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FARM PLANNING UNDER RISK AND UNCERTAINTY

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Abstract

This study was designed to develop a farm plan for the study area using Target-MOTAD model. This is within the framework of risk and uncertainty in crop production of small scale farmers in Kwara State. The study determined the set and the level of production activities that optimize household's production under risk.

Questionnaire method of data collection was used to obtain information from 80 randomly selected farming household heads in the study area. Secondary data were collected from relevant journals and texts to supplement the response. Descriptive and inferential statistics such as frequency, percentage, means; standard deviation and target-MOTAD programming were used to analyze the data.

The target—MOTAD programming solution, under safety-First Principle, guarantees returns large enough to cover subsistence need, that is, food security of the small farmers. If decisions would be effective in improving efficiency of agricultural production in the study area, farm planning models should incorporate risk. An increase in capital and labour availability was shown to expand the risk-returns efficiency limitation confronting the farmers.

Keywords: Risk, Uncertainty and Target-MOTAD

Introduction

The development of agriculture in early times was partly a response to the riskiness of relying on hunting and gathering of food. Since then farmers and others have tried ways to make farming itself less risky by achieving better control over the production process. Yet in agriculture as in other areas of human concern, risk remains a seemingly inevitable feature of life because agriculture is often carried out in the open air and is always exposed to risk; And, also, because many farmers in Africa south of the Sahara operate at a small scale, one would expect them to be particularly vulnerable to these sorts of risk (Adubi and Atobatele 1992, Dercon 2002)

The quality of planning and decision-making by these farmers will largely determine the outcome and productivity of their farming operation. This is because planning is the most basic function of management (Kay, 1986). Planning involves the organization of resources such as land, labour and capital; so that as far as possible the future operation of the business will best comply with the objectives set for it. Absence of planning entails hesitation, wrong steps and untimely changes of direction that are frequent causes of weakness if not of disaster in business (Koontz and O'Donnel, 1968).

Agricultural planning, apart from shedding light on efficient utilization of farm resources, makes the charting of causes of action that help in attainment of maximum net returns possible. (Adewumi and Omotesho, 2002). It used to be held that planning is not often required in traditional farming, because farmers mainly practice agriculture which is suited to the soil type and that such programs have stood the test of time. This is however proving to be no longer tenable (Adewumi et al., 1999).

The inclusion of risk in farm-planning model has been the subject of many theoretical discussions, often with the conclusion that explicit risk consideration features are desirable. Operational linear programming-based models are maintained by universities and businesses in farm planning. These operational farm-planning models do not generally include explicit risk consideration. (Brink and McCarl, 1978) However, risk is everywhere and is substantially unavoidable. Hence, a need to include risk in decision analysis especially should be made explicit in an operational farm planning model.

Understanding the concept of farm planning under risk and uncertainty is therefore, a necessity as well as a key opener to the

importance of risk in agricultural planning and will lead to the development of a normative decision theory based on the inclusion of stochastic element in whole farm planning models.

In view of this, in development of the methodology for handling the incorporation of risk in a programming matrix, the theory of games from which a number of criteria were developed (Agrawl and Heady, 1968) was criticized for lack of generality (Scott and Baker, 1972). An area which has proved fertile in the literature on risk is the safety-first concept which regards choice as being dependent upon for instance, the expected value of a variable, disaster level of that variable and the probability of that disaster level (Kennedy and Francisco, 1974).

The methodology chosen for this study was formulated first by Kataoka(1963), and improved upon by Tauer(1983) and Berbel (1990). Umoh and Adegeye (2000) and Adubi (2000) have also given application to this approach.

Objectives of the Study

The main objective of this study is to develop a farm plan for small scale farming households in Kwara state using target-MOTAD model. The specific objectives are:

(a) to elicit farmers' subjective risk perception in crop production

(b) to observe the diversity of enterprise choice combination among farmers

(c) to calculate the set and level of production activities which optimize farming household's production under risk;

(d) to highlight the policy implications of the findings.

Methodology

This study was conducted in Kwara State of Nigeria. It comprises of sixteen local government areas, which have been divided into four zones by the Kwara State Agricultural Development Project (KWADP) in consonance with ecological characteristics and cultural practices (Ajayi, 1998).

Zone C comprising Asa, Ilorin west, Ilorin east, Ilorin south and Moro (LGA's) was randomly selected for the study. A random

sample of farming households with probability proportional to the farming population size of each block was taken. A random sample of 100 respondents from these blocks was selected with 19 from Oloru,18 from Alapa, 14 from Ganmon, 17 from BodeSadu, 17 from Afon and 17 from Ipaye. However, data obtained from 80% of these respondents were found useful for this study.

Model Formulation

This study used the Target-MOTAD (Minimization Of Total Absolute Deviation of Returns) model. Risk co-efficient for farmers were obtained through the output approach using a modification of linear programming model called Target MOTAD. In the model, the farmer is assumed to evaluate risk on the basis of safety-first criteria; that is he minimizes the probability of his farm output falling below his subsistence requirements. This safety-first criterion is introduced as a risk constraint into a linear programming model of a representative farm. The decision criterion used measures risk as mean absolute deviations from an expectation.

Mathematically, the model is stated as

$$\text{Max } E(Z) = \sum_{j=1}^{n} c_j x_j \quad \text{---------- (1)}$$

$$\text{Subject to: } \sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad \text{---------- (2)}$$

$$i = 1, \text{----------}, m \qquad j = 1, \text{-----}, n$$

$$T - Y_r^+ - Y_r^- \leq 0 \quad \text{---------- (3)}$$

$$\text{Or} \quad Y_r^+ + Y_r^- > T \quad \text{---------- (4)}$$

$$\sum P_r Y_r^- = \alpha \quad \text{---------- (5)}$$

$$\alpha = (M \longrightarrow 0)$$

$$X, Y > 0$$

Where

E (Z) = expected returns of the plan or solution to the plan in C_j ;c_j =expected returns of activity j; X_j = level of activity j ;a_{ij} =technical requirement of activity j for resource i ; b_i =level of resource i; T = target level of returns in naira (it was derived from mean absolute deviation); C_{ij}=returns of activity j for state of nature or observation

r (N) ; Y^+= deviation above expected returns; Y^- = deviation below expected returns; Pr = probability that state of nature or observation r will occur; α =a constant parametererized from M to 0

Note that $Y_r = \sum_{j=1}^{n} (c_{ij} - c_j) x_j$

m =number of constraints or resource equation; s =number of state of nature or observation. M =large number (represents the maximum total absolute deviation of return of the model)

Equation 1 maximizes expected returns of the solution set. Equation 2 fulfils the technical constraints for the activities. Equation 3 measures the revenue of a solution under state of nature(r). If that revenue is less than target T, the difference is transferred to equation (5) via variable Y_r. Equation 5 sums the negative deviations after weighing them by their probability of occurrence (P_r). Since the Target – MOTAD model has a linear objective function and linear constraints; the model can be solved with a linear programming algorithm. The model solves for the various expected returns along the efficiency frontier. The E-A efficient frontier was derived by parametrically varying the pre-specified level of the constant (α) to the maximum of Total Absolute Deviation of Returns. The selection of best farm plan along the risk efficiency frontier depends on individual farmer's perception of risk and his resource endowment.

An efficiency frontier is defined as the locus of maximum expected income for each level of risk or alternatively, the minimum amount of risk associated with each level of expected returns. The model is superior to other programming model under risk because it is computational efficient and generates solutions that meet the second degree stochastic dominance (SSD) test (Tauer, 1983; Berbel, 1990; Anderson et al 1997).

Two major data requirements for the operation of the model are constraints specification for the average farm, and the deviation of the gross margins from their expectations.

Through ranking, the farmers' subjective judgment of risk, in crop production was elicited. Farmers classified crops according to the degree of risk involved in their cultivation.

Results and Discussion

The optimal farm plan is hypothesized to be a function of the household heads' perception of risk and other factors such as social and economic status: access to production factor, family composition, education and years of farming experience.

It was found out that only 15.3 per cent of the respondents are between 21-40 years of age, which could be regarded as the most active age bracket. The mean age of the respondents is 52.04 years and 50 per cent of the respondent are above 50 years of age. This has implication on the available family labour and productivity of the labour. The result implies that most of the household heads are old with consequent reduction in their productive activity. Given the ageing nature of the sample, the effective labour force for agricultural productivity in the study area may tend to reduce.

The most common and productive resources in small holder agriculture are the land and labour resources. Land availability is determined by population, the land area, topography and the tenural system operating in an area.

Table 1 highlights the nature of land ownership pattern in the study area

Table 1: *Land tenure System Profile and Perception on Expansion Possibilities in the Study Area.*

S/N	Mode of Land Acquisition	No of Respondents	% (Percentage)	Expansion Possibility	
				No of household	% (Percentage)
1	Family Land	22	27.5	13	15.0
2	Rent/Lease	7	8.8	67	85.0
3	Gift	7	8.8	-	-
4	Inheritance	42	52.5	-	-
5	Purchase	2	2.5	-	-
6	Total	80	100	80	100

Source: *Field Survey data 2002*

About 80 percent of the respondents obtain their land through the extended family system as inheritance or family possession. The land tenure system is therefore still a special feature of these farming households' production. Further examination of means of expansion

for these respondents is shown in table 1. Table 1 indicates that only about 15 percent hope to get more land through family land while the majority (of 85.0 per cent) only depend on rent land, if available. This further shows the nature of primary production in the study area, as, the respondents have fragments of farm holdings mainly from the family land and it is practicably impossible to expand production through acquiring more family land even if available. The average cropped area of the respondents is 2.26 hectares

Farming household heads perceived weather as the most risky variable affecting farm operations irrespective of the crops under cultivation. Respondents in the study area reported production risk in terms of causes of either crop failure or constraints to overall production. Crop failures due to bad weather (drought or too much rain), lack of fertilizers at critical periods, disease and pest attacks, erosion, soil type, untimely planting due to poor rain forecasting, damage to crops by cattle invasion, low prices, and lack of capital were all reported as forms of risk. Crop diversification, crop rotation, shifting cultivation, fallowing, mixed cropping and timely planting were mentioned as risk aversion measures.

Table 2: *The Percentage of Respondents that accord Cultivation of Specified Crops Varying Degrees of risk.*

Crop	Very High Risk (%)	High Risk (%)	Medium Risk (%)	Low Risk (%)	Very Low Risk (%)	Total Percentage (%)
Maize	50	25.9	14.6	0.6	1.9	100
Groundnut	45	22	28.5	1.3	3.2	100
Yam	52	30.0	12.0	6.0	-	100
Cassava	30.1	16.1	45.2	6.1	2.5	100
Melon	12.5	12.5	25.0	37.5	12.5	100
Cowpea	72.7	18.9	6.8	1.6	-	100

Source: *Field Survey Data, 2002.*

Fifty seven percent of the respondents considered maize as highly risky while yam was considered highly risky by about 52 percent of

the respondents. Guinea corn was considered to have medium risk as about 45 percent respondents classified it in this category.

Melon was adjudged to be of low risk while cowpea was considered highly risky. The latter was ascertained by almost 73 percent of the respondents. This is revealed in table 2.

The socio-cultural factors influence the cropping patterns in any environment and make it different from one ecological zone to the other. In the study area the cropping patterns in order of priority or commonality are as shown in table 3.

Table 3: *Distribution of Respondents by Cropping Pattern, 2001/2002.*

S/N	Cropping Pattern	Label	% of respondents Cultivating crop	Average Cultivated Hectarage per Households
1	Sole Yam	YAM	70.80	0.92
2	Sole Maize	MZE	56.25	0.80
3	Maize/Cassava	MZE/CSV	46.25	0.32
4	Sole Guinea-corn	GNC	36.25	0.46
5	Sole Cowpea	CWP	26.25	0.08
6	Maize/Guinea- corn	MZE/GNC	17.50	0.09
7	Maize/Groundnut	MZE/GNT	17.50	0.07
8	Sole Rice	RCE	13.75	0.12
9	Sole Cassava	CSV	13.75	0.05
10	Sole Groundnut	GNT	3.75	0.06

Source: *Field Survey Data, 2002*

From these deviations, the Mean Absolute Deviation (MAD) is computed and indicated in Table 4.

Farm Plans

Table 5 presents the existing and normative plans for the farmers in the study area. The existing farm plan is the farmers' plan as practiced on the various farms based on average of each group. Lesser returns is observed in existing plan (Plan 1)

Table 5: *Existing and Normative Plans for Farmers in the Study Area*

ENTER-PRISES	EXISTING SITUATION	NORMATIVE SITUATION				
		RISK MINIMIZING				PROFIT MAXIM-AZING
PLANS	I	II	III	IV	V	VI
RETURNS	3,264.34	3,642.60	4,757.10	5,504.33	6,087.47	7,043.88
YAM (Ha)	0.92	0.2431 (10.76)	0.2448 (10.83)	0.1073 (4.73)	———	———
MZE (Ha)	0.80	———	———	———	———	———
CVS (Ha)	0.055	0.0404 (1.79)	0.2166 (9.58)	0.3234 (14.31)	0.467 (18.00)	1.1753 (52.04)
CWP (Ha)	0.0 8	0.2585 (11.44)	———	———	———	———
GNC (Ha)	0.46	———	———	———	———	———
GNT (Ha)	0.06	———	———	———	———	———
MZE/CSV (Ha)	0.32	0.2591 (11.46)	0.2889 (12.74)	0.4374 (19.36)	0.5534 (24.49)	———
MZE/GNC (Ha)	0.46	———	———	———	———	———
MZE/GNT (Ha)	0.07	———	———	———	———	———
PLAN TOTAL CROPPED AREA		0.8012 (35.45)	0.7503 (33.70)	0.8681 (38.41)	0.9601 (42.48)	1.1753 (52.04)
CROPPED AREA	2.26	———	———	———	———	———

Note: *Figures in parenthesis represent the percentages of Cultivated Area.*

Source: *L.P Output*

Normative plan VI in table 5 is based on the profit-maximizing model. This plan is likely to be selected by a risk neutral decision maker. The plan has the highest expec9ted returns and hence the highest risk. Interestingly, the plan also has the highest cropping intensity compared with all parameterized risk minimized plans.

However, the cropping intensity under this plan is much nearer the existing plan intensity of the sampled farms.

Generally it could be observed from table 5 that when farmers shifted from existing plan to risk minimizing plans, activities for sole cropping decreased. However, activities increased for mixed cropping in plan IV and V. Hence, the impact of diversification through mixed cropping could be derived from the plans. This is an indication that the mixed crops are less risky enterprises.

Conclusion

The target-MOTAD procedure was found applicable and useful for analysis of decision problems faced by farmers in the study area especially when risk and uncertainty are considered. The usefulness in this particular case stems from the major variation in mean and variance of returns to variable costs among enterprises being considered, availability of data which permitted accurate modeling of the complex alternative enterprises and technologies, and target-MOTAD's capacity for handling risk in an explicit manner.

Recommendations

From the results of this study, the following measures are recommended:

(1) The use of Target- MOTAD model as a tool for small-scale farmers' resource use and allocation is recommended to farmers through policy analysts and researchers.

(2) It is recommended that low-cost storage methods for various crops be introduced into the study area. This will minimize the impact of low prices at harvest period and the rush to dispose-off produce at this period.

(3) Emanating from the study is the need to encourage farmers to form cooperatives. This will facilitate positive interactions especially on risk sharing. This will present a collective bargaining