

SOCIOLOGICAL ANALYSIS OF SOCIAL INTERACTIONS FROM THE PERSPECTIVE OF GAME THEORY

SEYED MEHDI KAZEMI TORBAGHAN*, AMIR SAHAMI, SHAGHAYEGH AMANDAR AND KIMIA EBRAHIMI

ABSTRACT. Understanding the social interactions between individuals and social groups whose decisions and the way they achieve their goals are interdependent, has been the basis for the formation of game theory. By expanding its scope of application from economics to general sciences, mathematics and then political science, game theory is a suitable platform for determining social balances in such a way that it has created the adoption of optimal strategies in cultural and social interactions. By analyzing comprehensive cognitive, economic and environmental issues in determining the policies of the macro-nations, this theory is of interest to experts and policymakers. Therefore, by localizing this theory, it is possible to take advantage of its capacities in the field of holistic analysis, examining different scenarios, providing possible solutions and forecasts in determining the macro-strategic policies of the country. In this regard, in this article, the necessity of using game theory in solving comprehensive cognitive problems with regard to the ecology of Shirvan city is investigated. For this purpose, the game theory will be investigated with a comprehensive cognitive approach, and then the famous patterns of game theory that are effective in analyzing people's daily behavior by considering local and regional conditions will be studied and various examples will be presented in this field. Finally, the interaction of passengers and drivers in the intra-city transportation system of Shirvan city as an example of social behavior which has been analyzed according to the game theory is investigated.

Keywords: Game theory, Nash equilibrium, Public goods, Prisoner's dilemma, Chicken game

Communicated by Soghra Nobakhtian.

Article Type: Research Paper.

*Corresponding author.

Received: 31/12/2022, Accepted: 09/08/2023, Published Online: 29-06-2023.

Cite this article: S. M. Kazemi Torbaghan, A. Sahami, Sh. Amandar and K. Ebrahimi, Sociological Analysis of Social Interactions from the perspective of Game Theory, *Journal of Mathematics and Society*, 8 no. 2 (2023) 63–91.

<http://dx.doi.org/10.22108/msci.2023.136503.1557> .

1. Introduction

In all human societies, humans have continuous interaction with each other. These interactions are sometimes in the form of competition and sometimes in the form of cooperation, but most of the time a combination of aspects of competition and cooperation can be observed simultaneously. Usually, the behavior and decisions of each person or group also affect the goals and policies of another person or group, and there is a kind of mutual dependency between them. Situations of interdependence are called "strategic conditions" because each actor must carefully monitor the behavior of other actors before deciding what choices to make to best achieve their goals. In social science, game theory is used as a branch of mathematics in the analysis of social interactions to understand the behavior of others and to make appropriate decisions in strategic situations. In other words, game theory is a common language for analysts in the social science so that they can share their ideas and opinions about human behavior and design suitable models in facing any type of strategic situation to create a suitable models for analyzing results based on their assumptions. It should be noted that game theory is not necessarily exclusive to games in their general sense, although competitive and cooperative conditions that characterize most games can be studied in game theory. It should be noted that game theory is not necessarily exclusive to games in their general sense, although competitive and cooperative conditions that characterize most games can be studied in game theory. In game theory, the word "game" is used to analyze those social situations that include at least two actors and that their interests are interdependent.

2. Main Results

Considering the importance of this theory in the analysis of social phenomena, many analysts in this field are of the opinion that the emergence of this theory in social sciences is comparable to the discovery of DNA in biological sciences, and it is considered as "a tool capable of analyzing all social situations, [26]. Based on this perception, game theory provides a codified analysis of the rational behavior of actors in the context of strategic interdependence. In such a situation, each actor finds himself in a network of predictions according to the behavior of other actors. This situation is called "Strategic Uncertainty" or "Strategic Interdependence". This theory was introduced for the first time in 1920 by "Emil Burrell" and "John Van Neumann" and with the publication of the book "Game Theory and economic behavior" was popularized and recognized by Oscar Moore Genstern and Newman in 1944, [16]. It should be noted that similar issues of this theory have been considered by philosophers for centuries. As an example, Aristotle studied the optimal solutions for effective management of slave owners' real estate, which aimed to reduce the tension between slave owners and slaves and increase productivity, [26]. The ancient Greek philosopher Sophocles examined the problem of the infinite chain of causality between beliefs and actions, [6] . Niccolò Machiavelli in

the book "The Mayor" provided the leaders of Florence with strategies to achieve political goals and maximize control over society's affairs. In Leviathan, Thomas Hobbes explored why people are willing to sacrifice their freedom to achieve a better position. Today, his arguments in this field are considered by many researchers as the basis of game theory, [19]. David Hume conducted studies on the chances of cooperation among neighbors when they are committed to a common goal and at the same time are doubtful about fulfilling their commitments to other partners, [14]. Adam Smith presented a strategic analysis in the form of the "invisible hand" discussion in relation to how the public good can be an unintended consequence of mindless greed. According to Smith's findings, if economic enterprises and individuals behave based on maximizing their profit and utility - based on the mechanism of supply and demand, which is called the invisible hand in economic texts - then ultimately the society's profit, which is from the total profit each person achieves, is maximized, [4]. This feature is not only in economic enterprises and financial markets, but also in the fields of social and comprehensive sciences. Based on people's rationality, freedom of choice and observance of division of labor, societies reach a stable equilibrium that achieves people's satisfaction along with maximizing social benefits, [30]. In this research, inspired by articles, [1, 2, 10, 15, 17, 19, 23, 25, 29] we will investigate game theory with a comprehensive cognitive approach and then study the famous patterns of game theory that are effective in analyzing people's daily behavior considering local and regional conditions. In this sense, various examples will be presented in this field. Finally, the interaction of passengers and drivers in the intra-city transportation system of Shirvan city is investigated as an example of holistic behavior that can be analyzed according to the game theory.

3. Summary of Proofs/Conclusions

This article is organized in four parts. In the second part, we examine the method of ideation in game theory. In this regard, three important steps in game theory including metaphorization, allegory and modeling are examined and the characteristics of each of these three steps will be presented. Accordingly, metaphorization in the field of game theory will be discussed first, and examples will be presented in this field. Then we will explain the role of allegory in game theory and we will study its two main characteristics, i.e. externality and inductiveness. Finally, we state the modeling method in game theory and study the difference between the application of analogical method in the modeling of popular and practical games of game theory with holistic theories in the field of meta-theoretical foundations and explanation of social phenomena. In the third part, first, we examine the difference between the concept of the principle of rationality as the basis of game theory and the concept of rationality in famous philosophical theories such as functional structural theory and confirmationist theory, and the efficiency of these theories is compared in comprehensive analysis. Then the explanatory, prescriptive and predictive power of game theory in the analysis of social

interactions is examined. After that, the concept of balance will be studied as a predictive dimension of game theory. In this regard, we examine the concept of balance along with statistical concepts such as Bayesian inference in the analysis of static and dynamic games, as well as games where players have different degrees of risk-taking in adopting their strategies. Finally, we will express the mechanism of adaptation and mutation as well as evolutionary processes in the analysis of games where the actors lack rationality in their behavior. In the fourth section, the central elements of each game in game theory, including the number of players, available strategies, utilities, and the way information is distributed among players, are examined. In this regard, we will describe methods that are able to calculate the value of each strategy for each of the actors, and we will also study the concept of screening in the transfer of information between actors. In the fifth section, firstly, the classification of games in comprehensive cognitive analysis is introduced, and then the famous games in this field are introduced along with practical examples. As a result, we first examine the important categories of game theory, such as zero-sum and non-zero-sum games, games with an equilibrium point and without an equilibrium point, games with a dominant strategy and without a dominant strategy. Then, the famous game theory games that are of interest to researchers in comprehensive cognitive analysis, such as the prisoner's dilemma game, the guarantee game, the dictator game, the ultimatum game, the chicken game, and the social two-way game, and their application in social sciences are analyzed with various examples. In the last part, using the basics of game theory and its patterns, we will analyze the comprehensive cognitive analysis of the interaction between passengers and taxi drivers in Shirvan city. Shirvan city with a population of 85,000 is the second most populous city in North Khorasan province, 55 kilometers east of Bojnord. According to the official statistics announced by the municipal transportation organization of this city in 1400, there are 352 intra-city taxis operating each of whom carries an average of 120 passengers daily. This is despite the fact that due to the directives of the National Corona Headquarters in recent years on the need to pay fares in taxis electronically and online, the use of cash is still common in this city and drivers have little acceptance of electronic and internet equipment to receive fares. Therefore, the lack of round taxi fares and the constant excuse of change causes citizens to pay illegal fares, which has also caused their complaints. In this regard, in this article, first, different strategies are studied in the interaction of two parties (driver-passenger). Then we analyze this situation by using the prisoner's dilemma game, the coward's game, the ultimatum game, and the social dilemma game, and introduce the optimal strategy from the perspective of the game theory in the interaction of the two parties, and finally, from a comprehensive cognitive perspective, we analyze this issue and the policies that have been implemented by The municipality of this city has been implemented.

REFERENCES

- [1] G. Abdoli, *Game theory and its applications*, Academic Jihad Publications, 2008. [In Persian]
- [2] M. Argayl, *Cooperation and collaboration*, Publications of the Ministry of Cooperatives, 2000. [In Persian]
- [3] R. Axelro, *The evolution of cooperation*, New York: Basic Books, 1984.
- [4] B. D. Bernheim, Rationalizable strategic behavior, *Econometrica*, **52** (1984) 1007–1028.
- [5] M. D. Davis, *Game theory: a nontechnical introduction*, Courier Corporation, 2012.
- [6] A. Dixit, Restoring fun to game theory, *The Journal of Economic Education*, **36** (2005) 205–219.
- [7] J. C. Harsanyi, *Advances in understanding rational behavior*, In Essays on ethics, social behavior, and scientific explanation, Springer, (1980) 89–117.
- [8] M. Hollis, *Reason in action: Essays in the philosophy of social science*, Cambridge University Press, 1996.
- [9] J. P. Henrich and N. Smith, *Culture matters in bargaining and cooperation: cross-cultural evidence from Peru, Chile and the US.*, University of Michigan, Business School, Research Support, 1999.
- [10] M. R. Javadi Yegane, The application of game theory in the analysis of everyday behavior; With a comprehensive cognitive analysis of gasoline waste, *Social Welfare Quarterly*, **15** (2004) 57–98. [In Persian]
- [11] P. Kollock, Social dilemmas: The anatomy of cooperation, *Annual review of sociology*, **24** (1998) 183–214.
- [12] G. Mil, *Utilitarianism*, Nashr Ney, 2009. [In Persian]
- [13] R. Jervis, Realism, game theory, and cooperation, *World politics*, **40** (1988) 317–349.
- [14] C. Jolls and C. R. Sunstein, The law of implicit bias, *Calif. L. Rev.*, **94** (2006) 969–986.
- [15] G. L. Munck, Game theory and comparative politics: New perspectives and old concerns, *World Politics.*, **53** (2001) 173–204.
- [16] M. J. Osborne, *An introduction to game theory*, New York, Oxford university press, 2004.
- [17] B. Pi, Y. Li and M. Feng, An evolutionary game with conformists and profiteers regarding the memory mechanism, *Phys. Stat. Mech. Its Appl.*, **597** (2022).
- [18] D. Salvatore, *Theory and issues of microeconomics*, Nashr ney, 2009. [In Persian]
- [19] Y. Shi and Z. Rong, Analysis of Q-learning like algorithms through evolutionary game dynamics, *IEEE Trans. Circuits Syst. II*, **69** (2022) 2463–2467.
- [20] D. Snidal, The game theory of international politics, *World Politics*, **38** (1985) 25–57.
- [21] G. H. Snyder and P. Diesing, *Conflict among nations: Bargaining, decision making, and system structure in international crises*, Princeton University Press, 2015.
- [22] L. A. Stout, *Other-regarding preferences and social norms*, 2001 pp. 34, Available at SSRN 265902.
- [23] S. Taherkhani, *An introduction to game theory*, *Foreign Policy Quarterly*, **1** (2011) 219–242. [In Persian]
- [24] J. Tang and S. Li, Study on the multi-governance of public rental housing exit in china based on the evolutionary game theory, *Complexity*, **2022** (2022).
- [25] P. Van Lange, M. Van Vugt and D. De Cremer, Choosing between personal comfort and the environment: Solutions to the transportation dilemma, *InCooperation in modern society*, (2012) 61–79.
- [26] Y. Varoufakis, S. Hargreaves-Heap, *Game theory: a critical introduction*, Routledge, 2004.
- [27] P. Weirich, *Equilibrium and rationality*, Cambridge Books, 1998.

- [28] F. Yuval, To compete or cooperate? Intermunicipal management of overtourism. *Journal of Travel Research*, **61** 2022 1327–1341.
- [29] W. Yu, Solution analysis of prisoner's dilemma based on referee game theory, *CMU Academy Journal of Management and Business Education*, **1** (2022) 10–15.
- [30] F. C. Zagare, *Game theory*, diplomatic history and security studies. Oxford University Press, Oxford, 2019.

Seyed Mehdi Kazemi Torbaghan

Department of Mathematics, Faculty of Basic Science, University of Bojnord, P.O.Box 9453155111, Bojnord, Iran.

Email: m.kazemi@ub.ac.ir

Amir Sahami

Department of Mathematics, Faculty of Basic Science, Ilam University, P.O.Box 69315-516 Ilam, Iran

Email: a.sahami@ilam.ac.ir

Shaghayegh Amandar

Department of Mathematics, Faculty of Basic Science, University of Bojnord, P.O.Box 9453155111, Bojnord, Iran.

Email: Amandar.shaghi79@gmail.com

Kimia Ebrahimi

Department of Mathematics, Faculty of Basic Science, University of Bojnord, P.O.Box 9453155111, Bojnord, Iran.

Email: kimiyaebi99@gmail.com