GAME THEORY AND AUDIT

1. Introduction - General concepts

Game theory began as a branch of economics with John von Neumann and Oskar Morgenstern's book "Theory of Games and Economic Behaviour" on zero-sum games. Its main object is the analysis of decisions in situations (games) of strategic interdependence.

Game theory deals with the study of elements that characterize situations of competitive interdependence with an emphasis on the decision-making process between at least two players, i.e. it can be described as the process by which one can analyze and possibly predict how individuals or groups of individuals (players) make decisions in a competitive environment.

The first studies of this theory appear in the early 18th century with the French mathematicians Antoine Cournot and Joseph Bertrand who examined the problems of production in oligopolistic conditions, but it began to become more widely known and function as an independent scientific field in the mid-twentieth century. This impetus was given by John von Neumann with his work in 1928 and his book with Oskar Morgenstern "Game Theory and Economic Behaviour" in 1944.

Further pioneers of the theory include:

• John Forbes Nash, who generalized the problem to non-zero sum games and offered the Nash Equilibrium solution.

• Reinhard Selten paved the way for a satisfactory solution to the problem in dynamic games with the concept of Subgame Perfect Nash Equilibrium and trembling hand perfect equilibrium

• John Harsanyi dealt with Incomplete Information games.

For their work they were honored in 1994 with the prize of the Swedish Academy of Sciences in memory of Alfred Bernhard Nobel. Also, in 2005, game theorists Thomas Schelling and Robert Aumann won the Nobel Prize in Economics, while Game Theory is now considered so scientifically important that, by 2014, 11 of its scholars/theorists have been awarded the Nobel Prize.

For the last 30 years, game theory has been widely used in economics, political economy, evolutionary biology, psychology, sociology, etc.

2. The prisoner's dilemma

The prisoner's dilemma is a standard example of a game analyzed in game theory that shows why two completely rational individuals might not cooperate, even if it appears that it is in their best interests to do so. It was originally framed by Merrill Flood and Melvin Dresher while working at RAND in 1950. Albert W. Tucker formalized the game with prison sentence rewards and named it "prisoner's dilemma" presenting it as follows:

Two members of a criminal gang are arrested and imprisoned. Each prisoner is in solitary confinement with no means of communicating with the other. The prosecutors lack sufficient evidence to convict the pair on the principal charge, but they have enough to convict both on a lesser charge. Simultaneously, the prosecutors offer each prisoner a bargain. Each prisoner is given the opportunity either to betray the other by testifying that the other committed the crime or to cooperate with the other by remaining silent. The possible outcomes are:

- If A and B each betrays the other, each of them serves two years in prison
- If A betrays B but B remains silent, A will be set free and B will serve three years in prison
- If A remains silent but B betrays A, A will serve three years in prison and B will be set free
- If A and B both remain silent, both of them will serve only one year in prison (on the lesser charge).

Prisoner's dilemma payoff matrix

A/B	B Stay silent	B Betrays
A Stays silent	-1, -1	-3, 0
A betrays	0, -3	-2, -2

It is implied that the prisoners will have no opportunity to reward or punish their partner other than the prison sentences they get and that their decision will not affect their reputation in the future. Because betraying a partner offers a greater reward than

cooperating with them, all purely rational self-interested prisoners will betray the other, meaning the only possible outcome for two purely rational prisoners is for them to betray each other.

The prisoner's dilemma game can be used as a model for many real world situations involving cooperative behavior. In casual usage, the label "prisoner's dilemma" may be applied to situations not strictly matching the formal criteria of the classic or iterative games: for instance, those in which two entities could gain important benefits from cooperating or suffer from the failure to do so but find it difficult or expensive—not necessarily impossible—to coordinate their activities.

Another equally well-known strategy for resolving an extended form of the "prisoner's dilemma" is the "one for you and one for me" (tit for tat). This strategy was introduced by Anatol Rapoport in a tournament hosted by Robert Axelrod, a political scientist at the University of Michigan in the late 1970s. The strategy is that the player's first move is always cooperation, while in the next steps he chooses the strategy of his opponent in the previous round.

3. GAME THEORY AND AUDIT

Game theory can be particularly useful in strategic decision-making processes as well as in situations of conflict of interest, such as the principal-agent problem. In this problem, the principals delegate the decision-making power to agents. The problem arises because the two parties have "asymmetry of information" (usually the agent has more information than the principal) as well as different priorities and interests.

For this reason, audit is a way for principals to check whether the information provided by management is correct and reliable and the agents act in the interest of the principal and not in their own, individual interest. Therefore, audit can be considered as a tool which can reduce the conflicts of interest between multiple decision makers.

In auditing, game theory has been used as a tool to explain and analyze how auditors and managers make their own decisions after taking into account decisions made by other players, as well as a tool for predicting human behavior. The application of Game Theory in the field of audit is of particular interest, although there are not many practical applications in this area.

Some researchers used game theory in order to examine ie: the decisions of auditees in the effort they put in their internal control and the decisions of the auditors concerning the extent of their tests (game developed by Fellingham and Newman, 1985), while others focused on the strategic interaction between the manager and the auditor and especially the dilemma of the manager to commit (or not) a fraud (game developed by Matsumura and Tucker, 1992).

In such cases, game theory may prove useful because it seeks to predict behaviors that support players' better response to their motivations and the expected actions of their opponents. In reality, however, it is quite difficult to predict human behavior, such as the auditor's reaction to the auditor's strategy, due to a lack of sufficient data. After all, some of the audit strategy game studies were conducted by students of business schools who played the role of managers and auditors.

For this reason, it is proposed to further develop and apply game theory in auditing, taking into account real observation of auditor's strategies (Ben Abdelaziz et al., 2015).

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