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Application of Game Theory to Cocoa Production Management Systems in Ondo State, Nigeria

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Abstract - Cocoa production is susceptible to a number of risks such as unavailability of enough land, unavailability of agro-chemicals, variation in product prices and a host of others. This study utilized game theory to determine the cocoa production management system which maximizes the income of farmers under risks. Data on cocoa production were collected from a random sample of 200 farmers practicing the three cocoa production management systems viz: Owner management system, Lease management system as well as Sharecropped management system. The games were constructed based on the income per hectare obtained from each of the three management systems. Maximax and Maximin criteria of game theory were used in the analysis. The Maximax criterion showed that the best management system to practice by cocoa farmers was Sharecropped management system (Income per hectare of ₦214,847) while the result of the Maximin showed that the best management system was Owner management system (Income per hectare of ₦92,463). The study therefore recommended for optimistic farmers to practice Sharecropped management system while Owner management system is recommended for pessimistic farmers.

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I. INTRODUCTION

Agricultural production is the mainstay of the Nigerian economy; considering the fact that over 80 percent of the economically active populations are involved in agricultural production and that over 90 percent of the food consumed in the country is from the local agricultural production. It is the second largest earner of foreign exchange; next to the petroleum sector, and also it provides a ready market for industrial products (Ayanwale, 2002). The main agricultural sub-sector which contributes immensely to Nigeria's GDP is cocoa. Cocoa contributes about 15% to the total Nigerian export in 1970 (Adebile and Amusan, 2011). Cocoa which belongs to the family *Steruliaceae* and genus *Theobroma* was discovered in 18th century at the Amazon basin and later spread to other tropical areas of South and Central America, and West Africa (Opeke 1987). Since the end of the first world war, West Africa

has been the highest producer of cocoa. The crop was eventually introduced into Nigeria in 1887 (Ayorinde 1966). Nigeria as a developing country was rated the second largest world producer of cocoa in the 1960s (Adegbola and Abe, 1983), and, for a long time, the crop has been generating substantial foreign exchange earnings for the country. However, the production of this important cash crop for export has suffered a reduction in the recent years in the country owing to a number of factors. Villalobos (1989) identified some of these factors as: low yield, inconsistent production patterns, disease incidence, pest attack and use of simple farm tools. In addition, Oduwole (2004) identified ageing cocoa farms as one of the factors responsible for the decline in cocoa production in south western Nigeria. He observed that many farms were over 40 years old and such farms constitute as much as 60% of the cocoa farms in Nigeria. However, in a study conducted by Daramola *et al.* (2003), it was found that most cocoa farms in Ondo and Osun states are very old with low productivity. Government in her effort to curb these problems has introduced some policies aiming at resuscitating cocoa production in Nigeria. One and perhaps the most recent policy is the establishment of National Cocoa Development Committee (NCDC). The committee is saddled with the responsibility of increasing cocoa output in Nigeria.

According to Nkang *et al.* (2009), there are three cocoa production management systems. These are Owner-managed farms, Lease-managed farms and Sharecropped farms. These management systems are practiced across all cocoa producing regions in Nigeria. One fundamental issue is the approach to the understanding of how different farm management systems have implications on cocoa production. For this reason and other reasons, the theory of games has been utilised to analyse cocoa production management systems especially in this study. Game theory is a situation where outcomes depend on the behaviour of all competitors (Gough and Hill 1979). Game theory is a probabilistic model which as already mentioned is used in analyzing, and driving rules for making decisions when two or more people are competing for some objectives. Game theory attempts to look at the relationships between participants in a particular model

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and predict their optimal decisions (Investopedia, 2010). According to Wikipedia (2010), economists and business professors suggest two primary use of game theory: *descriptive* and *prescriptive*. In the descriptive use, game theory has been used to study a wide variety of human and animal behaviors; thus when finding the equilibrium of games we can predict how actual human prediction can be understood. One frequently cited example of descriptive use of game theory is the Nash equilibrium (Investopedia, 2010). In the prescriptive (normative) use, game theory has also been used to attempt to develop theories of ethical or normative behavior. That is, an attempt to look at economic and human practices as they ought to be, talking about judgment and looking at what is right and what is wrong. One frequently cited example of descriptive use of game theory is the prisoner's dilemma (Investopedia, 2010). Game theory bridges mathematics, statistics, economics, and psychology to model conflict between two or more rational decision-makers.

Game theory was developed in 1953 by John Von Neumann (Mathematician) and Oskar Morgenstern (Mathematical Economist), and was greatly in use then in the field of Economics (Oziegbe, 2011). According to the empirical studies by Gough *et al.* 1991, game theory is being used with low frequency by corporate managers in the developed countries. On the other hand, from the surveys in underdeveloped country like Nigeria, corporate managers do not use the theory at all; moreover, most of the managers have little or no idea about the technique (Oziegbe, 2011).

Game theory is a theory of rational behavior for interactive decision problems. In a game, several agents strive to maximize their expected utility index by chosen particular courses of action and each agent final utility payoffs depend on the profile of courses of action chosen by all agents. The interactive situation, specified by the set of participants, the possible courses of actions of each agent and the set of all possible utility payoffs, is called a game; the agents playing a game are called the players (Fudenberg and Tirole, 1991.)

Agricultural productions are risky activities. These risks can be caused by production, market, credit etc. (Ferdosi, 1995). Some policies have been made to reduce the risk in traditional practices and support programmes by farmers and government such as diversification, rotation, price stabilization, crop insurance as well as delivery contracts (Ferdosi, 1995; Martin, 1997; Mishra and Perry, 1999; Olesen, 2003). If producers wants to maximize their profits, they have to accept the risk of production and marketing process. Growers must take risks if they are to have any chance of obtaining profit. It is not possible for a management strategy to be potentially profitable and free from risk. Growers must balance the risks of loss against the potential for profit among alternative management strategies. Farmers have to manage risk and

uncertainty. In these structures, management of farms has become more important than in previous years. The main objective of this paper, therefore, is to discuss some of the various ways in which the choice of farm management systems can influence the effective and efficient cocoa production through the use of the game theory.

II. METHODOLOGY

a) Study Area

The study was conducted in Ondo State. The state is one of the thirty-six states in Nigeria and was carved out of the old Western State in 1976. Ekiti state was carved out of the state in 1996. Ondo State has a land area of 14,769Km². Going by 2006 census, the state has a population of 3,441,024million. There are eighteen Local Government Areas (LGAs) in Ondo state. Out of these, fifteen Local Government Areas produce cocoa. The occupation of the inhabitants of the State is predominantly farming. Ondo State is the highest cocoa producing State in Nigeria (Ojo, 2003). Geographically, Ondo state is located in south west of Nigeria between Longitude 4.30°E and 6.00°E of the Greenwich and Latitude 5°45' and 8°15' of the equator. Kogi and Ekiti states bounded the State to the North; Edo and Delta States in the East; Ogun and Osun States in the west and Atlantic Ocean in the south. With respect to the climate, it is tropical with two distinct seasons of rainy and dry season in the state. The rainy season occurs between April and October, while the dry season begins in November and last till April. Although in recent times, minor alterations are noticeable in rainfall regimes due to global climatic change. The state is blessed with a moderate year temperature of around 25°C. Annual rainfall varies from 2000mm in the southern part to 1,150mm in the Northern extremes (Ondo state, 2003).

b) Data Collection

The study employed stratified random sampling technique for the selection of its respondents. There was random selection of four notable cocoa producing Local Government Areas (LGAs) out of a total of fifteen cocoa producing LGAs in the state. The selected LGAs included two high cocoa producing LGAs (Idanre and Ondo East) and two low cocoa producing LGAs (Akoko South East and Akoko North West). The classification is in accordance with Cocoa Research Institute of Nigeria classification of the cocoa producing LGAs in the state and is based on the quantity of cocoa beans being produced by each LGA. From each of the four selected LGAs, there was random selection of two communities while the respondent households were randomly selected from the selected communities. However, from the eight communities, a total of two hundred respondent households were randomly selected. Meanwhile, the two hundred respondents cut across the three cocoa production management systems in the

study area viz: Owner management system, Lease management system and Sharecropped management system. The number of samples taken from each community depended on the entire population of cocoa farming households in the communities. Hence, the sampling was carried out proportionate to size.

High cocoa producing LGAs are the LGAs where the substantial proportion of cocoa produce in the State comes from and as such there are some good conditions favouring the production of cocoa in the area. These conditions include more available land for cocoa production, availability of agro-chemicals and increase in product price. However, low cocoa producing LGAs are the LGAs where a little proportion of cocoa produced in the State comes from. This is due to the fact that the conditions of cocoa production in the area are not favourable. These conditions include less available land for cocoa production (because the cocoa farmers in the LGAs devotes the substantial proportion of their land for food crop production), unavailability of agro-chemicals and decrease in product price.

For each of cocoa production management systems, the highest and lowest income per hectare was calculated under good and bad conditions. Following Sahin *et al*, (2009), successful production situation represented a good condition where there is more available land for cocoa production, availability of agro-chemicals and increase in product price. On the other hand, unsuccessful production situation represented a bad condition where there is less available land for cocoa production, unavailability of agro-chemicals and decrease in product price.

Table 1 : Strategies of players which represent production conditions

Strategies	Characteristics of production conditions
Good conditions	-More available land for cocoa production -Availability of agro-chemicals -Increase in product price
Bad conditions	-Less available land for cocoa production -Unavailability of agro-chemicals -Decrease in product price

III. RESULTS AND DISCUSSION

a) *Maximax Criterion*

Considering the Maximax criterion, the farmer is optimistic about production, availability of land and pricing conditions. An optimistic farmer will therefore adopt Sharecropped management system. Sharecropped management system had the highest average income per hectare of N214,847 in good conditions. This is followed by Owner management system with N168,000 (Table 2).

Optimists prefer the adoption of Sharecropped management system might be due to the fact that the

c) *Decision Criteria*

In game theory, there are different criteria for which decision can be taken. Some of these include maximax criterion, maximin (Wald's) criterion, Laplace criterion, Hurwicz's criterion and Salvage regret criterion (Burhan and Handan, 2001). Each criterion requires different strategies. However, in this study, two criteria will be considered, these are maximax criterion and maximin (Wald's) criterion.

d) *Maximax Criterion*

The maximax criterion indicates that the decision-maker should choose the alternative which maximizes the maximum value of the outcome. This optimistic approach implies that the decision-maker should assume the best of all possible worlds (Business Dictionary, 2011).

e) *Wald's (maximin) Criterion*

According to the maximin criterion, the players tries to choose "the best of the worst". The player in this study is farmer. This means that the farmer selects the management system which will maximise his minimum income. This strategy gives the farmer maximum security. The reasons behind this strategy for the farmer can be several. The farmer has only small equity in his farm; he has large and different family responsibilities and so on. If the farmer pursues the maximin strategy he can be regarded as a pessimist or an ultra careful (Barnard and Nix, 1979).

management system is a joint management system. Under the Sharecropped management system, a farm is jointly managed by the original owner of the farm and the sharecropper. The owner of the farm provides the agro-chemical input needed for the farm while the sharecropper provides the labour input. The proceeds from the farm is shared between the owner of the farm and the sharecropper in certain proportion. Hence, the fact that the resources to maintain the farm managed by sharecropped management system come from different sources enables the farm to be properly managed and hence enabling the system to have more income per hectare than the other management systems thus

making the optimists to prefer the management system. Another advantage of sharecropped management system is that in case of crop failure, the loss is shared by the two parties instead of it being borne by an individual. Sharecropped system of farm management is a means by which the State (Ondo) can provide job for the people from other parts of the country since sharecroppers are mostly from the Southern or Southeastern part of the country. However, the greatest disadvantage of Sharecropped management system is that sole decision on the farm can not be taken. Any major decision on the farm has to be jointly agreed upon by the two parties.

b) Maximin (Wald's) Criterion

According to the Wald's criterion, the player (which is farmer in this case) tries to choose the best of the worst. Table 2 shows that the highest income per hectare under bad condition is obtained from owner management system with N92,463 per hectare. The

farmer is regarded as a pessimist based on this criterion. This means that the farmer selects the management system that will maximize his minimum income. The strategy gives the farmer maximum security. Owner management system of cocoa production might however be preferred by the pessimists due to the fact that under the system, the farmer gets a full control of the farm. There is no need to consult anybody before a decision on the farm is taken. Also, under owner management system, the proceeds from the farm does not need to be shared with anybody. The whole proceeds belongs to the owner of the farm. However, one of the disadvantages of the system is that the whole cost of maintaining the farm is borne by the owner of the farm. Hence the owner provides the cost of agro-chemicals as well as the cost of labour. Also, the owner of the farm solely bears the risk of the farm. The risks may include crop failure as a result of bad weather or the incidence of fire outbreak on the farm.

Table 2 : Game theory results for cocoa farmers

Criteria	Income per hectare (N)	Preferred management system
Maximax	214,847	Sharecropped management system
Minimax	92,463	Owner management system

Source: Field survey, 2011.

The decision criteria used in the study are maximax and minimax. These were used to take decision on the best cocoa production management systems to be chosen by the optimistic and pessimistic farmers. Based on the result of the findings, the optimistic farmer will choose sharecropped management system while pessimistic farmer will choose owner management system. This is due to the fact that optimistic farmers are not risk averse while pessimistic farmers are risk averse in nature.

IV. CONCLUSION

Decision criteria used in the study are maximax and maximin criteria. Optimistic farmer will adopt sharecropped management system while pessimistic farmers will adopt owner management system on the farm. This is due to the fact that optimistic farmers are not risk averse while pessimistic farmers are risk averse in nature.

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