural production. Output of crop is subjected to change due to weather, disease, insect, weeds and inadequate technology. These factors cannot be predicted accurately and hence results in the variability of the output. In fact, the yield variations are due to many factors. Some of them are under control, while some others are not under control of management. Thus, the production risk is due to many factors rather than a single factor. Weather risk and technical risk are the most important components of production risk. The cost of production per unit of output is also changing due to productivity levels and magnitude of cost both over time and space. When the technology is changing in a particular place, it would have greater bearing on production risk. The new technology, though it brings higher profit, it would also involve greater variation of the output.

5. PRICE RISK

It is also called as market risk because prices are determined due to interaction of demand and supply in the market. Production of crop is influenced by prices in the market which are beyond the control of farmers and the consumers price of commodities vary from year to year, season to season and exhibit seasonal variation. If there is less time lag between production and marketing activity, we could expect less price risk for agricultural commodities, because there is enough time for price to fluctuate when the commodities move from production centre to consumption centre. Supply of the commodity is very much affected if there is a situation of weather risk and production risk. Demand for a commodity is mainly changing due to consumers' income, habits, tastes and preferences, export and import policies and overall, general economic measures taken by government with regard to price stabilization.

6. FINANCIAL RISK

Sources of financial risk include production risks and price risks from above, inflation, especially cost increases on key inputs and changes in interest and exchange rates. This type of risk increases with increased amount of barrowed money in the farm business. The aspect is explained by the principle of increasing risk. According to this principle, if borrowing increases there would be greater risk of foregoing the equity capital in the event of losses and this leads to increase in the debt-equity ratio. This is due to changes in future interest rates and changes in the ability of farm to generate required cash flow for clearing of debt.

7. INSTITUTIONAL RISK

This type of risk results from uncertainties surrounding government actions. Tax laws, regulations for chemical use, rules for animal waste disposal, and the level of price or income support payments are examples of government decisions that can have a major impact on the farm business.

8. HUMAN OR PERSONAL RISK

This risk refers to factors such as problems with human health or personal relationships that can affect the farm business. Accidents, illness, death, and divorce are examples of personal crises that can threaten a farm business.

All these types are interrelated and mixed and hence a careful analysis is to be made considering all types of risk including their sources to follow the relevant risk management strategies.

9. MEASUREMENT OF RISK

The risk associated with a single asset is assessed from behavioural and quantitative point of view. The behavioural view of risk can be obtained by using sensitivity analysis and probability. The statistical measures of risk are standard deviation and coefficient of variation.

10. SENSITIVITY ANALYSIS

It is one of the behavioural measures of risk. It provides information as to how sensitive the estimated project parameters, namely, the cash flow, discount rate and project life. This is important as future is uncertain and there will always be estimation errors. Sensitivity analysis provides different cash flow estimates under three assumptions.

1) Worst or pessimistic
2) Expected or most likely
3) Best or optimistic

This is explained with an example below.

Consider we have two projects X and Y. The initial investment for both projects is Rs.40000.

Table 1: Hypothetical example for sensitivity analysis

Particulars	Project X (RS in '000)	Project Y (RS in '000)
Initial cash outlay (t=0)	40	40
Cash inflow estimates (t=1-15)		
Worst	6	0
Most likely	8	8

Best	10	16
Required rate of returns	0.10	0.10
Economic life (years)	15	15

Source: Khan and Jain, 2004 and Author

The NPV of each project at 10 percent required rate can be calculated for each cash flow by multiplying by present value interest factor annuity (PVIFA) which is 7.606 for this case.

Table 2: NPV for different cash flows of two projects (Rs)

Expected cash flow	Project X		Project Y	
	PV	NPV	PV	NPV
Worst	45,636	5,636	Nil	-40,000
Most likely	60,848	20,848	60,848	20,484
Best	76,060	36,060	1,21,696	81,696

Source: Khan and Jain, 2004 and Author)
Note: PV=Present Value

NPV= Net Present Value

The above table demonstrates that sensitivity analysis can produce some useful; information about projects that appear equally desirable on the basis of the most likely estimates of their cash flows. Project X is less risky than project Y.

11. PROBABILITY

Table 3: Calculation of NPV by probability method

Possible NPV		Probability of NPV occurrence	NPV *Probability (Rs)
Project X (Rs)	5,636	0.25	1,409
	20,848	0.50	10,424
	36,060	0.25	9,015
			Expected NPV 20,848
Project Y (Rs)	-40,000	0.25	- 10,000
	20,484	0.50	10,424
	81,696	0.25	20,424
			Expected NPV 20,848

Source: Khan and Jain, 2004 and Author)

Note: NPV= Net Present Value

In this case cash flows are assigned with probabilities. The concept of probability is helpful as it indicates the percentage chances of occurrence of each possible cash flow.

The quantification of variability of returns involves two steps. First, depending on the chance of occurrence of a particular cash flow estimate, probabilities are assigned. Second is to estimate the expected returns on the project. The expected value of the project is a weighted average return, as it will be multiplied by respective probability.

Since the expected NPV are same this method shows that both projects are of same risk.

For precise measures of risk we can go for statistical methods. Two methods discussed are below

12. STANDARD DEVIATION

It is the square root of mean of the squared deviation, where deviation is the difference between an outcome and the expected mean value of all outcomes. Further to calculate the value of standard deviation, we provide weights to the square of each deviation by its probability of occurrence.

Assume there are 'n' possible levels of cash flows which are signified as CF_1, CF_2..... CF_n. The mean of these cash flows equals MCF. The probability of any CF_i signified as P_i. The formula to calculate the standard deviation (σ) is as follows:

$$\sigma = \sqrt{\sum_{i=1}^{n} P_i (CF_i - \overline{CF_i})^2}$$

CF_i = Cash flow at probabilty i

P_i=Probability of CF_i

The greater the standard deviation of a probability distribution, the greater is the dispersion of outcomes around the expected value. Standard deviation measures the degree of uncertainty of cash flow and is one of the precise measure of risk.

Table 4: Calculation of standard deviation

CFi		$\overline{CF}$ (Rs)	(CFi-$\overline{CF}$) (Rs)	(CFi-$\overline{CF}$)2 (Rs)	Pi	(CFi-$\overline{CF}$)2 Pi (Rs)
Project X (Rs)	5,636	20,484	15,212	23,14,04,944	0.25	5,78,51,236
	20,848	20,484	Nil	Nil	0.50	Nil
	36,060	20,484	15,212	23,14,04,944	0.25	5,78,51,236
∑(CF-$\overline{CF}$)2 Pi						11,57,02,472
σ X						10,756.4
Project Y (Rs)	-40,000	20,484	60,848	3,70,24,79,104	0.25	92,56,19,776
	20,484	20,484	Nil	Nil	0.50	Nil
	81,696	20,484	60,848	3,70,24,79,104	0.25	92,56,19,776
∑(CF-$\overline{CF}$)2 Pi						1,85,12,39,552
σ Y						43,026.0

Source: Khan and Jain, 2004 and Author
Note: CF_i=Cash flow at probabilty i

$\overline{CF}$ =Mean Cash Flow

The standard deviation of project X is smaller than that of project Y. Therefore, it can be concluded that project X is less risky than project Y.

If the sizes of the projects outlay differ, the decision maker should make use of the coefficient of variation to judge the riskiness of the project.

13. COEFFICIENT OF VARIATION

It is a relative measure of risk. Standard deviation cab be misleading in comparing the risk of alternative projects, if

they differ in size. The coefficient of variation (V) is a correct technique in such cases. It is calculated as follows:

$$V = \frac{\sigma}{CF}$$

σ= Standard deviation

CF=Expected cash flow

The coefficient of variation for project X and Y are 0.516 (Rs 10,756.4/ Rs 20,848) and 2.06 (Rs 43,026/ Rs 20,848). The higher the coefficient, the more risky is the project. Project Y, therefore is more risky than project X. The real utility of V is apparent when we compare the projects of different expected values.

14. CONCLUSION

Before going for measurement of risk, it is very important to understand different types of risk which are common in agriculture. All four methods discussed in the paper have their own advantages and disadvantages. But still we can conclude that the coefficient of variation is a best of four in measuring risk. This is because it adjusts for the size of the cash flow, whereas the standard deviation does not. Application of different method to measure the risk depends on physical and mental behavior of the decision maker and also depends on the magnitude and frequency of cash flows from the project where he/she has to invest.

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