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Application of Operation Research Techniques-Game Theory in Agricultural Field

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Abstract**—** Agricultural production is depend to a number of risks such as, price variation, climatic condition, organisms and diseases infestation to mention a few to this theory of operation research. The study utilized game theory to determine vegetables and fruits and other crops which maximize net profit of farmers under risks, based on different characteristics of the farmers. This theory is related to decide when two or more than two competitors /farmers compete in a rational. The purpose of this paper is twofold. The first objective of this study is to demonstrate the relationship between game theory and linear programming by using various methods of these research techniques. The second objective is determination of the highest expected income of lowest expected outcome earned from studied products in the worst conditions and also highest output in lowest time with minimum investments. The third aim is to apply game theory to field crops. It can be concluded that the game theory model is a good sign for growers selecting alternative management strategies and also applicable for more crop production.

Keywords- *game theory, agricultural production, Risk programming, Field crops, linear programming*.

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I. Introduction

'Good management is the art of making problems so interesting and there solutions so constructive that everyone want to get to work and deal with them with their new tricks and techniques'.

The objectives of agricultural development is achieved only by possible on the condition that the determinate policies and formulated appropriate problems in the agricultural sector this situation largely depends on the awareness level of planner farmer reaction. In a world free of risk and uncertainty, the problems of farmer would be greatly simplified by decision making function. Agriculture is the principal source of food crop production is an engine for economic growth; it creates jobs, supports agricultural businesses and generates more income than staple crops per unit area and per person. The potential benefits of for the developing world and the problems of farmers are numerous. Uncertainty is introduced by technical and technological change, industrial change, climate change, price variation and unpredictable human action. A farmer could make plans for obtaining decided goals and then simply carry out the plans. Resource use alternatives and the outcomes of alternative resource employment are differentiate by physical scientists. Horticulture crops can generate higher profits than staple crops, especially when land is relatively minimum and labor is maximum. Since the agriculture problems results are signified in the future scope and there is no assurance what happens in the future, so agricultural systems programs are always accompanied with uncertainty and risk. Growers/farmers must balance the risks of loss against the potential for profit among alternative management strategies. However, linear programming determines the maximum profit according to given data and support, but risk and uncertainty are not taken into consideration. Game theory is the formal study of decision-making where several players must take decision that potentially affect the interests of the other players. Game theory is a useful tool used in planning under uncertainties. Growers must balance the risks of loss against the potential for profit among alternative management strategies. Risk perceptions play a key role in the production and investment behavior of farmer's .The aim of this study is to determine the crops that will be selected by each category of farmers in good and bad using game theory techniques. In game theory, players want their outcome, which the existing limitations influence on the amount of it, reach the optimal level. The first objective of this study is to demonstrate the relationship between game theory and linear programming by using various methods. The second objective is determination of the highest expected income of minimum expected outcome earned from studied products in the worst conditions and also highest output in lowest time with minimum investments.

TABLE I.

<table>
<tr><td colspan="4">Decision Making Environment</td></tr>
<tr><td colspan="3">Certainty</td><td>Uncertainty</td></tr>
<tr><td rowspan="5">Non Competitive Situation</td><td colspan="2">Competitive Situation</td><td rowspan="5"></td></tr>
<tr><td rowspan="4">Pure Strategy</td><td>Mixed Strategy</td></tr>
<tr><td>Algebric method</td></tr>
<tr><td>Analytical method</td></tr>
<tr><td>Matrix method</td></tr>
</table>

II. Objectives

Farmers will follow any of any models that which specify a way to operate underneath uncertainty.

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138 - 141

(1)To examine the game theoretic decision criteria, to work out the mechanics of their use and to point out their relationship to alternative decision models.
(2) To examine at the game theoretic criteria to be used as decision models underneath uncertainty by
(a) Demonstrating the categories of drawbacks solution that they recommended and obtained; and
(b) Determining the kind of problem solving for which they are appropriate.
(3) To work out the big selection of drawback finding techniques that farmers logically could have and to point out the necessity for recommendations that area unit suited to those settings.
(4) To find out traditional approaches to decision making under uncertainty.

III. CHOICE OF CROP VARIABLES

Farmers must choose crop varieties each production season. Some farmers do not spend much time in making this choice. They plant varieties which have had satisfactory yields and have displayed other desirable characteristics in past years. The farmer or his neighbors may have had actual experience with the variety or varieties chosen. Other farmers consult with research and extension personnel and review experiment station and commercial literature before making a choice. Research and extension specialists spend considerable time and other resources in evaluating crop varieties and presenting variety data and recommendations to farmers. Usually several varieties are rated as acceptable because their yields, disease resistance, maturity time, test weight and other characteristics meet certain standards.

A. Decision Criteria

Change in production techniques, development in new crops, development of new products or inputs, and introduction of other innovations cannot be accurately solved. Such developments may affect the desirability of alternative options which farmers can make. Price uncertainty is a third major problem of farmers. The static, dynamic and economic models are really heavily on knowledge of prices for making choices. Thus, the quality of these models is sharply reduced by the existence of worth uncertainty (minimum or maximum).The complicated of reticulated factors that contribute to cost variability include:

- World and national economic condition, and,
- The overall state of uncontrollable, natural phenomena affecting production.

B. *Minimax (Optimist)*

The optimist criterion (min-max) indicates that the decision-maker should choose the alternative which maximizes the value of the outcome. This optimistic approach implies that the decision-maker should assume the best of all possible worlds.

C. Maximin (Pessimist)

This pessimistic approach (max-min) implies that the decision-maker should expect the worst to happen. The maximin person looks at the worst condition that could happen under each action and then the person have to choose the action with the largest payoff. They assume that the worst that can happen will, and then they take the action with the best worst case scenario.

D.Regret Criterion

The regret of an outcome is the difference between the value of the maximum outcome and the maximum value of all the possible outcomes, in the way of the particular chance event that actually obtained. The decision maker should choose the alternative that minimizes the maximum regret he could suffer.

E.Utility Criterion

The utility criterion approach implies that the farmer is a risk averter. A risk is someone who preferred a more certain return to an alternative with an equal return but which is more risky.

F.Laplace Criterion

The lap lace criterion is when the probabilities of many chance of events are square measure unknown, and therefore they should be assumed equal, and the different actions should be judged according to their payoffs averaged over all the states of nature.

IV. MATERIAL AND STRATEGIES

Game theory was used to analyses gross product price knowledge obtained within the production. Gross production price/value was calculated by multiplying crop yield and prices received by farmers depend upon their financial cost and outcomes. The gross product values of crops are different from each other and fluctuated from year to year. In this study, gross product value data, including price and yield of major products and the crop classification. Games usually are classified according to two criteria:

- The number of participants within the game (theory of games) and
- The net outcome of the theory of game.

The first criterion is that the number of participants/farmers with conflicting interests. The second criterion makes it attainable to differentiate between the zero-sum games (equal value) and non-zero sum games (non equal value). A zero-sum game could be a game in during which the algebraic sum outcomes for all participants or farmers and for all possible combinations of strategy are equal to zero or non-zero values. Farmers are working in a situation combined with risk, certainty and uncertainty. Uncertainty of future worth price and crops yield can cause uncertainty in income of as well as outcomes of farmer. Thus, all the entering of risk in agricultural processing planning is essential. Therefore all the risks, certainties and uncertainty facing a farmer can be summarized in the form of a combination of natural production and farmer in front of nature are considered as actors in two-person zero-sum game or non-zero game that largely nature may be ineffective Decision of a farmer in finalized in his farm financial monetary programs randomly. During this state of game theory, there are different decision-making criterions to help to obtain a farm program. Game theory depend on postulate the behavior of participants or farmers and may make possible to achieve balance in these conditions. The first player is scared of the second player can

acknowledge his chosen strategy; accordingly, prediction of his behavior for his behavior would be easy. If the first player has 'm' strategy and second player has 'n' strategy, the possible outcomes of game can be shown by the following benefit matrix. Operation research techniques on game theory continues to deliver into rather complicated types of competitive situations. However, the main target during this paper is on the simplest case, called two-person, zero-sum games. As the name implies, these games involve only two players or farmers. They are referred to as zero-sum games because one player wins whatever the other one loses, so that the sum of their net result is zero. To illustrate the basic characteristics of two-person, zero-sum games and non-zero sum games consider the game called odds and evens. If the number of fingers matches, so that the total number for both farmer is even, then the farmer taking evens (say, farmer 1) wins the bet from the farmer taking odds (farmer 2). If the number or quantity does not match, farmer 1 pays some cash or money or the grains to farmer2. Thus, every farmer has two strategies: to show either one finger or two fingers.
A basic objective of game theory is that the event development of rational criteria for choosing
a strategy. Two key assumptions are made:

- Each farmer are rational.
- Each farmer choose their methods exclusively to market their own welfare.

A. *The Formulation of Two-Person,Zero Sum Game*

The **payoff table** shows the gain (positive or negative) for farmer 1 that would result from every combination of strategies for the two methods for players or farmers. It's given just for player or farmer 1 that may result of the table for player or farmer 2 is just the negative of this one game, due to the zero-sum nature of the game. The entries in the payoff table may be in any units desired, provided that they accurately represent the *utility* to farmer 1 of the corresponding outcome. However, utility is not essentially proportional to the amount of money (or any other commodity) when large quantities are involved.

TABLE II. Payoff table for the odds and evens game

strategy		**Farmer 2**	
		1	2
Farmer 1	1	1	-1
	2	-1	1

B. *Games with Mixed Strategies*

Whenever a game does not exists a saddle point, game theory advises each player or farmer to assign a probability distribution over her set of strategies. To express this mathematically, let

x_i _ probability that farmer 1 will use strategy i (i _ 1, 2, . . . , m),

y_j _ probability that farmer 2 will use strategy j (j _ 1, 2, . . . , n),

Where m and n are the respective numbers of available strategies. Thus, player 1 would specify her plan for playing the game by assigning values to $x1$, $x2$, . . . , xm. Because these Values are probabilities, they would need to be non-negative and add to equation 1.Similarly, the plan for player 2 would be obtained by described by the values she assigned to their decision variables $y1$, $y2$, . . . , yn. These plans ($x1$, $x2$, . . . , xm) and ($y1$, $y2$, . . . , yn) are usually defined as **mixed strategies,** and the original strategies are then called as **pure strategies.** When the game is actually played, it is necessary for each player or farmer to use one or more of their pure strategies. However, this pure strategy would be chosen by using some random variable to obtain a random variable observation from the probability distribution specified by the mixed strategy, where this observation would indicate which particular pure strategy to use in the further game for obtaining the result, suppose that players 1 and 2 in variation 3 of the farmer campaign problem
select the mixed strategies or the pure strategy

x_i _ probability that **Farmer** 1 will use strategy i (i _ 1, 2, . . . , m),

y_j _ probability that **Farmer** 2 will use strategy j (j _ 1, 2, . . . , n),

Where m and n are the numbers of available strategies.
Although no completely satisfactory measure of practical is available for evaluating mixed strategies or the pure strategy, a very useful one is the *expected payoff.* By applying the probability

Expected payoff for **Farmer** 1=$_{i=1}\sum\ _{j=1}\sum$pijxiyj,

Expected payoff for **Farmer** 2=$_{i=1}\sum\ _{j=1}\sum$pijxiyj,

Where pij is the payoff if **Farmer** 1 uses pure strategy i and **Farmer** 2 uses pure strategy 'j'. In the example of mixed strategies just given, there are four possible payoff (-2, 2, 4, -3) each occurring with a probability, so the expected payoff is=1/4 (-2,+2,+4,-3) -1/4.
Thus, this measure of performance does not disclose anything about the risks and the results consisting in playing the game, but it does indicate what the average payoff will tend to be if the game is played many times.

V. RESULT AND DISCUSSION

Farmers must make decisions in their given, certain uncertain environment. How are those decisions and result to be made? Lack of knowledge and experience of production conditions does not lessen farmer's desires to maximize the production of certain ends through use of available resources and the natural resources. They must observe, finding new techniques, conceive received ideas, take a decision, implement their plan and action and accept the consequences (profit or loss).

A.Game theory and linear programming

Linear programming issue should have three elements: objective function, constraints and nonnegativity conditions. During this study, Wald's criterion (maximin) was used. According to which the maximin criterion the farmer tries to settle on "the better of the worst". This suggest that the farmer selects the mixture of activities which can maximize his minimum financial gain. These three elements or components also exist in a two-person zero-sum game. A two-person zero-sum game can be turn or converted into an equivalent linear programming problem. In a two-person zero-sum game, the aim of one player is to maximize the expected gain while the other player tries to minimize the expected loss. In other words the aim of the players in theory of game is either to maximize or minimize gains. In short, the target of the game is a linear function of the decision variables. In linear programming the players or farmers wish to optimize their gain (income) subject to given constraints and the variables (outcomes) should be always non-negative. When each players select the optimal methods or strategies in a two-person zero-sum game or non-zero game, one farmer highest expected gain is equal to the other farmer lowest expected loss. Therefore the value of the maximum problem is exactly the same as that of the minimum problem. This strategy gives the farmer maximum security and another chance to play. Life of farmer may be dependent to his farm's income such that, if he loses all his farm income, he can't prepare essential goods,crops,fruits,etc.If the farmer pursued the maximin strategy then he can be regarded a pessimist or as more careful. This is the same as the primal or dual relationship in linear programming. However, there are some important differences between theory of game problems and standard linear programming applications.

In result, the farmers that their life dependent to their farm incomes, prefer strategies which have less income and with more secure, to risky strategies whit major incomes. Given the level of Expected financial gain and the degree of risk, farmers can choose their desired programs. The expected income increases after this level the average lowest income decreases. If expected financial gain decreases once the optimum solution the lowest financial gain decreases also.

B.An optimal solution

One game can be stated by converting to a linear programming problem. Linear programming problems must have three elements: physical functioning, limitations and non-negative conditions. These three elements are as well as in a two-person game where it's total score is zero. So between game theory and linear programming, there are common elements (Linear objective function, linear side constraints, the non-negative conditions and primal/ dual relationship) so a two-person zero-sum game can be converted into an equivalent linear programming problem. In a two-person zero-sum game, each player's goal is to maximize the amount of his acquired points, whereas the rival player tries to minimize his lost points. In other words, the players` aim in game theory is to maximize their consequences or minimize the outcome of the opponent (maximum for themselves and minimum for competitor).

C.Uncertainty theory

The body of theory discussed in this paper has grown out of various attempts to improve man's ability to deal with his uncertain environment. Contributors to the theory have included mathematicians, psychologists, economists, statisticians and representatives from other disciplines. The theory provides models for classifying knowledge situations and predicting choice under various states of knowledge. It also provides alternative normative models for making decisions under different knowledge situations. Thus, are view of ideas relating to uncertainty provides an important background for the analysis undertaken in this dissertation. Uncertainty theory is reviewed in two parts. First, schemes for classifying knowledge situations are presented. Second, theories concerning the way individuals may or do choose in an uncertain environment are examined. This division is useful for presentation; however, the two topics are not entirely separable. The nature of the uncertainty is determined subjectively by an individual and its classification is influenced by his psychology can be specified for events of interest. If they can be, the situation is one of risk, and if they cannot, uncertainty prevails. His knowledge situations Include: (a) perfect certainty, (b) risk, and (c) uncertainty. Certainty is the state of knowledge. In which static economic theory applies. Knight's classification is convenient for setting up decision models. Some decision models may be specified for use in risk situations and others for use under uncertainty.

VI. CONCLUSION

Game theory is concerned with competitive situations. Farm planning problems conceive the farmer playing a game against nature. A two-person zero-sum game can be converted into a linear programming model due to several similarities between the two. Therefore, the optimal solution to game theory may be found by formulating it as a linear programming problem. The objective of the game theory model in agriculture is to find the highest income under the worst circumstances. In this study the highest expected income level under the worst circumstances was determined using the game. Decision making will be influenced by farmer’s characteristics. Decision criteria used in the study are minimax, maximin, regret, utility and lap lace criteria. 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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