DYNAMICS AND APPLICABILITY OF GAME THEORETICAL MODEL APPROACH ON SMALL HOLDERS FARMERS DECISION-MAKING SUPPORTS FOR PROFIT MAXIMIZATION IN NIGER STATE, NIGERIA

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Abstract

Agricultural production is susceptible to a number of factors that must work together for its success and profit maximization such as climate, agricultural decision making supports, crops and fields selections, credits usage and cooperative society incentives management, labour inputs, farm size, pests and diseases control systems, etc. This investigation apply game theoretical model approach on smallholder farmers decision making supports for crop production and profit maximizing among some selected farmers in Niger State, Nigeria. 360 farmers were selected from 17 LGA in 6 clusters of farm fields in Niger State i.e ABCDEF. Reconnaissance visits, pilot visits and convenient visits were made to the fields. Participatory rural appraisal techniques were also employed. Taro Yamanes formula were used for sample size selection. Data were collected through field observations, and memory recall methods. Data were analysis using point biseral correlation and quadratic program formulation. The results revealed that, the rpb – 19.713 and rpb – 0.0967 were obtained. The main findings revealed that, the cooperative recipients made profits of ₦42,706,000,000 than non-recipients which made ₦2,314,936,000. Recommendations were made for the way forward to improve small holders farmers productions through cooperative management.

Keywords: *Dynamics and Applicability, Game Theoretical Model Approach, Small Holders Farmer Decision Making Support, Profit Maximization, Niger State, Nigeria*

Introduction

The theory of games is a mathematical discipline design to treat rigorously the question of optimal behaviour of participants in games of strategic and to determine the resulting equilibria. In such a game each participants is striving for his greatest advantages in situations where the outcome depends not only on his actions alone, nor solely on those of nature, but also on those of other participants whose interests are sometimes opposed, sometimes parallel to his own. Thus, in games of strategy there is conflict of interest as well as possible co-operation among the participants. There may be uncertainty for each participants because the actions of others may not be known with certainty.

Such situations, often of extreme complexity are found not only in games but also in business, agriculture, politics, war and other social activities. Therefore, the game Theoretical Model Approach serves to interpret both games themselves and social phenomena with which certain games are strictly identical. This theory is normative in that it aims at giving advice to each player about his optimal behavior, it is descriptive when viewed as a model for analyzing empirically given occurrences. In analyzing games, this theory does not assume rational behavior, rather it attempts to determine what "rational" can mean when an individual is confronted with the problem of optimal behavior in games and equivalent situation. The results of the interlocking individual actions are expressed by numbers, such as money or a numerically defined utility for each player transferable among all.

Games of strategy include games of chance as a sub-case in games of chance. The problem for the player is merely to determine and evaluate the probability of each possible outcome. Joseph (2010) observed that in games of strategy the outcome for a player cannot be determined by mere probability calculations. We have different types of games such as nature game, two-person, zero-sum games, n-person, simple games, nonzero -sum games etc.

Game theory is applicable to the study of those social phenomena such as Agriculture and farmers decisions for choice of land, crops to be planted, fertilizers, pesticides, herbicides and the host of others and in competition with

the nature such as rainfall, temperature, sunshine, humidity, soil and the host of others that aid the profitability of farmers in Agricultural business. Other major economic application of the theory have been in oligopoly theory, bargaining theory and general equilibrium theory which all are limited to economic behaviour (Vogelsang, 2006).

Statement of the Problem

Across the globe particularly, the developing regions such as the central America, Caribbean's, South America, Middle east, Asia, Australia and Africa and sub-Saharan Africa that more than 75% of the population lives in rural areas (FAO, STAT, 2007). These set of people earn their income primarily from farming and related activities (Manyoung et al 2005). These set of rural dwellers smallholders farmers are of small scale who has small farm sizes, applied crude implements, like hoes, cutlass, sickles, axes and family labour. The income from the farm are small as the farming is substance in nature with very weak infrastructural facilities like roads, electricity, communications, poor access to agricultural inputs and market outlets and lacks basic amenities.

Internationally and nationally, many modern agricultural development programmes have evolved to mitigate against the problems of smallholders farmers such hunger, poverty, malnutrition and diseases, poor agricultural yields and so on. Various governments have come up with scientific research focused on Agricultural Research Institutes such as centre and department of Econometrics and Operations Research Netherlands, (CDEOR), International Institute of Tropical Agriculture (IITA) International Food Policies Research Institute (IFPRI); Wageningen University and Research Center (WURC) (2012), Food and Agriculture Organization (FAO) (2007), National Cereals Research Institute (NRCRI), (2017) Umudike, Cocoa Research Institute (CRI) Ondo, among others are striving to reduce poverty levels of these smallholders farmers through agricultural innovations to improve yields.

A considerable part of their research and innovative activities are focused mainly on development of new agricultural technologies, such as new varieties of crops and improved agricultural systems with the major aim to increase local production and generate surplus wealth for the farmers and the nation at large (World Bank, 2008). Many mathematical programmes have been developed over the past 50 years to aid agricultural experts and other farming decision

makers experts and other farming decision makers such as Schweigman (1985), Hazell & Norton (1986), Plaet (2013), Dorward (2006), Abdoulaye and Sanders (2006), Ruben and Pender (2004), Butterworth (1985), Binswanger & Rosenzweig (1986), Tijs (1981), Shaplay (1953), Schmeidler (1969), Lejano and Davos (1999), Suzuki and Nakayama (1976). Empirical applicability of the game theoretical Model Approach for Smallholder farmers decision making supports for profit maximization on crops selections and production is inadequate in the selected 6 cluster areas of study. Hence this study to fill the literature gap.

Objectives of the Study

The main aim of this research is to make an assessment into the dynamic and applicability of Game Theoretical Model Approach for Smallholder farmers Decision making supports for profit maximization on crops selection and production in Niger state, Nigeria. The specific objective to be achieved are as follow:

i. To investigate the heterogeneous nature of the smallholders farmers and cluster them in Groups.
ii. To examine the nature and types of crops to be selected for production.
iii. To employ simulation and mathematical programming decision-making support for maximum production.
iv. To make a comparative analysis of the input-output of crops of cooperative beneficiaries and non-cooperative beneficiaries.
v. Examine Mayers crops rotation impacts on the crop profitability and maximum production by the smallholders.

Hypothesis

Ho_1: There is significant relationships between smallholder farmers cooperative incentives beneficiaries and non-cooperative beneficiaries.

Ho_2: There is no significant differences between simulation and mathematical programming decision-making support for cooperative incentives beneficiaries and non-beneficiaries.

Scope of the Study

The scope of this research was limited to the dynamic and applicability of Game Theoretical Model Approach for Smallholders farmers decision-making

support for profit maximization on crops selections and production in Niger State, Nigeria. The study area is the entire Niger State. However about 17 Local Government Area were carefully chosen and grouped into six clusters based on the common characteristics of the smallholder farmers found in the such area. Cluster 1 was made of Mariga, Magoma, Rijau and Mashegu LGA. Cluster two was made up of Lavun, Edati, Gbako, Katcha and Wushishu LGA Nupe speaking. Cluster Three – Rafi, Shiroro and Bosso LGA. Cluster Four – Agwara – Kainji LGA. Cluster Five - Agaie and Lapai LGA and Cluster Six – Paiko and Gurara LGA respectively, A total of 360 respondents were used for this work. Time frame for this study was 2016– 2020 (5 years), 191 respondents were cooperative incentive receivers and 169 non recipients.

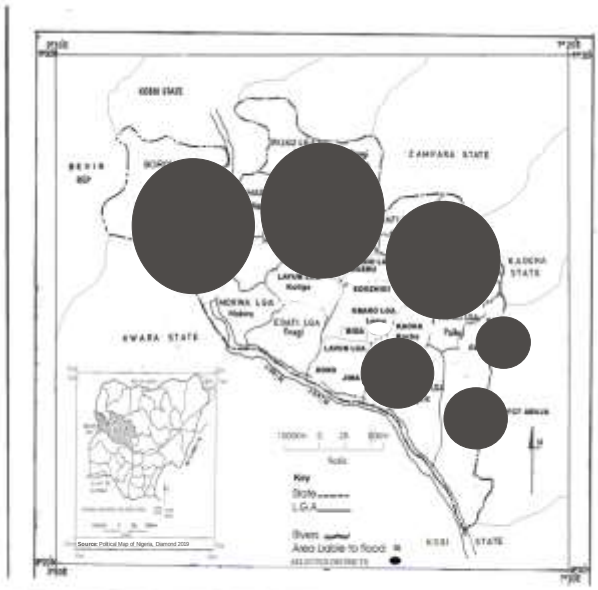

Figure 1: Niger state showing the selected study area
Source: Macmillian Map 2019

Figure 2: Melon **Source:** Field Survey, 2020

Figure 3: Maize
Source: Field Survey, 2020

Figure 5: Sorghum
Source: Field Survey, 2020

Figure 4: Rice
Source: Field Survey, 2020

Figure 6: Groundnut
Source: Field Survey, 2020

Materials and Methods

The bulk of the data needed for the research were generated from smallholder farmer in the Local Government Area understudy. Participatory Rural Appraisal Techniques were employed as the smallholder farmer were interviewed both at home and on farm fields. Telephone conversations were also used to obtain firsthand data. Crops selected of the study were maize, rice, groundnut, sorghum, sweet potatoes, melon, soybeans and cow pea.

Multi-stage sampling techniques were employed in the selection of the seventeen (17) Local Governments Area under study, six clusters of smallholders farmers were grouped based on their heterogeneous characteristics, types of crops rotated, types of co-operative memberships and non-memberships, fertilizers, herbicides, pesticides and other chemicals used in the crop productions and so on. A total of three hundred and sixty (360) respondents were used for the study. One hundred and ninety one (191) respondents been cooperative incentive beneficiaries and non-cooperative beneficiaries been one Hundred and sixty nine (169) making a total of 360

respondents respectively. Data were analysed using Point Biseral Correlation and quadratic and linear program formulation to spell out the input-output analysis of cooperative and non-co-operative beneficiaries.

Identification of the 6 Clusters according to their heteronologies

Cluster A = Mariga, Magama, Rijau and Mashegu LGAs.
Cluster B = Lavun, Edati, Gbako, Katcha and Wushishi LGA
Cluster C = Rafi, Shiroro and Bosso LGA
Cluster D = Agwara LGA
Cluster E = Agaie and Lapai LGA
Cluster F = Paiko and Gurara LGA
17 LGA out of 25 LGA in Niger State

Table 1: Respondents on Cooperative and Non-cooperative beneficiaries

ABC Cooperatives Recipients			DEF Non-cooperative	Total
Cluster A	=	80	62	142
Cluster B	=	61	58	119
Cluster C	=	50	49	99
		191	**169**	**360**

Source: Field survey 2020

General characteristics of the six clusters respondents for the co-operative recipients and non-recipients. A total number of 360 respondents were clustered are A, B, C as co-operative recipients and D, E, F were non-recipients respectively. There parameter that were considered are number of farmers, Household size, farm size (ha) resources utilization, labour ownership of live stocks, energy required, crops cultivated, crops harvested, maximum self help and profitability.

Table 3: Cooperative incentive beneficiaries Clusters A, B and C

Respondents Cluster	A	B	C	Total
Number of Farmers	80	61	50	191
Household size	28.9	27.8	21.8	78.5
Farm size	84.01	65.05	43.9	192.96
Resource Utilization	455118	32516	28713	516347
Labour input	23631	30231	19621	73483
Ownership of Livestock	4416	4803	4304	13523

Coop Loan	4230,000	3280,000	3520,000	11,080,000
Farm outputs	1,496,600	1,421,000	1,434,500	17,274,610
Profitability	12,178,000	600,000	18,728,000	42,706,000

Source: Field Survey 2020

Table 4: Non Recipients Contingence D, E and F Clusters

Respondents Cluster	D	E	F	Total
Number of Farmers	62	58	49	169
Household size	27.4	22.6	23.9	73.9
Farm size	85.02	64.04	44.7	193.76
Resource Utilization	13,100	10,612	12,111	35,823
Labour input	8,751	1,106	91,11	19,768
Ownership of Livestock	2.0	4.7	5.3	12
Coop Loan	5,663	6,387	5,423	17,473
Farm outputs	1961122	1834272	1617230	5412614
Profitability	5958944	4838766	3024427	2,314,936,000

Source: Field Survey 2020

Table 5: Crop Output and Profitability

Crops	ABC (Xi)	Y (Xi)
Melon	3452526	8,541,200,000
Rice	3356524	10,728,000,000
Sorghum	3652540	9,260,000,000
Groundnut	3560520	9,420,000,000
Maize	3252500	4,756,800,000
Total	**17,274,610**	**42,706,000,000**

Source: Field Survey 2020

Non Recipients D,E and F Results

Table 6: Crop Output and Profitability

Crops	DEF (Xi)	Y (Xi)
Melon	121,734	486,936
Rice	196,000	784,000
Sorghum	100,000	400,000
Groundnut	94,000	376,000
Maize	67,000	268,000

Total	**578,734**	**2,314,936,000**

Source: Field Survey 2020

RESULTS AND DISCUSSIONS

Based on maximum criteria, the players are optimistic about crop selection production and profit maximization. Therefore, the discussions are based on the analysis, interpretation and discussion on the views of 191 farmers that benefited from cooperative incentives and 169 farmers that are non-beneficiaries as indicated in table 5 and table 6 respectively.

Point biserial correction coefficient analysis formulas were used to make a comparative analysis of dynamics and applicability of Game theoretical model approach on smallholder farmers decision-making supports for crop selection, production and profit maximization in Niger state, Nigeria.

Table 7: Point Biserial Correlation Formulae

$$r_{pb} = \frac{M_1 - M_0}{S_n} \frac{\sqrt{n_1 n_0}}{n^2}$$

Where S_n is the standard deviation,

$$S_n = \sqrt{\frac{1}{n} \sum_{i=1}^{n} (X_i - X)^2}, \quad —$$

M_1 being the mean value

There is an equivalent formula that uses S_1-1:

$$r_{pb} = \frac{M_1 - M_0}{S_{n-1}} \frac{\sqrt{n_1 n_0}}{n(n-1)'}$$

Where S_{n-1} *is the standard deviation*

$$r_{pb} = \frac{M_1 - M_0}{S_n} \sqrt{\frac{n_1 - n_0}{n^2}} = \frac{M_1 - M_0}{S_{n-1}} \sqrt{\frac{n_1 - n_0}{n(n-1)'}}$$

Table 8: Contingency table of cooperative recipients and Non recipient

ABC GROUP		DEF GROUP	
COOPERATIVE RECIPIENTS		**NON RECIPIENTS**	
Inputs	**Outputs**	**Inputs**	**Outputs**
3452526	8,541,200,000	121,734	486,936
3356524	10,728,000,000	196,000	784,000
3652540	9,260,000,000	100,000	400,000
3560520	9,420,000,000	94,000	376,000

3252500	4,756,800,000	67,000	268,000
17,274,610	**42,706,000,000**	**578,734**	**2,314,936**

Source: Field Survey 2020

X = 0	x = 1	**Total**
n 191	.169	360
- ∑ x^1 42,706,000,000	2,314,936	
-∑ x^2 213,530, 000, 000 2,325,104,680,000	11,574,680	
std 1,295,632.04 2,453,100	11,574,468	
Mean 239,126.4	490,620.00	

Table 9: Cross Tabulation

X = 0	x = 1
n 191	.169
- ∑ y^1 87972428	366474
-∑ y^2 3297701	135450
std 741.24	35.23
Mean 148248	**7046**

Table 10: Two Tail Point Correlation Coefficient

rpb	**t**	**df**	**p**
-.194	-.0580	31	<0.0001
rpb	**t**	**df**	**p**
0.967	-19.713	31	<0.0001

Analysis of the farmers from the result, the significant level of profitability for cooperative recipients was 42, 706, 000.000 while that of non-recipients stood at 2,324,936,000 respectively given a clear differences of 40,391,067,000 in favour of the cooperative incentives recipients. This is in line with Tijs (2003) Abdoulaye and Sunders (2006), Dorward (2006), Winston (2003), World Bank, (2008) Woeleke, (2006), Van Heenst (2002), FAO (2007), NCRI (2018), C.R.I (2015), Wagemingen URC (2013). IFRRI (2018), and the host of other researchers and Agriculturist that agricultural incentive inputs either in form of

organic or inorganic are very vital for farmers decision making supports for crop productions and profit maximization across the universe. The two tales cross tabulation for X = O stood at rpb - 0.967 and rpb - 0.194. The t - value was - 19.713 and -0.580 respectively. The df was 31, while the probability was p< 0.100 & P<0.0001.

Conclusion

The Nigerian economy is in undated with adequate labour supply but a shortage of capital credits facilities. This situation limits agricultural output. The smallholders farmers are grossly undercapitalized thus making agricultural production predominantly rudimentary. Game theoretical model approach on smallholders farmers decision making supports for crop production and profit maximization indicating that cooperative farm credit incentives leads to a substantial improvement in profit maximization for the cooperative incentives recipients.

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