ARTICLE

Game Theory as an Instrument for the Analysis of International Relations

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1. Introduction

International relations, as characterized, among other authors, by Evans and Newnham (1998, pp. 274n), Lake and Powell (1999, pp. 3n), Reynolds (1994, pp. 15n) and Wolfers (1991, pp. 31n) deals with the interactions among specific actors which include nation-states, international organizations, and multinational corporations.

From this it follows that game theory, whose objective is the formalized analysis of relationships among two or more actors, can assist international relations theoreticians in explaining the interactions among the actors it considers, and practitioners in the field to influence those interactions to benefit the actors they represent or, hopefully, all humankind.

In fact, as eloquently shown by Poundstone (1992), game theory and international relations have influenced each other almost since the publication of The Theory of Games and Economic Behavior by von Neumann and Morgenstern (1944), usually considered to be the first systematic and extensive formal analysis of social interactions. Bennett and Nicholson (1994, p. 209) indicate that this interaction has been both friendly and conflictive, and considered by some to be constructive and by others destructive.

The object of this paper is to demonstrate the possibilities and limitations of game theory as an instrument for the study of international relations. The approach to be used describes elementary game theoretic models as an integral part of international relations, rather than as a collection of examples of the mathematics of game theory. A similar approach, but at a higher level of sophistication and with a more limited coverage, is used by Powell (1999).

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As a basis for the analysis, a systematization of the main issues studied in international relations is presented in Section 2. In Section 3, each of these issues is analyzed from a game theoretic point of view. No attempt is made to review all or the most advanced relevant publications. Attention is focused on elementary games, which are used to illuminate the core elements of the interactions among nation-states and to illustrate the ways those interactions are likely to proceed.

Reference is made in the main text of this paper to some of the numerous literature reviews available of applications of game theory to the analysis of international relations. In general, these presentations have a more restricted focus than that of this paper, and they emphasize the point of view of game theory rather than that of international relations.

This paper is addressed to theoreticians and practitioners of international relations not particularly versed in game theory, rather than to those who are fluent in its mathematical language and intricacies. For this reason it is appropriate to mention O'Neil's (1994, pp. 9) paper, appropriately called "Sources of Game Theory for international relations Specialists". It reviews a substantial number of publications and classifies them by their level of mathematical sophistication. This paper can be complemented with the following more recent textbooks: Bierman and Fernandez (1998), Dixit and Skeath (1999), Gardner (1995), Gintis (2000), Morrow (1994), Straffin (1993) and Taylor (1995). All of these present the subject at an intermediate mathematical level at most, and include relevant applications to international relations issues.

Section 3 ends with the elementary formalization of the Israeli-Palestinian conflict presented in Section 3.5. Finally, Section 4 includes a critical evaluation of the possibilities and limitations of game theory as an instrument for the study of international relations issues.

2. Observations on the content and scope of international relations

As was mentioned above, the object of the study of international relations (as restricted for the purposes of this paper) is the analysis of interactions among nation-states. These interactions involve interdependent goal-directed activities. Interdependency means that the achievement of the goals of any nation-state does not depend only upon its own actions, but also upon those of the other nation-states.

Lake and Powell (1994, pp 3n) emphasize that the subject matter of international relations is simply the study of the interactions themselves, rather than of the issues that constitute their substance and their particular form. If this point of view is adopted, the subject matter of international relations and game theory practically coincide, and international relations runs the risk of becoming an applied branch of game theory just as

microeconomic theory has sometimes been said to be an applied branch of calculus. To avoid this, the special characteristics of international actors, their interactions, the issues negotiated in them, and the particular form of the interactions themselves must be emphasized.

Some international actors are mentioned in Section 1. Evans and Newnham (1998, pp. 4n) list several more. The presentation below is restricted to the analysis of interactions among nation-states.

Distinctive characteristics of the international relations approach to the analysis of interactions among nation-states include the attention given to their motivation and the power they use to influence each other. The rather limited contribution that game theory can make to this topic is discussed in Section 3.1.

Strange (1991, pp. 4n) emphasizes that security and economics are the two main issues considered in the theory and practice of international relations. Other important issues include education, environment, human rights and international law. Despite their relevance, the other issues mentioned above are not considered in this paper. Their game theoretic analyses are only possibilities for future research. Attention is restricted here to the interactions considered in most applications of game theory to international relations topics, that is, those originating in defense and economic issues. The analysis is presented in Sections 3.2 and 3.3.

A separate dimension of the study of international relations is based on the fact that the interactions that constitute them generally proceed along well-defined lines not usually encountered in interactions among individuals, private institutions and different levels of government within nation-states. Specifically, diplomacy is the regular channel for international relations, and does not have an equivalent counterpart in the interactions within nation-states. Some observations about game theoretic analysis of diplomacy are presented in Section 3.4.

3. Game theoretic analyses of international relations topics

3.1. Game theory and the motivation and power of the actors in international relations

According to, say, Evans and Newnham (1998, pp. 645n) and Hollis and Smith (1990, pp. 10n), one of the basic assumptions of the realist approach to international relations is that nation-states are motivated only by their own interests. This school of thought emphasizes that nation-states consider the needs and interests of other nation-states only when the other nation-states have the capability to enforce their demands by threatening or performing damaging actions. This means that nation-states are not guided by ethical or humanitarian considerations, and that international law and even treaties and similar

formalized agreements do not really restrict the international activities of nation-states.

It is particularly interesting to consider these observations from the point of view of Game Theory. A basic and much criticized assumption of this discipline when applied to social interactions is that the actors involved are completely self-centered and tirelessly pursuing only their own satisfaction. Game Theory finds in the nation-states as described above the closest real-life examples of its abstract constructs. This is the true regardless of whether they are interacting with respect to security or to economic issues.

The observations above indicating that nation-states take into consideration the needs and interests of other nation-states only when these other nation-states are able, i.e., have the power, to threaten or perform damaging actions, shows that the determinants of the power of the different nation-states must be one of the main concerns of the theory of international relations.

Contrary to this, and despite the substantial agreement between the theories of games and of international relations with respect to the motivations of their actors, game theory pays little or no attention to the determinants of the actions available to the players. It is simply assumed that these actions are known and that the players can choose any one of them, guided only by their preferences, and without any restriction. The determinants of the actions available to the players are not studied in Game Theory. More explicitly, the determinants of power, one of the most important factors influencing the actions available to nation-states in the theory of international relations, receives little or no attention in Game Theory. This means that, in its present condition, this discipline is unable to contribute to all the areas of interest to theoreticians and practitioners of international relations.

3.2. Game theory and security and defense studies

3.2.1. Introduction

Extending the observation in Section 1 about the cross-fertilization between Game Theory and international relations that began taking place after the publication of von Neumann's and Morgenstern's (1944) pioneering book, it can be said that this cross fertilization was centered on security and defense problems. Part of the reason is that the most applicable component of the von Neumann and Morgenstern contribution deals with head-on conflicts, a topic that was of great practical interest during the Cold War. These 2 circumstances have subsided since that time. External pressures and internal decomposition have replaced the USSR threat with the smaller threat of Russia, and the contributions of Nash, Harsanyi and Selten and the insights of Maynard-Smith have enlarged Game Theory far beyond the area covered by von Neumann and Morgenstern. Despite this, most available applications of Game Theory to international relations are still restricted to the analysis of the interactions among nation-states based on security and defense issues.

For the systematic analysis of these topics, it is useful to subdivide the formal studies of security and defense into the following classes:

1. Defense alliances,
2. Deterrence and arms races,
3. Crises that may lead to war,
4. War and peace, and
5. Battles in a war

Each of these issues is analyzed below.

3.2.2. Defense alliances

Gardner (1995, pp. 401, 404) presents 2 brief analyses of the formation of international alliances. The first is limited to a study of how defense costs should be distributed among 3 nation-states interested in defending themselves from a common external threat. The only basis for this distribution is the length of the boundaries of the nation-states in direct contact with the enemy's territories. It is implicitly assumed that the nation-states will benefit equally from the protection provided by the alliance, and the capabilities of the nation-states to contribute the resources needed for their collective defense are not considered. In the second analysis, the author studies the conditions that prevailed in Bosnia around 1993, and shows that no alliance of any 2 of the 3 warring factions (Serbs, Croats and Muslins) could have lead to a sustainable peace. The continuous need for foreign armies in the area confirm Gardner's theoretical conclusions.

Powell (1999, pp. 149-196) makes an extensive and systematic study of alliances by applying game theoretic techniques. He analyzes the interactions of 3 nation-states, 2 of them involved in a direct confrontation that could lead to war, and a third that must decide whether to take one side or the other. The conclusions reached provide suggestions on the paths that the nation-states should follow and the possible war/peace consequences that different decisions would have.

Numerous additional topics related to alliances among nation-states can be analyzed using tools of cooperative game theory. For instance, Brams, Doherty and Weider (1994, pp. 95n) and Taylor (1995, pp. 45n, 71n) present a method for constructing an index of the power of each member of an alliance to influence the alliance's affairs, and apply it to the European Union. It is also possible to adapt the analyses of international cartels such as OPEC to study the willingness of the members of an alliance to fulfill their obligations and the benefits that non-members of an alliance can receive without contributing to it. This last point is analyzed, for instance, by Nicholson (1989, pp. 116n). Also using cooperative game theory, Intriligator (1994, pp. 47n) presents a general discussion of the problems and possibilities of cooperation among nation-states, and applies it to an analysis of bilateral and multilateral relations among China, the European Community, Japan, the Soviet Union and the U.S. This author's conclusions differ from those that were an accepted point

of view at the time when he made his analysis.

3.2.3. Deterrence and arms races

Analyses of deterrence and arms races are probably among the most studied topics in international relations in general, and are also among those most frequently analyzed using game theoretic instruments. Gleditsch (1990, pp. 1n) presents an insightful literature review of the studies available, regardless of the instruments used, and Intriligator and Brito (1990, pp. 58n) summarize the formalized analyses, paying special attention to studies using game theoretic tools. Brief updates dealing with this second type of studies are presented by Bolks and Stoll (2000, pp 580n) and Reuveny and Maxwell (1998, pp. 771n). In addition, these last two studies research aspects of the problem not previously investigated.

In the simplest formulations available, the case of 2 nation-states in a direct confrontation is considered. As indicated by Brams and Kilgour (1988, p.18), these actors use a policy of deterrence when each of them threatens to retaliate for a possible offense of the other as a means to prevent such an offense from occurring in the first place. In principle, an offense could involve derogatory comments, damaging economic policies, armed attacks, etc. Most of the analyses of deterrence refer to threats of using force, and only these cases are considered below. Under these circumstances, arms races are simply the sequences of events that take place when the nation-states in a confrontation want to increase the believability of their threats. The objective of the two nation-states in a direct confrontation is to protect themselves against the possibility of destruction or domination by the other. Either of the nation-states involved is likely to feel more secure if it acquires weapons, even if this is done purely from defensive reasons. On the other hand, since weapons can be used as much for defense as for attack, the other nation-state can never be sure of the intentions of the first. For this reason, it feels obliged to produce or purchase weapons to prepare itself to defend its interests. The final result is that the 2 nation-states involved adopt an armamentist strategy that benefits them less than the strategy acquiring weapons.

Numerous authors, including Brams (1975, p. 33), Clemens (1998, p. 165), Dixit and Skeath (1999, pp. 108, 267), Hamburger (1979, p. 76), Powell (1999, p. 8) and Taylor (1995, p. 31), formalize the presentation above in the well-known Prisoners' Dilemma game. Once this is done, the analysis can be expanded in several ways.

It is generally accepted in game theory that in a confrontation that takes place only once, the Prisoners' Dilemma pessimist outcome mentioned above cannot be avoided. However, most confrontations between nation-states involve a sequence of events. In this case, it can be shown that even in the simplified formulation of the problem presented above in which each of the nation-states involved has only 2 strategies, there is a possibility that these actors may adopt a non- or less confrontational strategy. This topic is extensively discussed by Poundstone (1992) who indicates that the logic behind the

Prisoners' Dilemma model and the model itself had a substantial influence on the USA's decisions about the hydrogen bomb and intercontinental missiles.

A minor conceptual modification of the arms race model involves the assumption that the strategies available to the nation-states specify the size of their defense budgets. An elementary example of this is presented by Hamburger (1979, p. 105). When it is assumed that the size of defense budgets is the instrument that each contending nation-state can use to prevent an attack by the other, it is possible to include a characteristic of arms races not considered in the Prisoners' Dilemma model. Specifically, the contending nation-states do not simply maintain their military capabilities at a fixed level. Instead, they tend to increase them as much as they can in an effort to gain the upper hand in their contest. This escalation process can continue for as long as the resources of the nation-states involved permit, or until an enforceable agreement is reached among them to limit their arms buildup. Leininger (1990, pp. 388n) and O'Neill (1985, pp. 220n) indicate that this form of behavior also takes place in what is called a Dollar Auction game. In this game, 2 players bid for a prize of 1 dollar. The highest bidder receives the prize but both pay their bids. Each bidder increases his/her bids to avoid a complete loss of the payments that he/she has to make. It can be mathematically shown, and has been experimentally observed, that bids higher than the expected prize are possible, and that bidding can proceed up to the point where financial capabilities impose a limit.

Richardson's arms races model, presented, for instance, by Luenberger (1979, pp. 206n) and Olinick (1978, 20n), studies a more sophisticated and dynamic form of escalation with what are considered to be non-game-theoretic methods. The reason for this is that Richardson assumes that the nation-state actors do not rationally select their strategies but rather that they automatically respond to each other changes in defense expenditures. A different approach is used by Powell (1999, pp. 49n), who not only explicitly considers rational behavior, but also the choice of the nation-states between expenditures on consumption and growth on the one hand, and expenditures on defense on the other.

3.2.4. International crises

International crises, as described, for instance, by Evans and Newnham (1998, pp. 101n), can be characterized by the events that take place when one or more nation-states perceive that their security is suddenly, immediately and seriously threatened by actions proposed or performed by other nation-states or by events accidentally taking place in them. No attempt will be made here to analyze international crises due to uncontrollable events such as human or animal epidemics. These differ in a basic way from crises that are due to threatened or performed actions, since cooperation among the nation-states affected by uncontrollable events is much more likely than when nation-states feel the need to defend themselves from others.

From the observations above it follows that international crises can be considered, at a conceptual level, as sharpening of arms races. In both cases, each set of nation-states in a

confrontation feels the need to defend itself from actions of the other. However, in a crisis, in view of the suddenness, immediacy and magnitude of the threat, the threatened nation-states show their willingness to use mainly military sanctions to force the threatening nation-states to reverse actions already taken or desist in those planned. The observations above suggest that there should be a substantial similarity between the game theoretic analysis of arms races and of international crises. It is shown below that, to a certain extent, this is the case.

At the most elementary level, it can be assumed that each of the two nation-states involved in a confrontational crisis has two strategies: confrontation and cooperation. With the first strategy, the threatening nation-state attempts to force the other to accommodate to its wishes, and the threatened nation-state attempts to force the other to halt its demands. It should be clear that threatening words can escalate to actions and finally to war. This suggests that a Prisoners' Dilemma game and its extensions can be used for a simplified analysis of a crisis. However, it will be seen below that, at least in some cases, the game called Chicken is a better representation of the phenomenon.

The Cuban Missile Crisis is probably the most frequently used example of a game theoretic analysis of an international crisis. One reason for this is its rather clear definition of the actions that the nation-states involved were able to take, the possible outcomes of those actions, and the time period in which the whole crisis developed.

In the most elementary formulation, presented, for instance, by Brams (1975, pp. 41n and 1990, pp. 105n), Clemens (1998, p. 75) and Poundstone (1992, pp. 204n), it is assumed that the strategies open to the USA were to blockade Cuba to stop the installation of the Soviet missiles or to attack the existing and any possible future facilities built there. The strategies for the USSR were to withdraw the missiles already installed or to maintain them and continue with their installation. It is interesting to observed that this game has 2 outcomes rather than the 1 found for the simplest arms race model. In one of the them the USA is the victor, while the USSR wins in the other. This is the characteristic of a game of Chicken. Extensions take into consideration that the Cuban Missile Crisis developed in fairly clearly defined stages. It began with the USSR's decision to place missiles in Cuba, continued with the reactions of the USA and then the final responses of the USSR. This sequence of events is streamlined in simplified models proposed by Morrow (1994, p. 51) and Straffin (1993, pp. 39, 227). It is interesting to observe that, as recognized by Straffin, the conclusions derived from these models do not reflect the actual outcomes of the Cuban crisis. A possible reason for this is that these models do not take into consideration the gradual increase of the threats and counterthreats of the USA and the USSR, nor the limited information that each had about the intentions and resolve of the other. These aspects of a crisis are discussed, for instance, by Dixit and Nalebuff (1991, p. 205) under the name of brinkmanship, that is, the strategy of taking an opponent to the brink of disaster in order to compel him/her/it to pull back. A formal model of the Cuban Missile Crisis that includes brinkmanship is presented and analyzed by Dixit and Skeath

(1999, p. 345). The conclusions derived from this model are in better agreement with the historic facts than those obtained with the models previously described.

Zagare (1984, pp. 17n and 22n) presents additional examples of game theoretic analysis of international crises. First he studies the emergency generated by Egypt's decision to close the Strait of Tiran to Israeli shipping. The analysis focuses on the possible responses of Israel and the U.S., taking into consideration the possible reactions of the USSR. Next, Zagare summarizes the particularly interesting analysis of the crises that culminated in the outbreak of WWI.

3.2.5. War and peace

The analysis of war and peace is one of the main concerns of international relations studies. For instance, Evans and Newnham (1998, pp. 565n) indicate that "(T)he idea that violence and war are intrinsic parts of the international system is the distinctive hallmark of realism", that is, of one of the conceptual bases available for the study of international relations. Mitchell (1985, pp. 121n) indicates that the investigations available of its causes, initiation, process, and consequences in its economic, political, social and military aspects reflect the great complexity of the phenomenon. Possibly as a consequence of this, a generally accepted overall theory of war is unavailable.

O'Neil (1994, pp. 995n) summarizes numerous game-theoretic studies of many different aspects of war and peace. On this basis, game theory may even be said to assist in the development of a general theory of the phenomenon. However, taking into consideration the complexity of war, international relations studies will not be able to relinquish their leading role in the development of such a theory.

In the game theoretical analysis of war, attention has been concentrated only on its military aspects. Simplifying even this restricted area, it is assumed here that 2 nation-states are involved in a conflict. The objective of each of them is to attack the other while at the same time shielding itself from the other's attacks. On this basis, 2 types of game theoretical analyses have been developed.

The decision of whether to attack first or only respond when attacked is studied in the first type. Poundstone (1992, p. 141) indicates that this analysis was particularly relevant during the Cold War, in view of the progressive development of nuclear weapons and their delivery. Particularly at the time when the U.S. had the monopoly on these weapons and systems, a first strike against the USSR was considered, at least by several distinguished and influential personalities, to be the most recommendable policy. The validity of this recommendation became questionable once the USSR developed the capability to survive a first strike and respond with an equally damaging second strike. Taylor (1995, p. 166) formalizes the description above in a simplified model in which each of the two nation-states involved in a conflict have 2 strategies: first and second strike. The conclusions obtained with this model are an important example of the limitations of game theory as a

basis for policy decisions. The results of the model recommend a first or a second strike depending on the assumptions made with respect to the valuations of the results of the nation-states involved, and, in practice, these valuations are not known and cannot be known. From this it follows that the main use of game theoretical models is as a basis for systematic analysis, not as a generator of rules for actual behavior.

Taylor's presentation can by extended along the lines of the so-called duel of timing models described, for instance, by Binmore (1992, pp. 76, 129, 225) and Dresher (1981, p. 128). In these games, 2 duelists approach each other. The longer one of them waits to fire, the more likely it becomes that the other will fire first and hit him. On the other hand, the closer the duelists get, the more likely it becomes that the first to fire will hit and disable the other. Contrary to the assumption in the first/second strike game, the duelists are not able to reload, but the game can be extended to include this possibility.

Maoz (1985, pp. 76n) extends these analyses with a model that studies international relationships beginning at the pre-conflict stage, followed by the initiation of a war, its management, and ending with a study of the conflict termination.

In the second type of game theoretic analysis of war, it is assumed that, in its essence, all that each warrior has to do is to deploy its armies along a limited number of posts to defend, invasion routes to protect or use, or a similar limited number of strategic alternatives. This has to be done taking into consideration the deployments that the enemy is likely to make in the same locations. The most elementary formulations of this problem are called Colonel Blotto games. They are described, for instance, by Davis (1970, pp. 31, 49) and Gintis (2000, pp. 22, 72, 396, 429). In these games it is usually assumed that what one of the nation-states gains, the other loses, and vice-versa. For this reason they form part of what are called zero-sum games.

A substantially more sophisticated analysis of a war is presented by Varoufakis (1991, p. 82) who studies the Peloponesian war between Athens and Sparta.

3.2.6. Battles within a war

The analysis of battles is easier than that of war because these events are much better defined in time and space. As evidence of this facility, the first applications of game theory to international relations included the analysis of battles.

The Battle of the Bismark Sea that took place during War World II and involved Japanese and American naval and air forces is a frequently used example. It is discussed, for instance, by Brams (1975, pp. 9n), Davis (1970, pp. 13n), Dixit and Skeath (1999, pp. 181n) and Zagare (1984, pp. 16n). Extensions of this model are presented by Dixit and Nalebuff (1991, pp. 70, 195) and Dresher (1981, p. 145). An interesting aspect of these analyses is that they are basically reformulations of Colonel Blotto games.

Another example is the analysis presented by Brams (1975, pp. 13n) and Zagare (1984, pp. 38n) of the battle of Avranches that took place during the Allied invasion of Normandy during World War II. This model is particularly interesting because it includes strategic decisions such as troop movements that are not considered in the war or battle models mentioned previously.

3.3. Game theory and the economic relations among nation-states

3.3.1. Introduction

As indicated by Strange (1991, pp. 4n), the economic relations among nation-states are part of the subject matter of international relations. As mentioned by Reynolds (1994, pp. 73n), the ability of nation-states to defend themselves and survive depends to a large extent on their economic capabilities. Even a superficial observation shows that a substantial part of the relations among nation-states has an economic focus. Despite this, theoreticians of the field, in particular, do not appear to have shown much interest in the study of international economic relations. This area has been left mainly to economists.

McMillan (1986, p. 2) presents a rather long list of topics that form part of what can be called international economics. In the presentation below, only 3 topics from among the numerous possible alternatives will be considered: agreements for economic cooperation, trade, and financial interactions, which will be covered in Sections 3.3.2, 3.3.3 and 3.3.4, respectively. It will be seen that at least some of the game theoretic instruments used for the analysis of security and defense issues can be applied to the study of the different aspects of international economics.

3.3.2. Agreements for economic cooperation

Agreements for economic cooperation among nation-states can take many concrete forms and can pursue more substantial and far-reaching economic and political objectives than those pursued by security alliances. Cartels among nation-states such as OPEC have the most limited goals, and can be characterized by the fact that the main objective of the member nation-states is to present a common front to the rest of the world, without modifying the interactions among themselves. On the other hand, there are several economic-political agreements whose main objective is to increase the interdependence of the nation-states involved in them. This type of accord, ordered by increasing comprehensiveness, includes most favored nation agreements, trade blocks, free trade associations, custom unions, common markets, and integrations or unifications. In principle, each of these agreements contains and expands the previous one. In a unification, separate nation-states decide to become one.

The observations above may lead to the conclusion that the game theoretic analyses of economic agreements should proceed along lines similar to those followed in the study of security alliances. This is not the case. As indicated in Section 3.2.2, the investigations of security alliances deal with the problems of their formation and the distribution of costs

and power within them. These issues, at least in principle, can be studied in agreements for international economic cooperation, but this has not happened so far. On the other hand, it will be seen below that models similar to those used to analyze arms races in particular have been applied to the study of trade and financial interactions among nation-states.

3.3.3. International trade

Economists' studies of international trade preceded by many years the development of game theory. Despite this, as indicated by Jepma, Jager and Kamphuis (1996, p. 62), even mercantilism, which can be considered to be the first formal theory of international trade, analyzes the relationships among trading nation-states with clearly game theoretic approaches. A simplified formal model of this point of view in which only 2 nation-states are considered leads to the conclusion that what one of them gains, the other loses. From this it follows that the zero-sum games used to study battles and war could be applied to the analysis of the mercantilist theory of international trade. This has not been done, in part due to the fact that this theory is not considered valid at the present time.

It is currently accepted that unrestricted trade benefits all the nation-states involved, since each of them can specialize in the production of the goods in which it has a comparative advantage over the others. This leads to the conclusion that free trade should be the rule in international economic relations; however, this is not the case.

Morrow (1994, p. 263) presents a clear game theoretic explanation of this fact. If one of two trading partners imposes a tariff, it will increase its benefits above the free trade level. This reduces the benefits of the other trading partner, who, as a consequence, attempts to correct the imbalance by also imposing a tariff. It should be clear that this struggle is the trade counterpart of the arms races described in Section 3.2.3, and as such can also be analyzed using the Prisoners' Dilemma game.

This simplified model can be and has been substantially extended. Examples are presented by Bierman and Fernandez (1998, p. 60) and McMillan (1986, p. 23). Further variations and extensions of the models mentioned above are possible. For instance, Luterbacker and Theler (1994, pp 191n) analyze the economic implications of North-South migrations.

The one-shot increment in tariff considered above can lead to what can be called a tariff or trade war, with successive increments in the magnitude of custom duties. This topic can be studied with the Dollar Auction games used to analyze escalation in arms races. Extensive and deeper analysis of this aspect of the topic are presented by Conybeare (1987) and Grossman and Helpman (1995, pp. 675n).

3.3.4. International financial interactions

The game theoretic models analyzing trade and tariffs clearly do not deal with all

aspects of the economic relations among nation-states. In particular, it is clear that the restriction of imports by means of tariffs is not the only way a nation-state can attempt to improve its balance of trade with other nation-states. This can also be achieved with modifications of the value of a nation-state's currency in relation to an international currency such as the dollar; that is, with modifications of its exchange rate. Devaluation of a nation-state's currency, that is, an increase in its exchange rate, lowers the price of its exports and, as a consequence, improves the competitiveness of its goods and services in the international markets.

These observations can be used as the basis for an analysis of the economic relations between 2 nation-states. One shot devaluations can be studied with Prisoners' Dilemma games, and the devaluation wars that they sometimes originate, with Dollar Auction games. This possibility is interesting due to the real-life importance of this phenomenon. A devaluation by one nation-state can initiate a devaluation war, in which nation-states alternate in devaluating their currencies. In the end this could damage not only their trade relations, but also their internal economies. Jepma, Jager and Kamhuis (1996, pp. 108n) describe the international efforts made to avoid these confrontations. These efforts have culminated in the formation of the International Monetary Fund (IMF) and the use of its Special Drawing Funds to make it possible for nation-states with temporary financial problems to obtain hard currency loans. On the other hand, the role of the IMF as an unregulated international economic authority is resented and resisted by the population and governments of many nation-states.

A different type of elementary game theoretic model is used by Hamada (1996, pp. 34n and 115n) to introduce his analyses of the impact of different types of monetary reserves (gold, dollar and SDR) and of fixed or flexible exchange rates on the income and prices of the interacting nation-states and on trade and capital transfers between them.

The limited models outlined above do not exhaust the possibilities of game theoretic analysis of relations between nation-states in which real and monetary influences are considered. Hamada (1996, pp. 3n), among other authors, presents several studies in which basic macroeconomic models of the real aspects of closed economies are extended to analyze the relations among 2 or more nation-states and the effect of the policies that directly affect their balances of payments, as well as those that are oriented mainly toward regulating their internal conditions. These models consider, on the one hand, the effects of monetary reserves, regulations to facilitate or hinder capital flows and the profits obtained with them, and on the other, of modifications of the internal rates of interest, the supply of money, employment promotion policies, etc.

3.4. Game Theory and diplomacy

By giving an extended meaning to the word "diplomacy", the study of international relations can be said to cover the same ground as the study of diplomacy. On the other

hand, it is more helpful to distinguish between the substance of the interactions among nation-states, that is, defense and security, economic or cultural and social issues, than with the form of these interactions, that is, with their diplomatic aspects. This second characterization of diplomacy is used below.

Reynolds (1994, p. 135), among other authors, indicates that a negotiation between 2 dissenting nation-states, to be called A and B, consists by a sequence initiated by a proposal presented by A to resolve their disagreement. Nation-state B now has 3 alternatives: a) Settle the disagreement under the terms included in the proposal, b) present a counter proposal, or c) break off the negotiations. If a counter-proposal is presented by B, A is in a situation equivalent to that of B, where A now has to choose between settling, counter-proposing or breaking off. These alternative steps can be repeated for as long as the 2 nation-states are willing to present counter-proposals and to consider them, that is, until one of them decides to settle or to break off negotiations. The bases for the decisions each nation-state has to make at its turn to move are the present values of the payoffs that it expects to receive in the future.

Once the elements of a negotiation described above, that is, the sequence of steps to be taken, available options at each step and payoffs' present values, are available, a well defined game is specified. This type of game is extensively studied in game theory. Some of its analysis preceeded by several decades Von Neumann's and Morgenstern's (1944) famous book. The initial results have been extended to consider the possibility that the game can be played without having a well defined expectation about when it will end, a condition that can be exemplified with the negotiations to end the Korean War, and when the payoffs of the players for settling their disagreement or for breaking off the negotiation are not known with certainty.

Dixit and Skeath (1999, pp. 298n) present an application of some of the game theoretic instruments mentioned above to the study of U.S.-Japan trade negotiations. This analysis is particularly interesting in that it is especially attentive to the promises and threats that the actors can make to each other, and the impact that these pledges can have on the interacting nation-states.

A more extended and sophisticated analysis of these topics is presented by Dupont (1994, pp. 156n), who uses a game theoretic model to study the negotiations between Switzerland and the League of Nations and those between the European Community and the European Free Trade Association. Hovi (1998) presents a book length discussion of these topics.

An obstacle for the application of the model outlined here to actual negotiation processes is raised as a consequence of what can be called a structural defect of game theory: it provides, at best, very limited guidance for the specification of the payoffs that the negotiating nation-states should receive when they select each of the strategies they

have available. It is simply assumed that certain or uncertain information about payoffs is available. However, as mentioned by Reynolds (1994, pp. 130n) important determinants of a nation-state's payoffs are the promises and threats that its counterpart can make and the military, economic and cultural and social instruments that the promising or threatening nation-state can use to implement its pledges. It should be clear that this limitation restricts the applicability of game theory to international negotiations.

Brams, Doherty and Weider (1994, pp. 95n) present an extension of the model outlined above in which the controversial issues being negotiated and the preferences of the nation-states negotiating them are considered in some detail. Specifically, these authors analyze the GATT negotiations initiated in Uruguay in 1986. They pay special attention to the roles of the European Community, Japan and the U.S.A., considered to be the major players, and conclude that their model accurately describes the negotiation sequence in which the actors moved from their most preferred to less favored positions until they reached an impasse and broke up the process.

3.5. An elementary example

The object of this Section is to present a simplified application of game theory to a current problem. This provides an opportunity to describe the main steps needed to construct a game theoretical model of real events, and also to elaborate on some of the contributions that game theory can make to the study of international relations and to call attention to the risks that the construction and use of these models may have.

The initial step in the construction of any game theoretic model is the identification of the actors involved in the interaction to be analyzed. To a large extent this step also determines the frame of reference of the analysis.

A simplified model of the Israeli-Palestinian conflict will be constructed below. It will be assumed that these are the only relevant actors in the process. This clearly is a significant simplification. For an analysis in which attention is also given to the influence of internal conditions in Israel and the Palestinian Territories, it may be more useful to identify Sharon and Arafat as the relevant actors. This would make it possible to consider that in the two "nation-states", different population groups are the real actors in the conflict. An additional aspect not taken into consideration in the framework being outlined is that all the other nation-states in the Arab World are much more than simply spectators at the interactions between Israelis and Palestinians. Finally, and at least in part in view of the economic significance of the Arab World, China, the European Union, Japan, Russia and the U.S. could be considered actors more or less directly involved in the conflict. These observations show some of the benefits and limitations of the game theoretic approach: it requires a simplified and well-defined point of departure. The simplification helps to call attention to the main aspects of the interaction being studied; unfortunately, at the cost of excluding other relevant aspects.

Next, the actions or strategies that the actors may use must be specified. Again simplifying the problem as much as possible, it can be said that each of the 2 actors has only 2 strategies: cooperation and confrontation. It should be clear that each of these strategies represents with a single point what really is a continuum between unfavorable and favorable alternatives.

Finally, the payoffs that the actors would receive when they enact their strategies must be specified. For this presentation, it is sufficient to indicate the rankings that the actors will give to the different outcomes of their interaction. It is assumed that the most preferred outcome of both Israelis and Palestinians is to adopt a confrontational stance while the other actor cooperates. The basis for this assumption is that the confrontational actor expects to obtain all it wants, while the cooperative actor makes all the concessions. In addition, there is no real armed conflict. Next it is assumed that both actors are willing to cooperate, that is, to make some concessions as a basis for a lasting peace. This is followed in the order of preferences by both actors behaving in a non-cooperative fashion, which would generate violence between the 2 "nation-states". Finally, the least desired outcome for each actor is to cooperate while the other has a confrontational attitude. With the information presented above it is possible to specify the matrix of the game in Table 1.

Table 1: Simplified game theoretic representation of the Israeli-Palestinian conflict

		Column Palestinian Strategies	
		Cooperation	Confrontation
Row Israeli Strategies	Cooperation	(3,3)	(1,4)
	Confrontation	(4,1)	(2,2)

The numbers in parenthesis in Table 1 represent the actors' rankings of the outcomes that would be realized with the different strategies. The first number in each parenthesis is the Israeli ranking, and the second, the Palestinian ranking. For instance, the pair (1,4) on the right side of the first row indicates that the least preferred alternative, ranked 1 by the Israelis, is to cooperate when the Palestinians adopt a confrontational attitude. However, the Palestinians consider this their most preferred condition and give it a ranking of 4. On the other hand, the combination Israeli cooperation and Palestinian confrontation is ranked (4,1) as shown on the left side of the second row of Table 1.

The analysis of the rankings shows that, in agreement with their preferences, the actors will select a confrontational attitude. Specifically, regardless of whether the Palestinians cooperate or confront, the Israelis prefer confrontation as shown by the larger values in the first entries of the pairs in the second row of Table 1. Similar conditions prevail for the Palestinians, whose rankings in the second entries of the pairs in the second column of Table 1 are larger than the corresponding entries in the first column of the Table.

These observations show that the relations between Israelis and Palestinians are likely to be confrontational despite that this gives them the outcome that they value at (2,2). This happen despite that both actors would be better off if both chose to cooperate with each other and have an outcome that they value at (3,3).

Further analysis of the problem shows two important consequences of the model considered. On the one hand, it can be demonstrated that if the game is repeated over time, conditions in which the 2 actors cooperate can be created with their own behavior. However, these conditions will always be somewhat fragile. On the other hand, it can also be shown that an outside arbiter could specify a reasonable balance of concessions by the 2 conflicting actors and achieve in this way a more stable cooperation between them.

Mishal, Schmeidler and Sened (1990, pp. 336n) have a substantially more elaborate form of this model. They take into consideration that neither Israel nor the Palestinians have reliable information about the strategies available to each other, or their preferences over the uncertain outcomes that can be achieved.

The unfortunate events in the last few years show that the conclusions arrived at with the models summarized here are to a large extent a reasonable reflection of what is actually taking place.

4. Conclusions

Section 1 indicates that one of the objectives of this paper is to show that elementary game theoretic models can be used a) to concentrate attention on the core elements of interactions among nation-states and b) to specify the ways these interactions are likely to proceed. In Section 3 the substantive issues in the interactions among nation-states were identified and characterized, and the game theoretic approaches to analyze them, or at least some representative examples, were discussed. Only the readers of this paper can decide whether the presentation above has achieved the objectives pursued.

In this Section an analysis is made of the common elements of the different topics presented in order to call attention to the contribution that game theory can make as a useful instrument for theoreticians and practitioners of international relations, and also to the limitations of this contribution.

Game theoreticians, like any mathematicians, are like young children striving to construct lattices or trellises with sticks. They identify the sticks that are needed, their shape and strength, how to put them together and how solid is the finished structure. They are very little or not at all concerned about any possible practical use of the frameworks they have created.

At a basic level, the sticks used by game theoreticians are the number of players, their strategies, and the payoffs that each player will receive with each combination of strategies used. The final trellis takes the form of mathematical theorems indicating the strategies that players interested only in themselves should adopt, or that there is no combination of strategies that would generate outcomes that are simultaneously considered acceptable by all the players. As already observed, these trellises by themselves, excluding the satisfaction and Nobel prizes that they bring to their constructors, do not have any practical use. Game theory identifies the components of any interaction that must receive attention, shows how they should be organized and analyzed, and the final form that the interactions analyzed may take. To use this in practice it is necessary to identify real-life counterparts of the players, strategies and payoffs. Pure game theoreticians, regardless of their brilliance, cannot do this. This means that in the case of international relations, theoreticians and practitioners of this field must specify with their knowledge of actual interactions among nation-states or other international actors the sticks use by game theoreticians. This knowledge is acquired by studying the history and current unfolding of the interactions to be studied with game theoretic methods. Once the sticks needed are specified, it is possible to structure them in agreement with the game theoretic requirements. Having done this, the theorems of game theory bring forth expected and unexpected characteristics of the interactions analyzed and provide bases for forecasting their future. This can be done without knowing the actual mathematical proof of the theorems.

An alternative metaphor of the relationship explained above could be that game theory provides a trellis that could help the plant of international relations to grow. However, the ground where the trellis and the plant stand, the seeds and the care needed by the plant must be provided by the theoreticians and practitioners of the field. Game theoreticians cannot do it. On the other hand, a better plant is obtained with an appropriate trellis, and some plants, without a trellis, would not grow at all.

References

Bennett, Peter and Nicholson, Michael (1994) "Formal methods of analysis in IR", in Groom, A. J. R. and Light, Margot (eds.), Contemporary International Relations: A Guide to Theory, Pinter Publishers: New York, NY

Bierman H. Scott and Fernandez, Luis (1998) "Game Theory with Economic Applications", (2nd. ed.), Addison Wesley: Reading, MA

Binmore, Ken (1992) "Fun and Games: A Text on Game Theory", D. C. Heath and Co: Lexington, MA

Brams, Steven J. (1975) "Game Theory and Politics", The Free Press: New York, NY

Brams, Steven J. (1990) "Negotiation Games: Applying Game Theory to Bargaining and Arbitration", Routledge, Chapman and Hall, Inc.: New York, NY

Brams, Steven J.; Doherty, Ann E. and Weidner, Matthew L. (1994) "Game Theory: Focusing on the Players, Decisions and Agreements", in Zarman, William I., International Multilateral Negotiation: Approaches to the Management of Complexity, Jossey-Bass Publishers: San Francisco, CA

Brams, Steven J. and Kilgour D. Marc (1988) "Game Theory and National Security", Basil Blackwell Inc.: New York, NY

Clemens, Walter C. (1998) "Dynamics of International Relations: Conflict and Mutual Gain in an Age of Global Interdependence", Rowman & Littlefield Publishers: Lanham, MD

Conybeare, John, A. C. (1987) "Trade Wars: The theory and practice of international commercial rivalry", Columbia University Press: New York, NY

Davis, Morton D. (1970) "Game Theory: A Nontechnical Introduction", Basic Books Inc.:New York, NY

Dixit, Avinash and Nalebuff, Barry (1991) "Thinking Strategically: The Competitive Edge in Business, Politics and Everyday Life", W. W. Norton & Co.: New York, NY

Dixit, Avinash and Skeath, Susan (1999) "Games of Strategy", W. W. Norton & Co.: New York, NY

Dresher, Melvin (1981) "The Mathematics of Games of Strategy: Theory and Applications", Dover Publications Inc.: New York, NY

Dupont, Cedric (1994) "Domestic politics and international negotiations: a sequential bargaining model", in Allan, Pierre and Schmidt, Christian, Game Theory and International Relations, Edward Elgar Publishing Limited: Brookfield, VT

Evans, Graham and Newnham, Jeffrey (1998) "Dictionary of International Relations", Penguin Putnam Inc.: New York, NY

Gardner, Roy (1995) "Games for Economics and Business", John Wiley & Sons, Inc.:New York, NY

Gintis, Herbert (2000) "Game Theory Evolving: A Problem Centered Introduction to Modeling Strategic Interaction", Princeton University Press: Princeton, NJ

Gleditsch, Nils P. (1990) "Research on Arms Races", in Gleditsch, Nils P. and Njolstad, Olav (eds.), Arms Races: Technological and Political Dynamics, Sage Publications: Newbury Part, CA

Grossman, Gene M. and Helpman, Elhanam (1995) "Trade wars and trade talks", Journal of Political Economy 103: 675-707

Hamada, Koichi (1996) "Strategic Approaches to the International Economy", Edward Elgar Publishing Co.: Brookfield VT

Hamburger, Henry (1979) "Games as Models of Social Phenomena", W. H. Freeman and Co.: New York, NY

Hollis, Martin and Smith, Steve (1990) "Explaining and Understanding International Relations", Oxford University Press: New York, NY

Hovi, Jon (1998) "Games, Threats and Treaties: Understanding Commitments in International

Relations", Pinter: Herndon, VA

Intriligator, Michael D. (1994) "From conflict to cooperation in the study of international security", in Intriligator, Michael D. and Luterbacher Urs (eds.), Cooperative Models in International Relations Research, Kluver Academic Publishers: Boston, MA

Intriligator, Michael D. and Brito, Dogobert L. (1990) "Arms Race Modeling: A Reconsideration", in Gleditsch, Nils P. and Njolstad, Olav (eds.), Arms Races: Technological and Political Dynamics, Sage Publications: Newbury Part, CA

Jepma, Catrinus J.; Jager, Henk and Kamhuis, Elise (1996) "Introduction to International Economics", Longman Publishing: New York, NY

Lake, David H. and Powell, Robert (1999) "International Relations: A Strategic-Choice Approach", in Lake, David H. and Powell, Robert (eds.), Strategic Choice and International Relations, Princeton University Press: Princeton, NJ

Leininger, Wolfgang (1990) "Escalation and Cooperation in International Conflicts: The Dollar-Auction Revisited", in Ichiishi, Tatsure; Neyman, Abrahaam and Tauman, Yair (eds.), Game Theory and Applications, Academic Press, Inc: San Diego, CA

Luenberger, David G.: (1979) "Introduction to Dynamic Systems: Theory, Models & Applications", John Wiley & Sons: New York, NY

Luterbacher, Urs and Theler, Jean-Paul (1994) "Some game theoretical consideration on negotiations about migrations", in Allan, Pierre and Schmidt, Christian (eds.), Game Theory and International Relations: Preferences, Information and Empirical Evidence, Edward Elgar Publishing Co.: Brookfield, VT

Maoz, Zeev (1985) "Decision-Theoretic and Game-Theoretic Models of International Conflict", in Luterbacher, Urs and Ward, Michael D. (eds.), Dynamic Models of International Conflict, Lynne Rienner Publishers: Boulder, CO

McMillan, John (1986) "Game Theory in International Economics", Harwood Academic Publishers: Chur, Switzerland

Mishal, Shaul; Schmeidler, David and Sened, Itai (1990) "Israel and the PLO: a Game with Differential Information", in Ichiishi, Tatsure; Neyman, Abrahaam and Tauman, Yair (eds.), Game Theory and Applications, Academic Press, Inc: San Diego, CA

Mitchell, Chris R. (1985) "Conflict, War and Conflict Management", in Light, Margot and Groom A.J.R. (1985) International Relations: A Handbook of Current Theory, Frances Pinter Publishers: London, UK

Morrow, James D. (1994) "Game Theory for Political Scientists", Princeton University Press: Princeton, NJ

Nicholson, Michael (1989) "Formal Theories in International Relations", Cambridge University Press: New York, NY

Olinick, Michael (1978) "An Introduction to Mathematical Modeling in the Social and Life Sciences", Addison-Wesley: Reading, MA

O'Neil, Barry (1985) "The Dollar Auction as a Model of International Escalation", in Luterbacher, Urs and Ward, Michael D. (eds.) Dynamic Models of International Conflict, Lynne Rienner Publishers: Boulder, CO

O'Neil, Barry (1994) "Game Theory Models of Peace and War", in Handbook of Game Theory, Vol 2, Aumann, Robert and Hart, Sergiu, Springer-Verlag: New York, NY

O'Neil, Barry (1994) "Sources in Game Theory for International Relations Specialists, in Intriligator."Michael D. and Luterbacher, Urs, Cooperative Models in International Relations Research, Kluver Academic Publishers: Boston, MA

Poundstone, William (1993) "Prisoners' Dilemma", Anchor Books: New York, NY

Powell, Robert (1999) "In the Shadow of Power", Princeton University Press: Princeton, NJ

Reuveny, Rafael and Maxwell, John (1998) "The Journal of Conflict Resolution", 42: 771-803

Reynolds, Philip A. (1994) "An Introduction to International Relations" (3rd. ed.), Longman Publishing: New York, NY

Straffin, Philip D. (1993) "Game Theory and Strategy", New Mathematical Library N. 36, The Mathematical Association of America: Washington, DC

Strange, Susan (1991) "What About International Relations?" in Olson William C. (ed.) The Theory and Practice of International Relations, Prentice-Hall Inc.: Englewood Cliffs, NJ

Taylor, Alan D. (1995) "Mathematics and Politics: Strategy, Voting, Power and Proof", Springer-Verlag: New York, NY Von Neumann, John and Morgenstern, Oskar (1994) "Theory of Games and Economic Behavior", John Wiley & Sons, Inc.:New York, NY

Varoufakis, Yanis (1991) "Rational Conflict", Blackwell Publishers: Cambridge, MA

Wolfers, Arnold (1991) "Actors in International Politics", in Olson, William C. (ed.) The Theory and Practice of International Relations (8th ed.), Prentice Hall Inc., Englewood, NJ

Zagare, Frank, C. (1984) "Game Theory: Concepts and Applications", Sage Publications: Newbury Park, CA

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ABSTRACT

The object of this paper is to demonstrate the possibilities and limitations of game theory as an instrument for the study of international relations. The approach to be used describes elementary game theoretic models as an integral part of international relations, rather than as examples of the mathematics of game theory. The paper is addressed to theoreticians and practitioners of international relations not particularly versed in game theory, rather than to those who are fluent in its mathematical language and intricacies. The presentation concludes with some general observations on the uses and limitations of game theory as an instrument for the study of international relations.