DOI: 10.55643/ser.4.50.2023.542

Damir Kulish
PhD in Economics, Doctoral Student,
Zaporizhzhya National University,
Zaporizhzhia, Ukraine;
e-mail: damir.kulish@gmail.com
ORCID: 0000-0003-2224-1078

Received: 15/09/2023
Accepted: 18/12/2023
Published: 25/12/2023

BUILDING A MODEL OF THE ANTAGONISTIC GAME OF CHOOSING THE STRATEGY OF FOREIGN ECONOMIC ACTIVITY IN THE CONDITIONS OF DIGITALIZATION

ABSTRACT

The purpose of the study is to build a model of the antagonistic game of choosing the strategy of the FEA in the conditions of digitalization. To do this, approaches to the use of Game Theory will be explored. The economic and mathematical apparatus and its application for the strategy of foreign economic activity are considered.

This study allows us to determine whether Game Theory is a suitable analytical tool for foreign economic activity-oriented decision-making. In this context, through strategic interdependence games, FEA is associated with making decisions to determine whether to collaborate or compete, innovate or emulate in order to create innovative advantages in the company.

It has been found that sometimes our economic decisions are influenced by the decisions of third parties; To understand how these decisions are made and which is the best among several alternatives, game theory arises. The study of game theory in economics will define a game as an abstraction of a specific economic situation. One or more solutions will be suggested, and the author will try to demonstrate which strategies correspond to the equilibrium in the presented game. Game theory cases are often represented graphically using matrices to better understand the reasoning of the participants.

Companies use game theory not only to set prices but also to determine when and in which market to conduct FEA and predict competitive decisions. Therefore, the theory of games was applied to foreign exchange for different markets. In order to use this theory, it is necessary to have information about other players, their advantages, and limitations. It consists in achieving a balance of benefits for all. When all players have made a decision and if changing it makes them feel worse, a Nash equilibrium is said to be reached.

Keywords: model, antagonistic game, game theory, strategy, foreign economic activity, Nash equilibrium, digitalization

JEL Classification: L100, D2, F6

INTRODUCTION

Decision-making based on game theory is a very under-researched area of microeconomics, especially based on innovative competition that develops through foreign economic activity (FEA). In order to build an FEA strategy, each of the decisions that the player must make is first determined. Game theory, also known as "interactive decision theory" or "social situation theory", is, according to Deutsch et al (1986) cited by San Roman (2002), one of the twelve major innovations in economic thought worldwide. twentieth century; and can be broadly defined as a decision-making technique in conflict situations based on the construction of a formal matrix that allows understanding of the conflict and its possible solutions.

In the field of business, it can be considered as a mathematical method that allows analyzing the behavior of companies in terms of possible actions or business strategies that they carry out for their placement, maintenance and expansion in the markets to which they belong.

Among the greatest representatives of game theory are the outstanding Hungarian mathematician John von Neumann and the Austrian economist and mathematician Oskar Morgenstern, who in 1944 published the book "The Theory of Games and Economic Behavior", which became one of the greatest achievements of modern times. economic theory, as well as a radical transformation of our understanding of decision-making and strategy selection in various fields of knowledge.

For Binmore (1994), the above-mentioned authors explored two different approaches to game theory, the first of which is the strategic or non-cooperative approach, which consists of a game with two players whose interests are diametrically opposed, and in which this requires defining in great detail what the players can and cannot do during the game, and then find the optimal strategy for each player. In this context, games are called strictly competitive, or zero-sum games, because any gain for one player is always exactly balanced by a corresponding loss for another player.

The second approach refers to the coalitional or cooperative one, in which the authors sought to describe the optimal behavior in games with a large number of players, a situation that did not allow to achieve the same exact results as those found in the zero-sum case. and two players.

According to Ayala and Arias (2003), game theory was created with the intention of resisting the limitations of neoclassical economic theory and providing a theory of economic and strategic behavior where the subject interacts directly, instead of doing so through the market. In this sense, game theory is a fundamental tool for dealing with complex interactions such as competition in markets.

However, it should be noted that although von Neumann and Morgenstern (1953) are considered the first formal game theorists, other authors have made important contributions to the mathematical concepts they originally expressed. For this reason, the purpose of this essay is to provide, from the perspective of Nailbuff (1997) and Shubik (1959), some theoretical reflections that contribute to a better understanding of the scope and limitations of game theory.

LITERATURE REVIEW

Game theory arose out of von Neumann's interest in certain aspects of poker, such as how players tried to give false tips by using the rules of the game. This author believed that there was something non-trivial about this, and from the mid-twenties to the forties he devoted himself to investigating the mathematical structure of poker and other games; realizing that the theorems can be applied to various fields such as economics, politics, and various situations of everyday life and war (Gastaldi et al., 1998).

In 1944, von Neumann and Morgenstern published the results of their analysis in the book "Game Theory and Economic Behavior". However, Shubik (1987) notes that other economists such as Cournot and Edgeworth already anticipated some ideas and were particularly innovative in the 19th century. Similarly, the author suggests that other contributions were made by the mathematicians Borel and Zermelo, and even von Neumann himself had already laid the foundations in 1928.

However, it was only after von Neumann and Morgenstern's book appeared in 1944 that the world realized the importance of an open-ended tool for the study of human relations, and in the last twenty years considerable progress has been made to the point that other modern books on game theory have been published, which no longer include some of the restrictive assumptions that Von Neumann and Morgenstern considered necessary for progress, such as the existence of players with perfect knowledge of the game and their opponent, which means that the Player knows the rules of the game in detail.

Gibbons (1996) in the analysis of game theory indicates the existence of four types of games, namely: static, dynamic, with complete and incomplete information; indicating that incomplete information represents a situation where there is no private information.

The aforementioned author, defining static games with complete information, starts from the existence of two players, each of whom chooses and simultaneously executes a certain option from the menu of possible alternatives, and at the end of which each receives a utility (payoff).

Speaking of static games with incomplete information, also known as Bayesian games, Gibbons (1996) defines them in the same way as the previous one, but considering that at least one player is uncertain about the utility or payoff function perceived by the other player.

Regarding dynamic games with complete information, the author assumes that player number one chooses an option from a possible set of alternatives, while player number two observes the decision chosen by player number one and then takes

DOI: 10.55643/ser.4.50.2023.542

his action from the set of possible alternatives. After performing each action, each of the involved agents (players) receives a reward (payout).

In turn, dynamic games with incomplete information consist in the fact that one of the players has private information, and the counterparty does not; resulting in the latter following an action taken by the player with the information. This type of game is called "signal games" because a signal sent by a player who knows private information is followed by an action taken by the opponent based on the latter's information.

However, when reviewing the existing literature on game classification, it is common to find that various authors, including Binmore (1994) and Shubik (1986), classify games as cooperative or coalition rather than cooperative or competitive.

Cooperative games study how rational people interact with each other in pursuit of interdependent goals, with the goal of maximizing the specific interests of each by achieving common goals established by consensus, and in which the maximization of specific interests means, in this case, the greatest value to be achieved together with the other side, and is not necessarily the greatest value that can be achieved in the game. Whereas non-cooperative games study how rational people interact with each other in an attempt to maximize their own goals, and where the maximization of specific goals means, in this case, the greatest value to be achieved, which generally coincides with the greatest value to be gained by the game.

Today, there is no doubt about the importance of game theory in society and how it has revolutionized the way of thinking and decision-making in the economic sphere. However, there are some authors such as Nash (1950), Simon (1993), Binmore (1994), Durand et al. (1996), Foss (1999), and Shubik (2000) among others who question and comment on the weaknesses of game theory.

In this sense, it is worth noting that in the early 1950s, according to Binmore (1994), Nash broke two barriers that von Neumann and Morgenstern had imposed on themselves. In the case of non-cooperative games, the authors did not take into account the concept of equilibrium for the construction of strategies, and therefore they were limited to zero-sum games. However, Nash's approaches to the idea of equilibrium showed that such a restriction was necessary, and in fact today it is a valuable tool for game theorists.

Regarding the cooperative approach of von Neumann and Morgenstern (1953), Nash (1953), Ermakova, O. M. (2016). also made some contributions, as he disagreed with the idea that game theory should treat negotiation problems between two people as uncertain, and in this sense offered arguments for defining them.

On the other hand, Mankiw, N. (2000). notes that game theory raises several criticisms, among which the formality and non-representation of human actions stand out. Among the first are the formal methods used by the theory of games, in which there are no constants in a person, and therefore quantitative and formal methods are not the guarantors of social sciences. Likewise, the author notes that game theory does not represent human actions, as it has an extremist nature of reality in which hyper-rational individuals (standard game theory) or simple puppets, programmed to follow strict rules, converge, although in some cases it is completely irrational decisions (evolutionary or Darwinian game theory).

In addition, Durand et al. (1996: 5) emphasize that game theory only provides models of real situations, so often the conclusions these models provide are only general guidelines for behavior that provide more precise rules of action. more accurately reflects reality.

According to Shubik (2000), when games are played strategically or broadly, the limitations of both implicit and explicit assumptions make rational people or decision-makers more problematic. According to the author, theoretical and primitive solutions provide a weak model of behavior. Even with regard to the concepts of non-cooperative equilibrium and its variants, such values were more subjective.

Similarly, Shubik (2000) emphasizes that one of the most important weaknesses of models in game theory is that they leave no room for innovation, mutation, and feedback between the game and its environment.

At the same time, he notes that the passions of the individual, namely: love, hatred, anger, envy, fear, joy, and regret, play a predominant role in decision-making (Ivashchenko G. A. 2021). Such senses of human and animal behavior are indicators of the complex coding process that individuals use, and in this sense, game theory presents a challenge to formulate models where the role of passions can be defined and analyzed.

In the same line of thought, Shackle (1972), Garafonova O. I. (2015), cited by Basili and Zappia (2003), emphasize the need to recognize the mental activity of the individual, in which he argues that each person imagines the future, and this process of imagination is vital. .in the decision-making process. Therefore, Shackle offers a conceptualization of non-probability decisions of individuals under conditions of uncertainty.

Furthermore, Simon (1993), Garafonova, O., Gruzina, I., Kozyreva, O., Margasova, V., Pishchenko, O., & Tarasyuk, G. (2023) cited by Mirjam (2003), strongly questions the assumption that each economic agent (player) has a well-defined utility or benefit function and that alternative strategies are known to decision makers; For this author, the above assumptions contradict his beliefs about the existence of external social constraints and internal cognitive constraints on decision-making, on which he bases the opposite assumptions in his program of partial rationality (bounded rationality).

In other words, Simon emphasizes his observations around the classical concept of rationality, which places strict demands on decision-makers; and criticizes this model for characterizing human beings with unbounded rationality. The main argument put forward is that this model would only work if all people had a uniform worldview, which would only be plausible if all people shared the same value codes.

Similarly, the author questions the predictable nature of the consequences caused by a certain strategy and rejects the fact that such consequences can be determined.

Building models of rationality can be an extremely qualitative task. As he says McKeown (1999: 179), the connection between TD and the qualitative tradition can be determined by noting the similarities between games and ideal types. Ideal types—Weber's concepts—are qualitative conceptual resources for abstracting the essential characteristics of a phenomenon in order to guide empirical inquiry and facilitate understanding (Ksendzuk V.V. 2020). Especially for the most well-known games in the literature (DP, Chicken Game, etc.), both preference tables and payoff matrices can be considered ideal types, since they economically synthesize the complexity of situational logic and decision-making processes, which they can repeat in a number of cases: they help to understand empirical problems, but at the same time it is clear that the analyzed actors do not behave completely according to the characteristics attributed to these concepts: the cognitive capacity that TJ assigns to them will rarely be found empirically, but they provide an initial orientation to real problems.

By reproducing only, the most important characteristics of a phenomenon or set of phenomena, ideal types help answer why, in light of the contextual conditions of the phenomenon, it deviates or does not deviate from the ideal model; They allow us to understand a phenomenon by comparing it with a concept of a higher level of abstraction. Consider, for example, the concept of instrumental rationality. By considering it as an ideal type, its presence could be predicted in order to later analyze the case and show how possible deviations from the ideal type are explained by the specific circumstances of the case, that is, by comparing it with the empirical world. One might begin with the TJ model, which in theoretical intuition shows similarity to empirical situational logic, and discuss how unique case conditions cause the model to deviate. Emphasizing the deviation from the model makes sense to explain the case itself, to show the limits of rationality - to find, for example, the presence of irrational motivations - and to emphasize the usefulness of the ideal type as a starting point. map of reality Games, as ideal types, are in the middle between abstract concepts - for example, a system - and empirical singularities. In this sense, TJ adapts to what Robert King Merton (2002: 56) understood as middle-range theories: theories that help in empirical research and allow moving "from top to bottom", while being between empirical descriptions and basic theoretical propositions. That's why Porter, M. (1990) built a general theoretical corpus from rationalist micro-foundations, in which TJ plays a primary role since its models play the role of "mediators" between individual phenomena and systems. Furthermore, as an intermediate theory, the scope of TK is both theoretical and empirical: they serve to explain real phenomena, but at the same time they generate debates whose usefulness can only be found in social philosophy. Finally, as San Román, Antonio Pulido (2002) said, games, being ideal types, allow us to analytically relate the social structure to the actor's point of view, the subjective to the objective. The author seems to think that the game, although an expression of methodological individualism, includes in its analysis the social construction of preferences, beliefs, and motivations, and that external mechanisms such as opportunities, interactions, structures, and decisions of other actors influence the formation of preferences.

Game theory has continued to develop over the last century, with the seminal contribution of mathematician John Nash, who won the Nobel Prize for his analysis of equilibria in non-cooperative game theory. A Nash equilibrium assumes a situation in which all players have chosen a strategy that maximizes their profits, given the strategies of the remaining players. At this point, neither player has an incentive to change their strategy.

Game theory researchers analyze the behavior of individuals in strategic games. These types of games represent a situation in which two or more players are faced with a choice. Each of them can win or lose depending on what the others choose. Therefore, the final result of the game is determined jointly by the strategies chosen by all its participants, that is, the outcome of each participant's decision depends on the actions of the rest.

The study of game theory in economics will define a game as an abstraction of a specific economic situation. One or more solutions will be suggested, and the author will try to demonstrate which strategies correspond to the equilibrium in the presented game. Game theory cases are often represented graphically using matrices or decision trees to better understand the reasoning of the participants.

AIMS AND OBJECTIVES

The purpose of the study is to substantiate and build a model of the antagonistic game of choosing the strategy of foreign exchange in the conditions of digitalization. For this, approaches to the use of game theory will be explored. The economic-mathematical apparatus and its application for the foreign exchange strategy are considered.

METHODS

This study allows us to determine whether game theory is an appropriate analytical tool for decision-making focused on FEA. In this context, through strategic interdependence games, FEA is related to decision-making to determine whether to cooperate or compete, innovate or imitate, to create innovative advantages in the company.

Therefore, the method used is deductive, which is based on a documentary review of previous studies of game theory and its application in reality for decision-making focused on the FEA. Modeling with the help of game theory was also applied in the case of FEA. Thus, on the basis of the relevant variables, specific conclusions are formulated regarding the application of game theory in the development of a foreign exchange strategy.

RESULTS

Game theory, created by Neumann and Morgenstern (1944), focuses on finding optimal strategies that players (agents) use to maximize their utility under cooperative and non-cooperative approaches. This new analytical tool for strategic decision-making had a major impact in the fields of economics and mathematics, especially through the doctoral dissertation of Nash (1950), who, building on the work of Neumann, Morgenstern, and Kuhn, demonstrated that there is a solution to non-cooperative strategic games where the players get the best possible outcome, given that they are in a situation of strategic interdependence, and therefore no player has the incentive to deviate from it, is called a Nash equilibrium.

According to Álvarez (2015), game theory is very useful for analyzing the functioning of basic market structures with a small number of participants, whose outcomes depend on the outcomes of others, which allows predicting behavior. certain predetermined rules of the game.

Based on the above, players form their optimal strategies, and they can change, according to Fernández and Parra (2012), depending on the size of the company, the sector of economic activity, the market, and the type of game they play. Such a situation leads to fiercely competitive (even vindictive) play or to alliances and cooperation that allow all players to get a fair share of the benefits. Thus, game theory has a strong analytical connection to the decision of companies to compete: this is a relevant element in this study.

In the new economy, there is a very deep connection with the thought of one of the greatest intellectuals of his time: John von Neumann, who, since 1928, has contributed profound discoveries that are now used in the field of business.

In this regard, authors such as Nalebuff and Brandenburger (1997) have used von Neumann's findings from game theory to develop several business-related projects. And in this sense, they introduce the term "cooperation", which is an abbreviation of the words "cooperation" and "cooperation", and with which the authors want to express that business is not just a war, as it was traditionally believed, in which there were winners and losers (zero-sum game); nor is business only peace, as was later believed, but rather business is both war and peace; You have to compete and cooperate at the same time.

Knowing that game theory is an abstract reflection of reality, and that the behavior of individuals in one way or another affects the state of other actors; When evaluating it, it is important to take into account the assumptions, since it is almost an impossible task to reflect what exactly happens in real life with the help of a model.

In this sense, game theory is based on the following assumptions:

- Each player has at his disposal two or more clearly defined options, called "games".
- Each possible combination of moves available to players directs them to a well-defined final state (win, lose, or fold) that ends the game.

- Each end-situation has a separate reward associated with each player.
- Each player knows the game and his opponent intimately, which means that the player knows the rules of the game in detail, as well as the preferences and beliefs of the players, the payoffs of the other players, and what each player can and cannot do.

All players are rational; this means that each player, given two options, will choose the one that represents the greatest benefit or utility.

Therefore, game theory is a general theory of rational behavior for situations in which: 1) two or more players have at their disposal 2) a finite number of options for actions (moves) that lead them to 3) a clearly defined outcome of winning and losing, expressed as numerical payoffs associated with each combination of actions and for each player. And where the players have 4) perfect knowledge of the rules of the game and 5) are rational, in the sense that each player optimizes his individual profit.

The game is a mathematical model of a real conflict situation. A conflict situation between two players is called a double game (Klemperer, P., 1990). An even zero-sum game is convenient to investigate if it is described as a matrix. Such a game is called a matrix game; the matrix consisting of the numbers a_{ij} is called the payment matrix. A mathematical model of an antagonistic game is a matrix game with matrix A, in which the moves (strategies) of player A are arranged in rows, and the moves (strategies) of player B are arranged in columns. The matrix itself records the winnings of player A based on the respective moves of players A and B (a negative win is a loss). The table presents options for solving the game given by the payment matrix A. The description of the algorithm includes:

- the analysis of the payment matrix should determine whether there are dominant strategies in it, and exclude them;
- finding the upper and lower price of the game and determining whether the given game has a saddle point (the lower price of the game must equal the upper price of the game);
- if a saddle point exists, then the players' optimal strategies that are the solution to the game will be their pure strategies corresponding to the saddle point. The price of the game is equal to the upper and lower prices of the game, which are equal to each other;
- if the game does not have a saddle point, then the solution of the game should be sought in mixed strategies. To determine the optimal mixed strategies in m × n games, the simplex method should be used, having previously reformulated the game task as a linear programming task.

In the case of V * ≠ V * - there is no saddle point (Fernández, J., and Parra, M. (March 18, 2012).

There is also no optimal solution in pure strategies. However, if you expand the concept of a pure strategy by introducing the concept of a mixed strategy, it is possible to implement an algorithm for finding the optimal solution to a not-quite-certain game task. In such a situation, it is proposed to use a statistical (probabilistic) approach to finding the optimal solution to the antagonistic game. For each player, along with a given set of possible strategies for him, an unknown vector of probabilities (relative frequencies) with which one or another strategy should be used is entered. Let us denote the vector of probabilities (relative frequencies) of choosing the given strategies of player A as follows:

$P = (p_1, p_2, \dots, p_m)$, where $p_i \geq 0$, $p_1 + p_2 + \dots + p_m = 1$.

The value pi is called the probability (relative frequency) of using the strategy A_i. Similarly, for player B, an unknown vector of probabilities (relative frequencies) is entered in the form (San Román, Antonio Pulido, 2002):

$Q = (q_1, q_2, \dots, q_n)$,

where $q_j \geq 0$, $q_1 + q_2 + \dots + q_n = 1$. The quantity qj is called the probability (relative frequency) of using strategy B_j. The set (combination) of pure strategies A1, A2, …Am and B1, B2, … Bn in combination with the vectors of probabilities of choosing each of them are called mixed strategies.

The main theorem of the theory of finite antagonistic games is von Neumann's Theorem: every finite matrix game has at least one optimal solution, possibly among mixed strategies.

It follows from this theorem that a non-definite game has at least one optimal solution in mixed strategies. In such games, the solution will be a pair of optimal mixed strategies P * and Q *, such that if one of the players adheres to his optimal strategy, then it is not profitable for the other player to deviate from his optimal strategy.

The average profit of player A is determined by mathematical expectation: if the probability (relative frequency) of using a strategy is different from zero, such a strategy is called active.

DOI: 10.55643/ser.4.50.2023.542

Strategies P*, Q* are called optimal mixed strategies if MA(P, Q*) ≤ MA (P *, Q *) ≤ MA(P *, Q) (1)

In this case, MA (P *, Q*) is called the price of the game and is denoted by V (V* ≤ V ≤ V*). The first of the inequalities (1) means that the deviation of player A from his optimal mixed strategy, provided that player B follows his optimal mixed strategy, leads to a decrease in the average payoff of player A. The second of the inequalities means that the deviation of player B from his optimal mixed strategy strategy, provided that player A adheres to his optimal mixed strategy, leads to an increase in the average loss of player B.

Therefore, if there is no saddle point, the game is solved in mixed strategies and solved by the following methods: solving the game through a system of equations. If the square matrix nxn(n=m) is given, then the vector of probabilities can be found by solving the system of equations. This method is not always used and is used only in certain cases (if the matrix is 2x2, then the game is solved almost always). If negative probabilities are solved, then this system is solved by the simplex method. In cases where n=2 or m=2, the matrix game can be solved graphically.

We believe that it is advisable to use the graphical method for solving mixed strategies when forming the strategy of the FEA (first, the saddle point is searched, if it is not there, then the dominated rows and columns are deleted, and then the search for the optimal strategy is carried out). In the current context, when globalization extends to many aspects of human life, not excluding the economic sphere, game theory provides a framework of analysis for technological negotiations (especially those that carry out scientific research activities). has at his disposal to maximize utility, taking into account the decisions of other players and the dilemma of cooperating or not cooperating with his rivals. According to Fernández and Parra (2012), it is in this scenario, based on the intensification of the globalization process, that the theory of Nash games appears to reproduce the main components of the technological process of negotiation in conditions of strong competition. In order to find the optimal solution to the dilemma, a game will be used, which consists of the following assumptions: There are markets where the enterprise can enter. At time t, the company must decide between markets, therefore, no market knows the movements of the other, information is imperfect. The rules of the game are predetermined and unchangeable, and the players know them, that is, there is complete information. Players are assumed to be rational.

Consider the game of two people whose interests are opposite. Such games are called antagonistic games. In this case, the gain of one player-strategy is equal to the loss of the other, and only one of the players can be described. It is assumed that each player can choose only one of the finite set of his actions. The choice of action is called the choice of the player's strategy. If each of the players has chosen his own strategy, then this pair of strategies is called a game situation. It should be noted that each player knows what strategy the opponent has chosen, i. e. has complete information about the result of the opponent's selection. The pure strategy of player I is to choose one of the n rows of the payoff matrix A, and the pure strategy of player II is to choose one of the columns of this matrix.

1. We check whether the payment matrix has a saddle point. If so, then we write the solution of the game in terms of pure strategies. We assume that player I chooses his strategy so as to get his maximum profit, and player II chooses his strategy so as to minimize the profit of player I.

Table 1 Input matrix for the game theory model of the choice of the FEA strategy for me.

The players	B1	B2	B3	B4	B5	B6	a = min(A_i)
A1	2224	85	14	698	24	124	14
A2	2864	96	18	692	21	128	18
A3	2936	120	19	645	26	123	19
A4	2865	123	20	691	28	158	20
A5	4567	108	42	456	26	169	26
A6	4587	104	34	481	29	154	29
b = max(Bi)	4587	123	42	698	29	169	

The players are the enterprises that carry out FDI. B1, B2, B3, B4, B5, B6 - *financial indicators of enterprises.*

We find the guaranteed win, which is determined by the lower price of the game a = max(a_i) = 29, which indicates the maximum pure strategy A6 (Ksendzuk V.V., 2020). The upper price of the game is b = min(b_j) = 29. The saddle point (6, 5) indicates the solution to the pair of alternatives (A6, B5). The price of the game is 29.

2. We check the payment matrix for dominant rows and dominant columns. Sometimes, based on a simple consideration of the game matrix, it can be said that some pure strategies can enter the optimal mixed strategy with only zero probability.

From the losing position of player B, strategy B2 dominates strategy B6 (all elements of column 2 are smaller than elements of column 6), so we exclude the 6th column of the matrix (Basco, A., Beliz, G., Coatz, D. y Garnero, P., 2018). The probability $q_6 = 0$.

14	24
18	21
19	26
20	28
42	26
34	29

Strategy A3 dominates strategy A1 (all elements of row 3 are greater than or equal to the value of the 1st row), therefore, we exclude the 1st row of the matrix (Contreras, H., 1995).

Strategy A4 dominates strategy A3 (all elements of row 4 are greater than or equal to the value of the 3rd row), therefore, we exclude the 3rd row of the matrix (Ermakova, O. M., 2016).

Strategy A6 dominates strategy A4 (all elements of row 6 are greater than or equal to the value of the 4th row), therefore, we exclude the 4th row of the matrix (Martínez, 2001).

42	26
34	29

We have reduced the 6 x 6 game to a 2 x 2 game. We will solve the problem using a geometric method, which includes the following stages:

1. In the Cartesian coordinate system, a segment whose length is equal to 1 is placed along the abscissa axis. The left end of the segment (point x = 0) corresponds to strategy A 1, the right - strategy A2(x = 1).
2. On the left axis of the ordinate, the winnings of strategy A1 are postponed. On the line parallel to the ordinate axis from point 1, the winnings of strategy A2 are deposited. The maximum optimal strategy of player A corresponds to the point N, for which the following system of equations can be written:

- $p_1 = 0$,
- $p_2 = 1$.

The cost of the game, y = 29. Player B's minimax strategy can now be found by writing down the corresponding system of equations, eliminating B's strategy 1 clearly gives player B a greater loss, and hence $q_1 = 0$, $q_2 = 1$. A geometric interpretation of the game theory model for foreign economic activity strategy is shown in Figure 1.

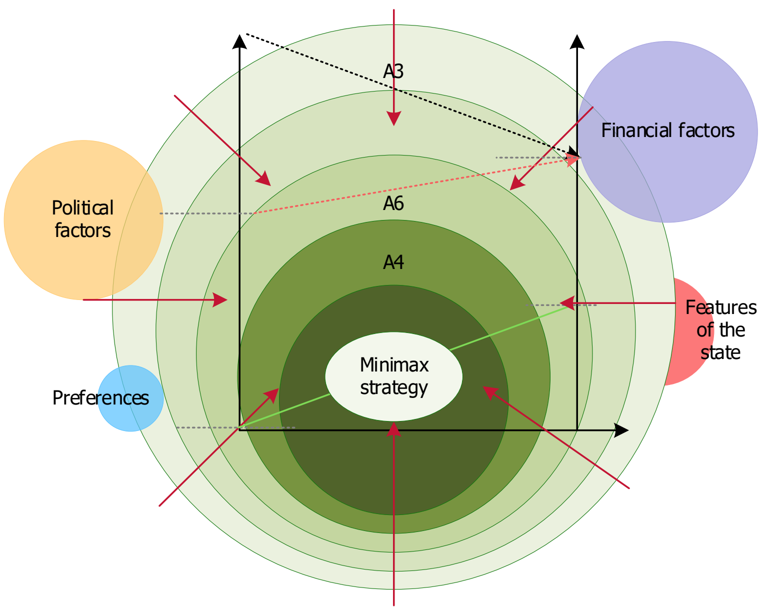

Figure 1. Geometric interpretation of the game theory model for the strategy of ZED.

DOI: 10.55643/ser.4.50.2023.542

Answer: Game price: y = 29, players' strategy vectors: Q(0, 1), P(0, 1)

4. Let's check the correctness of the game solution using the strategy optimality criterion.

$\sum a_{ij}\, q_j \vee \sum a_{ij}\, p_i \geq v$

$M(P_1; Q) = (42*0) + (26*1) = 26 \leq v$

$M(P_2; Q) = (34*0) + (29*1) = 29 = v$

$M(P; Q_1) = (42*0) + (34*1) = 34 \geq v$

$M(P; Q_2) = (26*0) + (29* 1) = 29 = v$

All inequalities are fulfilled as equalities or strict inequalities, so the solution of the game is found correctly. Since rows and columns were removed from the original matrix, the probability vectors found can be written in the form:

- *P(0,0,0,0,0,1)*
- *Q(0,0,0,0,1,0)*

Essentially, it is a strategy used in negotiations or scenarios involving two or more agents. Participants do not ask themselves how to act within their capabilities, but rather consider the capabilities of those in front of them. That is, your decision depends on the decision of others; and theirs, in turn, depends on yours.

DISCUSSION

Two important aspects that have been considered in relation to game theory and strategic management are the FEA market and research. The reviewed literature allows us to determine the importance of a company being strategic in these two areas. Therefore, game theory can be applied both in strategic management and in research and development. Strategic management includes a number of actions that affect the demand for goods or services offered by the company. Strategic activity is related to the development of product strategies for foreign trade, pricing, distribution, and sales promotion. However, game theory is the dominant conceptual framework for analyzing competitor and consumer behavior. Analytically, game theory can provide an ideal conceptual framework for investigating different contexts in which outcomes derive from interactions between different actors or players (competition, consumer, supply chain, government), especially in interpreting the relationship between competitive behavior and market reaction (Day & Wensley, 2002). Nevertheless, an important application of game theory in strategies is the modeling of horizontal competition among a small number of firms considering oligopolies in some industries (Chatterjee & Samuelson, 2014). Based on the game theory approach, there are four variables (known as the marketing mix) that firms play with product, price, country, and promotion. Of these four, the most easily modifiable yet most difficult to compromise is price, as this variable operates in tandem with consumer judgments and perceptions (Lalwani & Shavitt, 2013). Thus, price is the most tactical variable and is seen as the last step in the competitive moment after product, advertising, and distribution strategies have been developed and implemented (Saghezchi, Saghezchi, Nascimento, & Rodriguez, 2014). Cooperation is necessary to reduce costs. Despite the fact that companies that cooperate with each other, for example in the transfer of knowledge, do not fulfill part of the agreement; it becomes necessary to enter into a contract in order to achieve a balance at the FEA. Balance is easier to achieve when side effects occur. Patents, licenses, and royalties are among the possible outcomes that avoid damages from non-compliance by the parties. These payments can discourage vertical integration, especially by companies with resources.

CONCLUSIONS

Companies today must manage themselves in a world of extreme complexity, any factor can determine the success or failure of a company, and any change that occurs in these factors tends to affect many others.

Therefore, in this essentially turbulent and globalized environment, managers must have the ability to think strategically, enabling them to observe the organization and its environment from a holistic perspective. This is how game theory, which deals with the study of conflict and cooperation patterns between rational decision-makers, is presented as a framework that can be used to enhance and improve strategic thinking in organizations by helping to define the environment and how to act upon it. That is, it provides a more complete overview of each business situation, allowing us to observe aspects that might otherwise be ignored, and in which some of the greatest opportunities for a given company's business strategy can be found.

In the analyzed context of game theory and its predominant role in business decision-making, as noted by Lanza (2000), it is obvious that this theory, closely related to strategic thinking, has become the dominant form of economic reasoning in the industry. business strategy because it provides a method for determining optimal strategies that allow companies to better respond to the opportunities that present time and adapt to future changes in the environment.

Finally, in light of recent developments in game theory as a formal study of decision-making, it is undeniable that it has provided a way to synthesize the way in which decisions are made. persons in conflict.

However, taking into account the characteristics of each economic entity, game theory has significant drawbacks, as it mechanistically organizes the strategic way of thinking of each entity that participates in negotiations. Similarly, people interacting in negotiation or conflict situations almost never have a clear idea of what tools the other party has, a situation that adds a component of uncertainty that is very difficult to quantify.

REFERENCES

1. Álvarez, P. (2015). Teoría de Juegos. Cantabria: Universidad de Cantabria.
2. Ayala Ruiz, Luis Eduardo y Arias Amaya Ramiro (2003). Teoría de Juegos.
3. Basco, A., Beliz, G., Coatz, D., Garnero, P. (2018). Industria 4.0: Fabricando el Futuro. Banco Interamericano de Desarrollo. http://dx.doi.org/10.18235/0001229
4. Basili, Marcello and Zappia, Carlo (2003). Skackll´s economic agent and modern decision theory. Universitá Degli-Studi-di-Siena. Department of Political Economy. http://dx.doi.org/10.2139/ssrn.467401
5. Betegon, L. (2004). Compulsory pharmaceutical licenses in the World Organization of Commerce: an analysis from game theory. University of Salamanca, Department of Applied Economics 2.
6. Binmore, Ken (1994). Teoría de juegos. McGraw-Hill / Interamerica de España, SA España
7. Cantillo, M., and Guevara, P. (1999). The optimal length and amplitude of patents: a mechanism to encourage innovation. https://www.incae.edu/ES/clacds/publicaciones/pdf/cen1803.pdf
8. Contreras, H. (1995). Robert Lucas, las expectaziones rationales y la macroeconomía. *Economía Informa, 243*, 38-40. https://biblat.unam.mx/es/revista/economia-informa/articulo/robert-lucas-las-expectativas-racionales-y-la- macroeconomia
9. Cukierman, P. (1994). Los determinants de la competitividad de la Industria Química de Base en España. Department of Applied Economics of the Universitat Autònoma de Barcelona.
10. Durán, E., Bilbao, J., Fernández, F., Fernández, J., Hinojosa, M., Jiménez N., Jiménez, A., Lebrón, E., López, J., Mármol, A., & Monroy, L. (1996). Advances in game theory with economic and social applications. University of Seville. Department of Applied Economics. Editores JM Bilbao FR Fernández
11. Ermakova, O. M. (2016). STRATEGIC ENTERPRISE MANAGEMENT: ESSENCE AND FEATURES. *Polissya Scientific Bulletin, 4*(4), 92–96. retrieved from http://nvp.stu.cn.ua/article/view/68842
12. Federación Internacional de Robotica. (2020). World Robotics Report 2020. https://ifr.org/ifr-press-releases/news/record-2.7-million-robots-work-in-factories-around-the-globe#:~:text=Sales%20of%20new%20robots%20remain,highest%20sales%20volume%20ever%20recorded
13. Fernández, J., & Parra, M. (2012, March 18). Nash's game theory in technological negotiation models. *Ingeniría Solidaria, 8*(14), 89-93.
14. Foss, Nicolai (1999). Austrian Economics and game theory: a stocktaking and an evaluation. Department of industrial economics and strategy. Copenhagen Business School. http://dx.doi.org/10.1023/A:1007802112910
15. Garafonova, O. I., & Kalenska, O. L. (2015). Enterprise development strategies: theoretical foundations and peculiarities of formation in the conditions of the need for innovative activity. *Bulletin of the Kyiv National University of Technologies and Design. Series: Economic sciences, 1*, 36-49. http://nbuv.gov.ua/UJRN/vknutden_2015_1_6
16. Garafonova, O.I. (2015). Konkurentna Strategia: sutnist ta osoblyvosty formuvannia na pydpryemstvah legkoii promyslovosty. Sotsialno -

DOI: 10.55643/ser.4.50.2023.542

economicychny rozvytok regioniv v kontekty myzhnarodnoi integratsii, *18*(7), 16-20.

17. Garafonova, Olga Ivanivna, & Voronets, Dmytro Oleksandrovich (2023). Strategic Analysis of the Industry During Diversification of Enterprise Activities. *BY, 3*(494). https://cyberleninka.ru/article/n/strategichniy-analiz-galuzi-v-hodi-diversifikatsiyi-diyalnosti-pidpriemstva

18. Garafonova, O., Gruzina, I., Kozyreva, O., Margasova, V., Pishchenko, O., & Tarasyuk, G. (2023). Strategic perspectives of functioning of ukrainian organizations in the conditions of european integration and globalization of the digital economy. *Financial and Credit Activity Problems of Theory and Practice, 1*(48), 298–311. https://doi.org/10.55643/fcaptp.1.48.2023.3957

19. Gastaldi, Carlota, Urrea, Marcel, & Fernández, Pedro (1998). Decision theory: Von Neumann's contributions. Divulgaciones Matemáticas. Facultad Experimental de Ciencias. University of Zulia. Maracaibo, Venezuela, 6(1), 37-42. http://www.emis.de/journals/DM/v61/art5.pdf

20. Gibbons, Robert (1996). An introduction to applicable game theory. http://papers.nber.org/papers/to199.pdf

21. Ivashchenko, G. A. (2021). Formation of the enterprise's foreign economic strategy. Efficient economy, 5. https://doi.org/10.32702/2307-2105-2021.5.101

22. Klemperer, P. (1990). How broad should the scope of patent protection be rand? *Journal of Economics, 21*(1), 113-130. https://doi.org/10.2307/2555498

23. Ksendzuk, V.V. (2020) Mechanisms of formation and implementation of the state foreign trade policy of Ukraine: monograph. Zhytomyr: Ed. O.O. Evenok.

24. Lanza, César (2000). Applications of game theory to the telecommunications market. http://www.tecnova.es/ti/tribunalibre07.htm

25. Mafra, É. (2020, February 23). What are unicorn companies? https://roc-kcontent.com/es/blog/empresas-unicornio/

26. Mankiw, N. (2000). Principles of economics. Harcourt Brace & Company. First edition.

27. Martínez, Juan (2001). Introducción a la teoría de los juegos en la economia de mercado, virtudes e inconpenidos. www.eumed.net/cursecon/juegos/

28. Mirjam Sent, Esther (2003). The legacy of Herbert Simon in game. *Journal of Economic Behavior Organization, 53*(3), 303-317. https://doi.org/10.1016/j.jebo.2002.10.006

29. Nalebuff, Barry J., & Brandenburger, Adam (1997). Coopetition. Ediciones Díaz de Santos, SA Colombia.

30. Neumann, J., & Morgenstern, O. (1944). Theory of Games and Economic Behavior. Princeton University Press

31. Organization for Economic Cooperation and Development [OCDE]. (2006). Manual de Oslo: Guía para la recogida e interpretación de data sobre innovation (3.a ed.). Grupo Tragsa.

32. Porter, M. (1990). The competitive advantage of nations. Harvard Business Review. Ricardo, D. (1817). The Principles of Political Economy and Taxation.

33. John Murray. Schumpeter, J. (2015). Capitalism, Socialism and Democracy. Barcelona, Página.

34. San Román, Antonio Pulido (2002). Possibilities and limitations of mathematics in economics. Cuadernos del fondo de investigation Richard Stone. Centro Stone.

35. Shubik, Martin (2000). Game Theory: Some observations. Working Paper Series B. Operations Research. Yale School of Management. http://dx.doi.org/10.2139/ssrn.238964

36. Von Neumann, J., & Morgenstern, O. (1953). Theory of games and economic behavior. Third edition. John Wiley and sons, New York, NY.

37. World Economic Forum. (2016). Informe Global de Tecnología de la Información 2016. Foro Económico Mundial. https://www.club-bpm.com/Contenido/Estudios/est-2017-001.htm

Куліш Д.

ПОБУДОВА МОДЕЛІ АНТАГОНІСТИЧНОЇ ГРИ ВИБОРУ СТРАТЕГІЇ ЗОВНІШНЬОЕКОНОМІЧНОЇ ДІЯЛЬНОСТІ В УМОВАХ ДИДЖИТАЛІЗАЦІЇ

Мета дослідження – побудова моделі антагоністичної гри вибору стратегії ЗЕД в умовах диджиталізації. Для цього буде досліджено підходи до використання теорії ігор. Розглянуто економіко-математичний апарат і застосування його для стратегії ЗЕД. Це дослідження дозволяє визначити, чи є теорія ігор відповідним аналітичним інструментом для ухвалення рішень, орієнтованих на ЗЕД. У цьому контексті через ігри стратегічної взаємозалежності ЗЕД

пов'язано з ухваленням рішень, щоб визначити, співпрацювати чи конкурувати, впроваджувати інновації чи наслідувати, щоб створити інноваційні переваги в компанії.

Установлено, що іноді на наші економічні рішення впливають рішення третіх осіб. Щоб зрозуміти, як ухвалюють ці рішення і яке є найкращою з кількох альтернатив, виникає теорія ігор. Дослідження теорії ігор в економіці визначить гру як абстракцію конкретної економічної ситуації. Буде запропоновано одне або кілька рішень, і автор спробує продемонструвати, які стратегії відповідають рівновазі в представленій грі. Випадки теорії ігор часто представляють графічно за допомогою матриць, щоб краще зрозуміти міркування учасників.

Компанії використовують теорію ігор не лише для встановлення цін, але й для того, щоб визначити, коли й на якому ринку здійснювати ЗЕД, та передбачити конкурентні рішення. Тому було застосовано теорії ігор при ЗЕД для різних ринків. Щоб використовувати цю теорію, необхідно мати інформацію про інших гравців, їхні переваги та обмеження. Вона полягає в досягненні балансу переваг для всіх. Коли всі гравці ухвалили рішення і якщо його зміна погіршує їхнє самопочуття, вважається, що досягнуто рівноваги Неша. Моделі теорії ігор можуть бути корисно застосовані в ситуаціях переговорів між торговими партнерами, у яких наміри партнера з переговорів є лише частково прозорими, а варіанти його дій відомі лише частково. Те саме стосується відносин співпраці. Відносини між керівниками та працівниками є частиною відносин співпраці, як і відносини між виробниками та торговими представниками й відносини між партнерами за проєктом. Таким чином, дискусії співробітників можуть стати якіснішими завдяки моделям теорії ігор.

Ключові слова: модель, антагоністична гра, теорія ігор, стратегія, зовнішньоекономічна діяльність, рівновага Неша, диджиталізація

JEL Класифікація: L100, D2, F6

 DOI: 10.55643/ser.4.50.2023.542