

RISK, UNCERTAINTY AND INSURANCE IN SMALL-HOLDER AGRICULTURE

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INTRODUCTION

Agriculture as an enterprise is more sensitive to forces of nature than manufacturing hence the higher levels of risk and uncertainty in agriculture relative to manufacturing.

There are several ways of dealing with risk and uncertainty and these include diversification, specialization, forward contracting, flexibility, liquidity and insurance (Adesimi 1988). All these could be undertaken as technical, organizational or expectational modes of operation.

The literature on risk, uncertainty and insurance in agriculture is vast - among the most notable contributors are Knight (1921), Shackle (1949, 1955), Anderson and Dillon (1971), Adegeye and Akinwumi (1978), Adesimi and Alli (1980), Arrow (1965), Carter *et al* (1965), Richardson (1959), Roy (1952), Simon (1955), Theil (1957), Tintner (1941), Tisdell (1962), and Ray (1981).

A farmer faces two major forms of risk in his enterprise. The first arises in the process of production when biological forces alone can make or mar his efforts at securing favourable yield levels. The second comes in form of market forces which dictate the prices he (the farmer) receives for his produce. Agricultural products do not store for long as manufactured commodities.

The objective of this paper is to analyse the strategy of dealing with these two forms of risk so as to minimise unbearable losses to the farmer.

This is particularly relevant to Nigeria where in spite of seemingly laudable government agricultural policy measures, and huge expenditure allocations, her agriculture still remains largely subsistence. The nation's current structural adjustment policy has been credited with improving agricultural output in Nigeria (Oni 1990) but the vast majority of farmers still operate at near subsistence levels.

The risk management techniques discussed in this paper pertain to two aspects of positive agricultural price policy, namely, *insurance* scheme which can be initiated by government, and *utility analysis* which the farmer can tackle only by himself. These two techniques are discussed in detail so that a farmer may be able to help himself out of the possibility of catastrophic losses.

Positive agricultural price policy engenders an improvement in farmer's productive capacity, through provision - at incentive levels and at the appropriate times - of production enhancing inputs and services such as improved seeds, fertilizers, pesticides, water,

mechanical aids and credit. Favourable price movements accelerate innovation adoption, utilization of idle capacity and institutional adjustments.

Agricultural price policy is one area where government intervention has an immediate and often profound positive impact. Most governments in both industrialized and developing economies intervene (directly or indirectly) in agricultural markets to influence prices both for the rural producer and the urban consumer. How the governments intervene can have a profound effect both on agricultural production and on consumption. Specifically the prices at which agricultural produce are bought and sold play three vital roles:

- (1) the prices paid to farmers, and relation of those prices to prices farmers pay for key inputs such as fertilizer have a major impact on what and how much a farmer can produce.
- (2) the price paid to farmers together with the quantity of the produce sold are the primary determinants of farmers' cash income.
- (3) the prices at which agricultural products are sold in the cities are major determinants of the cost of living of urban residents in developing economies.

Prices have a profound impact on agricultural production because most farmers, even in very poor countries, [Oni (1969), Adesimi (1970) and Olayide (1972)] have shown that when prices change, small holder farmers respond much like any profit maximizing businessman operating in a world fraught with uncertainty.

The most important price relationship from the stand point of agricultural production is that between farms output and purchased inputs. From the farmer's point of view, it makes sense to use more inputs so long as these increase the value of farm output more than they increase cost. One of the simplest and most effective ways of increasing farm yield is either to raise the price of farm produce or to lower the price of farm inputs or both (Falcon and Timmer in Reynolds (1975).

In a nutshell, a positive price policy attempts to upgrade the productivity of the existing farm system. It accepts the pattern of land ownership and farming rights and attempts to stimulate rather than coerce subsistence farmers into adopting new methods. The main policy instruments of such a strategy would be:

- (1) to increase the effectiveness and coverage of the farm advisory service.
- (2) to upgrade the marketing system so as to make it easier for farmers to sell their produce and to obtain price and other market information.
- (3) possibly to extend credit to help small farmers purchase inputs.
- (4) certainly to take measures to improve supplies of fertilizers, improved seeds and improved knowledge about the cultivation techniques for traditional as well as non-traditional crops.

Theoretical background

Modern utility theory provides an efficient means of analysing decision-making under risk through the maximization of the utility of the decision maker as a function of the socio-economic variables confronting him. (Arrow, 1965) The guiding hypothesis underlying the test of efficiency of plans of actions under risk is that inadequate treatment of risk has been a major factor accounting for the discrepancies that often arise between the actual and predicted returns to an individual. Each farmer is taken as having an expected utility function he wishes to maximize subject to his marginal risk constraint. However, the optimal plan of the farmer is not activated beyond the point where the expected utility of such action is zero. A utility interval is used to measure the difference in efficiency of decision-making and hence the risk premium involved in taking different actions. (Arrow *op. cit.*)

Study Data

A group of ten villages - Iyanfoworogi, Erefe, Isoya, Akeredolu, Ladin, Olorombo, Aganran, Aroko, Walode and Esara - in old Oranmiyan local government area was studied in 1987 crop season and average yield (per hectare) of maize (shelled grains) among thirteen farmers in each village was computed as presented in Table 1.

Table 1: Average yield of maize per hectare among ten groups of farmer in Isoya (Oranmiyan Local Government) 1988

Group	Average yield (kg)
1	1915
2	1580
3	2139
4	2026
5	4773
6	1691
7	5590
8	2836
9	2172
10	911
Total	2506234

Source: Field Survey 1988.

This gives an overall average yield of 2506.23kg with a coefficient of dispersion of 0.5881. This yield pattern thus displays a wide variation which is an indication of the high level of risk an average maize farmer in the area faces. The impact of risk on the farmers' income may be reduced through:

- (i) seeking more information about better production techniques and prices of both inputs and outputs, and
- (ii) purchasing insurance cover against yield and price fluctuations.

Analysis

Market prices of maize at pre-harvest (t_1) and post-harvest (t_2) periods are used to analyse the risk faced by the respondents¹. The price levels are taken as the states of nature for each action which may be represented as a_i ($i = 1, 2$). The actions are to sell at t_1 at a known price or sell at t_2 when price level may have risen or fallen. The decision criterion is thus to maximize expected utility subject to the prior probabilities assumed by the farmers.

Formally: expected utility $E(u)$ is a function of the action taken, Q_i and the prior probabilities attached to the states of nature ($P(Q_j)$); thus $E(u) = u(a_i, Q_j)$, $i, j = 1, 2$.

The study indicates that price of maize varied from N1.20 per kg to N2.00 per kg. However, the farmers were certain that the t_1 price was N1.50 per kg while they estimated t_2 price at between N1.20 per kg and N1.60 per kg - with different degrees of belief.

In this wise N1.50 was taken as bench mark price and the only two actions assumed for the respondents are (1) sell early (t_1) or sell late (t_2). The actions are assumed to be mutually exclusive and exhaustive. The outcome of each action is conditioned on the state of nature subsisting i.e. $U = u(a_i/Q_j)$. Therefore the utility function can be presented as in Table 2.

Table 2: Utility function: $u(a_i, Q_j)$ for maize farmers

Possible actions	States of nature (Price at t_2)	
	Q_1 (N1.6/kg)	Q_2 (N1.2/kg)
a_1 Late sale	N256.2	-N828.6
a_2 Early sale	0	0
Prior probabilities	0.995	0.75

It is assumed that a farmer offers 2562kg of maize for sale. From table 2, one takes the probabilities of occurrence of the reactions as the probabilities attached to a price rise at t_2 by the farmers. In other words, the probabilities attached to a price fall at t_2 by those who store and sell later is $(1 - 0.25) = 0.75$ while the probability associated with a price fall at t_2 by those who sell earlier at t_1 is $(1 - 0.005) = 0.995$. Thus $P(Q_1) = 0.995$ and $P(Q_2) = 0.75$.

The expected utility in monetary terms can now be calculated for each action. Utility for action a_2 given Q_1 as the state of nature is

$$P(Q_2) U(a_2, Q_2) + P(Q_1) U(a_2, Q_1) \quad \text{---} \quad (1)$$

while the utility for action a_1 give Q_2 is

$$P(Q_1) U(a_1, Q_2) + P(Q_2) U(a_1, Q_2) \quad \text{---} \quad (2)$$

Utility of action a_2 give Q_1 and Q_2 respectively is zero since there exists no utility if all sales had been made at t_1 at N1.50 per kg.

¹ It is assumed that storage costs are negligible or non-existent.

$$\text{Now } (a_1) = 0.995 U(a_1, Q_1) + 0.75 (U(a_1, Q_2)) \text{ _____ (3)}$$

$U(a_1, Q_1)$ is the utility resulting from taking action 1 under the state of nature Q_1 , that is, selling at t_2

when the price is N1.60 per kg.

$$\begin{aligned} \text{This gives } U(a_1, Q_1) &= N(1.6 \times 2562) - (1.5 \times 2562) \\ &= N(4099.2 - 3843.0) = N256.2 \end{aligned}$$

and

$U(a_1, Q_2)$ which is the utility arising from selling at t_2 at a price of N1.20 per kg is

$$\begin{aligned} U(a_1, Q_2) &= N(1.2 \times 2562) - (1.5 \times 2562) \\ &= N(3074.4 - 3843.0) = N828.6 \end{aligned}$$

Therefore selling at t_2 at a price of N1.20 per kg results in a loss of N828.6 implying that the farmer puts a higher degree of belief in a wrong prediction.

The expected utility from a_1/Q_1 can be calculated from expression (3) as

$$\begin{aligned} &/(0.995 \times 256.2) - (0.75 \times 828.6) \\ &= - N366.53. \end{aligned}$$

Hence the farmer loses N366.53 by taking action a_1/Q_2 instead of a_1/Q_1 which is seen to be more profitable. However, $a_2 = 0$ is the optimum i.e. where there is neither gain nor loss.

Break-even Probabilities and Insurance Premium

The decision to sell the maize may be analysed to determine its sensitivity to prior probabilities the farmer attaches to situations.

The prior probabilities are reflection of a farmer's attitude towards risk. The break-even probabilities are calculated by equating the prior probabilities from all actions. Thus

$$\begin{aligned} P(Q_2)U(a_2, Q_1) + P(Q_1) U(a_2, Q_2) \\ = P(Q_1)U(a_1, Q_1) + P(Q_2) U(a_1, Q_2) \end{aligned} \quad (4)$$

that is

$$Q_1 (N256.2) - Q_2 (N828.6) = 0$$

or

$$\frac{Q_1}{Q_2} = \frac{N828.6}{N256.2} = \frac{3.2}{1.0}$$

Thus

$$P(Q_1); P(Q_2) \text{ or } 3.2: 1$$

Whereas the farmer had evaluated the odds to be 0.995: 0.75 or 1.3:1

The results indicate that the farmer needs to seek more information about the most likely price of maize at t_2 . However, information is not costless. The optimum action for the farmer yielded zero at t_2 , therefore the optimum expected utility from any action based on the subjective prior probabilities of the farmers is $N256.2 - 0 = N256.2$.

Therefore, the farmer can seek for more information through all known sources so long as the cost of such information does not exceed N256.20. This amount is his utility interval and it portrays his attitude to risky price situations.

With the additional information, the farmer may have to change his position if the extra information leads him to probabilities different from his prior estimations.

The analysis so far has been on the basis of a yield certainty equivalence², that is, the mean yield for all the farmers sampled.

On the other hand if analysis is based on price certainty equivalence, (that is, the price of maize at t , (N1.50 per kg) rather than on yield uncertainty then calculations of yield insurance premium rates need be undertaken.

Crop yield insurance scheme involves the substitution of a small known cost for the possibility of a larger but uncertain loss. The small known cost is the premium and it is the cost which the client has to pay periodically for purchasing the insurance cover corresponding to the indemnity schedule. The insurer calculates a schedule indicating the premium payable per hectare - these charges are based on an estimate of the average indemnity payable under each of the indemnity options over a period of years. The premium rate thus depends on the insured amount, that is, the particular value of the insurance. It tends to decrease over the years if no claims whatsoever is made and vice versa.

Indemnity Calculation

The data on maize yields from the respondents of this study are used to calculate the indemnity rates in table 3. The actual and insured yields of maize per hectare are used to illustrate the operation of the scheme. As an example, if the actual yield (kg per ha) in a year experienced by a farmer was 2172kg and the insured yield was 2562kg, the indemnity per hectare for that year would be the naira value of the difference between the actual and the insured yield, that is N1.5 (2562-2172) = N585.00. All other indemnities are calculated similarly.

However, a farmer has to decide on basis of yield and price experience whether it pays him to expend resources in seeking information and/or procuring insurance cover. If, historically, expected price and yield had always been close to certainty equivalence levels³ then resources need not be diverted to these schemes. If the converse is true, then action on the two fronts is needed to maximize expected returns. Similar advice should be followed in the event of either phenomenon occurring or not occurring.

Summary and Conclusion

This paper has indicated the ways by which farmers can deal with the two most pervasive risk problems confronting them - yield and price uncertainties. Nigeria's economy is changing and agriculture needs to become gradually commercialized if it is to take advantage of these changes. The methods treated in this paper are among several strategies needed to

This may be personal to him or may be the group average.

³ The certainty equivalence levels may be personal to him or it may be the group average - whichever is applicable.

be considered by producers, agricultural policy makers and agricultural change agents toward the commercialization goal.

They are aspects of positive agricultural price policy since they in conjunction with the other strategies (such as provision of technically sound and economically viable storage systems, good rural roads etc. etc.) result in reduction of these risks faced by the farmers.

Table 3: Indemnity calculations on crop yield insurance scheme based on actual maize yield in Isoya area (Kg/ha)

	911	1580	1691	1915	2026	2039	2372	2562	2836	4773	5580	6000
911	--	1004*	1170	1506	1673	1842	1892	2477	2888	5793	7004	7634
1580	--	--	167	503	669	839	886	1473	1884	4793	6000	6630
1691	--	--	--	336	503	687	722	1307	1718	4623	5834	6464
1915	--	--	--	--	167	336	386	971	1382	4287	5498	6123
2026	--	--	--	--	--	170	219	804	1215	4121	5331	5961
2139	--	--	--	--	--	--	50	635	1046	3951	5162	5792
2172	--	--	--	--	--	--	--	858	996	3902	5112	5792
2562	--	--	--	--	--	--	--	--	411	3317	4527	5152
2836	--	--	--	--	--	--	--	--	--	2906	4116	4746
4773	--	--	--	--	--	--	--	--	--	--	1211	1841
5580	--	--	--	--	--	--	--	--	--	--	--	630

* rates are calculated to the nearest interger

Source: Data analysis

References

- Adesimi A. A. (1970) "An econometric study of air-cured tobacco supply in Western Nigeria 1945-1964" *Nigerian Journal of Economic and Social Studies* 12(3): 315-321.
- Adesimi A. A. and K. M. Alli (1980) "Crop Yield Insurance Programme: A suggested policy approach to stabilize income in the old Western State of Nigeria" *Agricultural Administration* 7 (2): 97-106.
- Adegeye, A. J., and J. A. Akinwumi (1978) "Instituting an Insurance Scheme for Agriculture in Nigeria" *The Quarterly Journal of Administration. Department of Public Administration, University of Ife, Ile-Ife*, 13 (1): 73-84.
- Anderson, J. R. and J. L. Dillon (1971) "Allocative Efficiency, Traditional Agriculture and Risk" *American Journal of Agricultural Economics* 53 (31): 26-32.
- Arrow, K. J. (1965) *Aspects of the Theory of Risk-Bearing* Yrjo Janhsson Lecture. The Academic Book Store Helsinki.
- Knight F. H. (1921) *Risk, Uncertainty and Profit* Houghton Mifflin Company, New York.

- Olayide S. O. (1972) "Some estimates of supply elasticities for Nigeria's cash crops". *Journal of Agricultural Economics* 23 (3): 263-274.
- Oni S.A. (1969) "Production Response in Nigerian Agriculture: A Case Study of Palm Produce 1949-1966" *Nigerian Journal of Economic and Social Studies* 11 (1): 81-91.
- Ray P. K. (1981) *Agricultural Insurance Theory and Practice and Application to Developing Countries*, 2nd edition, Pergamon Press Oxford, p. 345.
- Richardson G. B. (1959) "Equilibrium, Expectations and Information" *Economic Journal* 69: 223-227.
- Roy A. D. (1962) "Safety First and the Holding of Assets" *Econometrica* 20: 431-449.
- Shackle G. L. S. (1949) *Expectations in Economics* The University Press Cambridge.
- Shackle G. L. S. (1955) *Uncertainty in Economics* The University Press Cambridge.
- Simon H. A. (1955) "A Behavioural Model of Rational Choice" *Quarterly Journal of Economics* 79: 99-118.
- Theil H. (1957) "A Note on Certainty Equivalence in Dynamic Planning" *Econometrica* 25: 346-349.
- Timmer C. P. and W. P. Falcon (1975) "The Political Economy of Rice Production and Trade in Asia" in Reynolds L.G. (Ed) *Agriculture in Development Theory*. Yale University Press.
- Tintner G. (1941) "A Pure Theory of Production Under Technological Risk and Uncertainty" *Econometrica* 9: 305-312.
- Tisdell C. (1962) "Decision-Making and the Probability of Loss" *Australian Economic Papers* 1: 109-118.