IMPLICATION OF GAME THEORY TO INTERNATIONAL TRADE

Assoc. Prof. Ph.D. Dobre I. Claudia,
„Ovidius" University of Constanta
Faculty of Economical Science
Constanta, Romania

Abstract: Game Theory is a general mathematical analysis to investigate the strategic interactions among players. Game theorists attempt to provide precise descriptions of situations of conflicting interests in order to study the behavior that such a conflict would (or, in some cases, should) elicit from rational agents. Players are assumed to consider the position and perceptions of other players while forming their strategies. In our examples, we will assume that there are two players, and that each has two choices and the fact that the players are selfish (operate in their own best interests) and rational (choose the best options available). First, I outline some basic concepts of game theory and, in the next section, I give some examples regarding the application of game theory to international trade (cartel, free trade & protection and trade policies).

Key words: Game Theory, cartel, trade policies

Introduction

Game theory is as old as social theory. It found application in the study of human behavior among the so-called contract theorists Thomas Hobbes (1588-1679), John Locke (1632-1704) and Jean-Jacques Rousseau (1712-1778) as they discussed the rationale behind individuals drawing up a "social contract." And it has seen use among a variety of writers attempting to analyze successful gambling strategies.

More formally, we can think of game theory as the systematic study of the relationship between rules, choice and outcome in competitive situations. Two main branches exist. *Analytical* game theory is the analysis of games played by non-empirical players; that is "ideal" players who may be endowed with any characteristics, which can be modeled. These players need not accurately correspond to real-world people and such work is only open to critique to the extent that the math involved is wrong. They are experiments in logic, not models of the real world. On the other hand, *behavioral* game theory is the study of actual human players as they are confronted with precisely defined games. In this branch, researchers study how people make choices and navigate social conflicts.

The birth of game theory in its modern form is commonly said to be the publication of Johan Von Neumann and Oskar Morgenstern's *Theory of Games and Economic Behavior* in 1944. The ideas put forth in this volume relied on complex mathematics with the ambitious goal of providing a solid scientific foundation for the discipline of economics. This work was expanded upon in the years to follow, reaching political science in the late 1960s and evolutionary biology in the early 1970s.

1. Concepts in Game Theory

Technically, a *strategy* here is a plan for dealing with all possible actions of other players. As opposed to less sophisticated conceptions of human behavior, game theory is decidedly social. In human conflict situations there is rarely one context-independent best strategy. What works well depends on the actions of others. And since these actions depend on perceptions, game theory takes into account that agents expect each other to have certain interests, and to do their best to attain them.

In order not to confuse issues, there is an important distinction to be made between payoff (measured in points, dollars or the like) and the personal joy gained through a game. The game theoretical concepts described in the following make sense in relation to game-internal payoff only.

Four characteristics of games are of particular interest: 1) The number of players, 2) the sum type, 3)whether the game is repeated and 4) the existence and type of equilibrium.

Number of Players- Game theory works with either ***two-person games*** or games with more than two players, termed ***n-player games***. An important difference between the two types, apart from the complexity of the mathematics involved, is the fact that coalitions may form between players of n-person games affecting the game dynamics. Since we are concerned with opposing interests, a player in this perspective needs not be a single person but can be a nation, a football team or a pair of Bridge partners.

The most famous among the key two-person games is "The Prisoner's Dilemma"-- "the game that launched a thousand studies". The game, explained below, is often considered a fundamental model for the study of conflict and its simplicity and potential scope has earned it a place in textbooks within a truly wide range of fields. Briefly, the Prisoner's Dilemma is a situation in which two people are faced with a temptation to act in their personal interest disregarding the interest of the other person. However, if they both choose this (individually rational) course of action they will both be worse off than if they had cooperated.

In Prisoner's Dilemma two people A and B, who are suspected of committing a crime together, are being questioned separately. They can choose to confess (strategy *C*) or deny (strategy *D*). The payoffs are as follows:

- If they both confess, they will each receive a moderate sentence.
- If they stand firm and both deny, there is insufficient evidence for a full conviction, so they will each receive a light sentence.

If one denies while the other confesses, the one who denies will receive a heavy sentence and the other will be set free for providing evidence against the other. The dilemma is whether an individual prisoner should confess or deny. As before, if we consider Prisoner A: if B chooses strategy *C*, then A has a higher payoff with strategy *C*. If B chooses strategy *D*, then A has a higher payoff with strategy *C*. Thus, strategy *C* is a dominant strategy for A, and, by symmetry, also a dominant strategy for B. This leads to a dominant strategy equilibrium at (*C, C*). Again, we find that the players choose an inferior strategy because they are not co-operating and do not trust each other.

Sum Type - A key to understanding game dynamics is considering the payoff sum. The crucial question is whether the sum is ***fixed*** or ***variable***. In the first case one player's loss is another's gain. A stand-alone game of chess where the loser pays the winner 10 dollars would qualify. In such a case there is no reason for negotiation since

there is no sense in cooperating: Both players' self-interest dictates that they try to reduce the opponent's payoff. Such games are termed ***zero-sum***, as the total sum of the players' gains and losses equals zero. Let's imagine, however, that our chess-players enter a tournament with the additional special rule that each opponent pawn killed earns the killing player 1 dollar, paid by the tournament sponsor. In this case the sum is not fixed; the game is ***non-zero sum*** (or variable sum), as the total sum of gains and losses experienced by the players is not necessarily zero. This calls for rather different strategies among the players and would inspire cooperation to a certain degree - for instance, by agreeing to perform a mutual sacrifice of all pawns before battling it out with the remaining pieces. The Prisoner's Dilemma is a non-zero sum game as the size of the combined pay-off depends on aggregate player choices.

Single-shot Games versus Repeated Games - The strategic dynamics may be quite different between games which are only played once (single-shot games) and games that are repeated. In single-shot games, players seek short-term gains while players of repeated games will be able to make short-term sacrifices in favor of perceived long-term opportunities. For instance, a single-shot Prisoner's Dilemma ends in mutual defection but a repeated version may not. The players in the repeated version operate under what Robert Axelrod (1984) has called "the shadow of the future": their actions in any given round will have consequences in later rounds. Thus, one very (if not universally) successful strategy is Tit-for-Tat, the prescription that one should start by cooperating and then do whatever the other player did in the previous round (Axelrod, 1984). By punishing defectors while not angering vengeful opponents, such as other versions of itself, Tit-for-Tat can manage to generate the trust necessary for collectively successful play (the cooperate-cooperate instance shown above). Often, the implication of interacting repeatedly with the same people will be that reputation becomes highly important.

Equilibrium - In a standard one-round version of the Prisoner's Dilemma, rational players will not cooperate. Thus, they get a payoff that could have been larger (if they had trusted each other) but are stuck in a situation where neither player by changing his strategy can do any better. The Prisoner's Dilemma, then, has an **equilibrium** (although a so-called deficient one since overall the players could do better); the game calls for particular strategies and players will not deviate from their set course. An equilibrium, then, may be thought of as a game state to which the game is likely to gravitate and once reached the players will generally not change their strategies. A game may have any number of equilibrium including none and these may be either of the pure strategy type where players play one particular strategy or of the mixed strategy type where players randomly pick a strategy each round. An example of the latter is rock-paper-scissors where rational players need to play one of the three available strategies with the probability of 1/3.

2. Implication for International Economics

2.1. Games with Dominant Strategy Equilibrium

The *cartel* is an example. There are two firms in the market, and they can choose to operate independently (strategy *I*) or form a cartel (strategy *C*). The payoffs are as follows:

- If they form a cartel, they agree to limit production, hence increasing price, so they both gain 8.

- If they both operate independently, they both gain 4.
- If they agree to form a cartel, thus increasing the price, but one firm betrays the other by producing more than agreed, then that firm gains a lot while the other loses a lot.

How should the two firms operate to maximize their gains? Consider Firm 1: if Firm 2 chooses strategy *C*, then Firm 1 has a higher payoff with strategy *I*, if Firm 2 chooses strategy *I*, then Firm 1 has a higher payoff with strategy *I*.

Thus, strategy *I* is a dominant strategy for Firm 1, because it gives the higher payoff regardless of the other player's strategy. The same reasoning applies for Firm 2: if Firm 1 chooses strategy *C*, then Firm 2 has a higher payoff with strategy *I*, if Firm 1 chooses strategy *I*, then Firm 2 has a higher payoff with strategy *I*.

So strategy *I* is a dominant strategy for Firm 2 as well. This leads to a dominant strategy equilibrium at (4, 4). If a certain strategy pays a player the highest payoff, regardless of the other player's strategies, then that strategy is known as a dominant strategy. If both players have dominant strategies, the point which they both choose is known as the dominant strategy equilibrium. We see from our example that the (C, C) strategy is Pareto Superior to (I, I). However, unless the players co-operate in choosing their strategies, they will choose the inferior (I, I). The dominant strategy equilibrium does not always provide the best result. If the players choose (C, C), either player can gain by moving to I unilaterally.

In other words, if they agree to form a cartel, either player can gain by reneging on the agreement. This is why cartels are considered unstable and easy to collapse. Both players try to maximize their own profit by defecting. However, as a result, both of them experience reduction of profit. Therefore, it is known as a "tragedy of commons".

How do firms keep a cartel strong? Invoke severe punishments for firms that renege on the agreement. If the game is played repeatedly, a player that reneges is not likely to be trusted, so will not be able to form a cartel with others again.

2.2. Free Trade and Protection

Consider the game between the United States and Japan, each of who can choose free trade (strategy *F*) or protection (strategy *P*). The payoffs are as follows:

- If they both choose free trade, both countries gain by trade.
- If they both choose protection, there is no gain for either country.
- If only one country chooses protection, they will gain by protecting their domestic market while still trading in the other country's market.

As before, to consider strategies, consider the United States: if Japan chooses strategy *F*, then U.S. has a higher payoff with strategy *P*. If Japan chooses strategy *P*, then U.S. has a higher payoff with strategy *P*. Thus, strategy *P* is a dominant strategy for the U.S., and, by symmetry, also a dominant strategy for Japan. This leads to a dominant strategy equilibrium at (*P, P*). The tragedy here is that, in the absence of any other information, both countries will choose the inferior but still dominant (*P, P*) when they could both gain by moving to (*F, F*).

How can they reach (*F, F*)? Integration (co-operation) is one way and Negotiation (with penalties for reneging) is another way.

2.3. Trade Policies

Strategic trade policies aim to promote exports or discourage imports in particular sectors, to increase a nation's welfare. While some policy makers advocate

the policy, many economists have raised questions on the justification and validity of the policy. Among many strategic trade policies, this section analyses "industrial subsidy" using game theory.

An example is *Airbus and Boeing*. In this example, Boeing (American) and Airbus (European) are competing in a world market. They can choose to produce (*P*) or not (*N)*.

- If they both produce, competition will drive down the price and they will both lose.
- If neither produces, neither gains.
- If one produces and the other doesn't, the producing company takes all the market share and the other company gets nothing.

This is similar to the previous example. Again, we find two Nash equilibrium (*P, N*) and (N, P). If we assume that Boeing is already in the market (in other words, has chosen strategy *P* already) and Airbus is considering entering it, how is the game played out? By the same process of backward induction as before, we find that Boeing chooses strategy *P* and Airbus chooses strategy *N.* In other words, it is not in Airbus's interests to enter the market.

Government Subsidy is another example. Suppose that the European government regards the aircraft industry as very important. To encourage Airbus to enter the market, the European government might subsidize production by, say, 25. This changes some payoffs, and changes the game's structure:

- If Boeing chooses strategy *P*, Airbus will choose strategy *P*.
- If Boeing chooses strategy *N*, Airbus will still choose strategy *P*.

Now Airbus has a dominant strategy *P*. Then, theoretically, Boeing calculates its payoff again and finds that strategy *N* is its best strategy. Although this looks attractive for Airbus, there are other factors to consider: if Airbus is subsidized by the European government, the U.S. government can retaliate by subsidizing Boeing. Then Boeing will keep producing (strategy *P*), which will incur losses to both producers. Both producers are then subsidized by their governments, and all the burden from the subsidy is borne by taxpayers. If Boeing is stable in the U.S. domestic market, it might be able to absorb the competition from Airbus. In other words, its strategy *P* payoff might be greater than anticipated by Airbus. If Boeing's payoff from strategy *P* is positive, it will keep producing. To finance the subsidy, the European government must use consumers' money. How can we justify the transfer of money from consumers to subsidize Airbus?

Another example is the *monopolist and new entrant in the world market*. In this example, there is a monopolist in the market facing a potential new entrant. The monopolist can choose to fight (*F*) or acquiesce (*A*). The new entrant can choose to enter (*E*) or not (*N*).

The payoffs are as follows:

- If the new entrant doesn't enter the market, the monopolist will retain its position.
- If the new entrant enters and the monopolist fights, they will both lose market share.
- If the new entrant enters and the monopolist acquiesces, they both gain, but the monopolist's share is reduced.

We find that there is no dominant strategy for either player, but there are two Nash equilibrium (*F, N*) and (*A, E*). In this game, it is the new entrant who makes the

first move - to enter or not. If it chooses strategy *E,* the monopolist has two choices strategies *F* and *A*, and will choose A for a payoff of 2. On the other hand, if the new entrant chooses strategy *N*, the monopolist again has two choices, both of which have the same payoff. Now, if the new entrant compares its payoffs for each of the monopolist's choices, it finds that its best payoff is 2, by entering the market and the monopolist acquiescing. If the government of the potential entrant considers the sector is important, the government can provide an incentive by subsidizing the entrant and guaranteeing positive profits when it enters the market.

Conclusion

Can government intervention raise national welfare by shifting oligopoly rents from foreign to domestic firms? In principle, government policies such as export subsidies can serve the strategic purpose of altering the subsequent incentives of firms, acting as a deterrent to foreign competitors. This seems to offer possible rationales for trade policies. The topic became especially 'hot' as the countries experienced so called competitiveness problems.

REFERENCES

1. Avinash K. Dixit & Gene M. Grossman – „Targeted Export Promotion with Several Oligopolistic Industries", NBER Working Papers 1344, National Bureau of Economic Research, 1987
2. Axelrod, Robert – „The Evolution of Co-Operation", London: Penguin Books, 1984
3. Camerer, Colin F., – „Behavioral Game Theory: Experiments in Strategic Interaction", Princeton: Princeton University Press, 2003
4. Jonathan Eaton & Gene M. Grossman – „Optimal Trade and Industrial Policy Under Oligopoly", NBER Working Papers 1236, National Bureau of Economic Research, 1986
5. Juul, Jesper – „The Repeatedly Lost Art of Studying Games" - Review of Elliott M. Avedon & Brian Sutton-Smith (Ed.): The Study of Games, Game Studies 1, 2003
6. Neumann, John von, and Oskar Morgenstern – „Theory of Games and Economic Behaviou", Princeton: Princeton University Press, 1944
7. Smith, Jonas Heide – „Playing Dirty - Understanding Conflicts in Multiplayer Games", 5th annual conference of The Association of Internet Researchers, The University of Sussex, 2004