A Short Note on the Use of Game Theory in Analyses of International Relations

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Iran's nuclear research program generates global suspicion and concern. We read news about the possibility of an Israeli or a U.S. attack upon Iranian nuclear facilities. The general idea is that if Iran continues its research, and, say, an Israeli attack occurs, Iran can retaliate. Thus, any potential attacker has to foresee the consequences of its action against Iran. Iran then has to assess the magnitude of costs that deter a potential attacker. Yet, the attacker can guess that Iran has strong incentives to misrepresent its incentives in its will and ability to retaliate. Iran can in turn try to guess whether the attacker takes its stand about retaliation seriously.

We can qualify the above interaction as constituting a game, that is, a situation of strategic interdependence. Each decision maker acts in function of actions the other (or others) can take. The best choices of Iran and the attacker depend on their forecasts of each other's behavior. An Iranian decision shapes gains an attacker obtains and costs an attacker suffers and the attacker's decision in turn shapes Iranian decision to retaliate or not.

Game theory, also known as interactive decision theory, studies the behavior of decision makers in situations of strategic interdependence. Its founders are John Von Neumann and Oskar Morgenstern who published the book*The Theory of Games and Economic Behavior* in 1944. The relevance of the theory for international relations (IR) goes undisputed; it is a truism to assert that states interact by trying to predict other states' reactions to their decisions. Yet one has to apply the theory to IR, because the tool of game theory cannot produce by itself insight about IR.

Game-theory applications to IR take the form of models, that is, the simplification and stylization of states' interactions. The three levels of game theory are of help here. The levels are extensive, strategic, and coalitional forms. In an extensive-form model, the analyst thinks in terms of states presented as players, actions available to players, sequences of players' actions, players' information conditions and preferences, and, finally, outcomes of interactions. In a game at the strategic level, there are nothing but players, players' strategies and preferences over outcomes. The coalitional form is the most abstract level analysis: coalitions of players and the values of these coalitions. The majority of IR game models are pitched at the first two levels, as the last level of analysis assumes that cooperation between players is binding. Yet if a state cooperates, it must do so only because of self-interest; not because of a higher authority above states enforcing cooperative agreements. At least, there is no supreme authority over sovereign and co-existing states.

The major advantage of game models comes through disciplined stylizations of international interactions.[1] The discipline comes out of precisely defined concepts of players, strategies, actions, preferences, and deductions formally derived from basic assumptions and concepts. The term of strategy, for example, does not take different meanings along derivations of results. All game theorists around the world would agree upon the meaning of central game-theory concepts and would derive the same results, for example, conditions for equilibrium existence. For example, if there is a model of Iran-Israel nuclear conflict in extensive form, then the same solution can be found provided that it exists. As a result, game theory becomes a paradigm through the existence of commonly agreed upon concepts and assumptions.

Starting in the 1950s, political scientists found game theory quite useful in their analyses. The 1960s, for example, were prolific years in the field of coalitional bargaining, voting, and coalition formation. Economists discovered how powerful the tool of game theory is much later in 1980s especially through a program called Nash equilibrium refinement. Nevertheless, while game theory became a major staple in economic analyses, there has been no parallel move in the field of international relations. To illustrate, no student who ignores Nash equilibrium can pass a microeconomics course yet no such condition exists for an IR student, say in a course on IR theory. The source of the difference is the tolerance for and the use of mathematics in economics.

The IR discipline is divided into many islands of theoretical approaches ranging from realism to liberalism, constructivism, and critical IR works. A majority of IR students would think that game theory is of use only if one frames an international interaction in realist terms like power, motives for expansion, and maximization of self-interest. Well, this is completely wrong. Preferences of players, the driving force of game models, are assessed through players' ideas, wishes, and desires. To illustrate, game-theoretic models do not require that all states are cast as selfish egoists; on the contrary, states can be presented as altruistic players.[2] Moreover, repeated games contain rigorous reflections of variables such as inter-subjectivity, shared knowledge, practices, and norms which are of interest for constructivists. Indeed, as long as there is room for ideas and beliefs in theories of preference formation, dynamic game models can dwell into areas where social constructions are argued to play a major role.[3]

Naturally, no one has an obligation to learn game theory. Yet, those motivated students can try to master it and enjoy its power in generating explanations.[4] However, students must realize that game models are abstractions; they are not equivalent to real interactions. If they construct a game, they must be aware that the assumptions of the model lead to constrained and stylized explanations. There is, in fact, a trade-off: game theory cannot help students to understand and predict international phenomena if it has no connection with empirical facts, and, if too many observed details are included in the model, deductions become intractable.

In gist, the creativity of modelers is of utmost importance in using game theory. The construction of correspondence between abstract concepts and empirical observations is not an easy task. Once the work is finished, and results are obtained, one can compare game-theoretic explanations with explanations other research tools and approaches to IR generate. It is possible that readers find game-theoretic explanations not as enriching as those other theories yield. Nevertheless, the game theorist has an upper hand: she can be certain that the model implies the explanation provided that assumptions are justified and she correctly derives conditions for equilibrium, equilibria or even no equilibrium. In addition, she can also develop her analysis in a deductive and a rigorous manner so that her findings inform users of other approaches.

Take, for example, the problem of Iran's nuclear research activities constituting yet another source of friction between Iran and Israel, and, opt for the simplest possible model at strategic level: a 2 × 2 game. Assume Israel has two strategies: attack and do not attack. Assume also that Iran has two strategies: stop nuclear research and do not stop. Hence, we have two players and each player has two strategies. The outcome matrix becomes:

Israel

Attack

Do not attack

Iran

Stop

Outcome 1

Outcome 2

Continue

Outcome 3

Outcome 4

To obtain a game matrix we need to specify both countries' preferences over these outcomes.[5]

The most convenient way to model the interaction is to specify players' preferences along their primary and secondary objectives.[6] Assume that Iran's main objective is to become a nuclear power and Israel's main objective is the inverse. Supposing that an Israeli attack cannot destroy all Iranian facilities, Iran mostly prefers outcomes 3 and 4 as compared to outcomes 1 and 2. The decision "stop" prevents Iran to attain its most preferred objective. Thus, for Iran, we have {outcome 3, outcome 4} > {outcome 1, outcome 2}. Suppose also that Iran prefers outcome 4 to outcome 3 and outcome 2 to outcome 1 as it prefers no Israeli attack; its secondary objective. These assumptions generate the following preference ordering for Iran: outcome 4 > outcome 3 > outcome 2 > outcome 1.

Israel mostly prefers outcomes 1 and 2 as compared to outcomes 3 and 4, as Iran's stop decision leads to the realization of Israel's main objective: Iran does not become a nuclear power. Thus, for Israel, we have {outcome 1, outcome 2} > {outcome 3, outcome 4}. Suppose also that Israel prefers outcome 2 to outcome 1 and outcome 4 to outcome 3 as it prefers to avoid a military failure; its secondary objective. These assumptions generate the following preference ordering for Israel: outcome 2 > outcome 1 > outcome 4 > outcome 3. Now assume also ordinal-level preferences, with 4 indicating the best, 3 the next-best, 2 the next-worst, and 1 the worst outcome for players. The game matrix therefore becomes:

Israel

Attack

Do not attack

Iran

Stop

1, 3

2, 4

Continue

3, 1

4, 2

The first number in each cell denotes Iran's preference for that outcome and the second number denotes that of Israel.

We realize that Israel obtains better outcomes by choosing "do not attack" regardless Iran's choices. Israel obtains 4 instead of 3 against Iran's decision "stop", and, 2 instead of 1 against Iran's decision of "continue" by choosing "do not attack". Similarly, Iran obtains better outcomes by choosing "continue" regardless Israeli choices: Iran obtains 3 instead of 1 against Israeli decision "attack" and 4 instead of 2 against Israeli decision of "do not attack". Therefore, the equilibrium is “continue, do not attack”.[7] Thus, we explain the current status quo between Iran and Israel regarding Iranian nuclear research through a drastic simplification: there are only two players, each has two strategies, they simultaneously interact only once, their preferences are ordered according to primary and secondary objectives, and each player strives to obtain highest possible outcome given other’s choices.

It can be a challenging exercise for students to change players’ primary and secondary objectives yielding a new game. The model asks for additional justifications or amendments; it does not represent the only possible stylization. Nevertheless, it is possible that the equilibrium does not change as a result of new assumptions. This would inform the modeler about the impact of different assumptions upon explanations. Consequently, game theory, as a deductive method, generates the joy and the suspense (may I say the thrill?) of obtaining new explanations for international interactions by changing game rules and assumptions.

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Serdar Ş. Güner *obtained his PhD from Graduate Institute of International Studies, Geneva in 1990. His interests cover IR theories, evolutionary processes, and game- theoretic modeling. He is currently an associate professor of international relations at Bilkent University, Ankara, Turkey.*

[1] Robert Powell, *In the Shadow of Power: States and Strategies in International Politics* (Princeton, New Jersey: Princeton University Press, 1999), pp. 23-39.

[2] Martin J. Osborne, *An Introduction to Game Theory* (New York, Oxford: Oxford University Press, 2004), p. 27.

[3] Barry O’Neill, *Honor, Symbols, and War* (Ann Arbor, the University of Michigan Press, 2001), pp. 253-261.

[4] Students can consult journals such as *Journal of Conflict Resolution*, *International Studies Quarterly*, *International Organization*, to name a few, to see the richness of game models as applied to IR.

[5] Eric Rasmussen, *Games and Information: An Introduction to Game Theory* (Cambridge, Massachusetts: Basil Blacwell, 1989), pp. 43-45.

[6] See, for example, Steven Brams, *Superpower Games: Applying Game Theory to Superpower Conflict* (New Haven and London: Yale University Press), pp.119-123.

[7] This is called a dominant-strategy equilibrium in game theory.