Short Exercise #4
Solving International Relations Games: A Primer on Game Theory

PS 3210 — International Relations

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Introduction

An important theory-building tool in international relations is the *strategic game*. Strategic games use game theory to explain different types of outcomes in global politics. For example, *deterrence* depends both on a defender's ability to deliver a believable threat and a potential attacker's decision to back down or to attack. Successful deterrence only occurs when the defender makes a believable threat and the attacker backs down. If the defender does not make a believable threat or the attacker does not back down, then deterrence might fail.

Defining a Strategic Game

More generally, a strategic game explains outcomes based on the *interdependence* of actors' decisions. Every strategic game is defined by

- the **Actors** involved;
- the set of **Actions** those actors might take; and
- each actor's **Preferences** over possible sets of actions.

Preferences in a strategic game may be represented through the payoffs that a player expects to receive from a course of action. Outcomes are then predicated on actors' available choices and their preferences.

Return to the deterrence example described above. In this example, there are two actors, the Defender and the Attacker. The Defender may either issue a threat or remain silent. The Attacker, alternatively, may either back down or attack. From these actions, there are four possible outcomes:

- *Deterrence Success*: The Defender threatens and the Attacker backs down.
- *Deterrence Failure*: The Attacker proceeds with its attack despite the Defender's threat.
- *Peace* (Status Quo): Neither actor carries out a militarized tactic.
- *Capitulation*: The Defender silently concedes to the Attacker's demands.

Using these possible outcomes, we can begin to define each actor's preferences. Suppose that the Attacker and the Defender have relatively equal capabilities, and that the Attacker is dissatisfied

with the status quo. In contrast, the Defender most prefers peace, which preserves the status quo. If it cannot do that, the Defender would prefer to deter the Attacker. If the Defender simply capitulates, it gives up its entire territory, whereas, if it assumes even an unsuccessful military posture, it still stands a chance of winning against the Attacker. In sum, the Defender's preference ordering can be described as follows:

- Peace >Deterrence Success >Deterrence Failure >Capitulation

Unsurprisingly, the Attacker has different preferences. The Attacker would most prefer the Defender simply capitulate so that it does not have to waste any resources fighting. However, because the Attacker is dissatisfied with the status quo, the Attacker prefers deterrence failure to peace. If the Attacker backs down based on the Defender's threat, the Attacker is humiliated; so the Attacker's least preferred outcome is deterrence success. In contrast to the Defender's preference ordering, then, the Attacker's preferences may be summarized:

- Capitulation >Deterrence Failure >Peace >Deterrence Success

Solving Strategic Games

The power of game theory is that, based on this information, we can explain what will happen! The game is solved by deducing each actor's *best response*. A best response is the action that results in an actor's highest payoff, given an opponent's decisions. An outcome that arises from each actor playing according to its best response strategy is the *equilibrium* — a stable outcome from which neither side has an incentive to change its mind or choose an alternative action.[1] In other words, the equilibrium indicates how the actors are likely to behave.

Setting up a Game

How can we solve the equilibrium of this deterrence game? One useful way of solving strategic games is by using a 2 x 2 table. This allows us to see how each combination of actions produces different outcomes. For example, our deterrence game may be represented as a 2 x 2 strategic game in the following way:

[1] More specifically, this equilibrium concept is called a *Nash equilibrium*.

		Attacker	
		Back Down	Attack
Defender	Threaten	3, -2	-2, 3
	Silent	5, 0	-5, 5

The Defender's actions are listed in the rows and the Attacker's actions are listed in the columns. Within each cell of the table, the actors' preferences are represented through ordinal payoffs, with the Defender's payoffs listed first. For instance, in the event of a deterrence success, the Defender receives 3 units and the Attacker loses 2 units. What these units represent is not really important. What matters is that they correspond with the actors' preference ordering over outcomes. In this case, they do: For example, the Defender prefers Peace >Deterrence Success >Deterrence Failure >Capitulation, and the payoffs match (5 >3 >-2 >-5).

Solving the Game

In order to see which actions represent best responses for the Defender and the Attacker we follow a few, simple steps:

1. *First*, determine the Defender's best response to the Attacker's choices.
    - If the Attacker chooses to Back Down, the Defender prefers to remain Silent rather than to Threaten (5 >3).
        - Therefore, the Defender's *best response* to the Attacker backing down is to remain Silent.
    - If the Attacker chooses to Attack, the Defender prefers to Threaten rather than to remain Silent (-2 >-5).
2. *Next*, we follow the same procedure for the Attacker. Focusing on the Defender's choices, what is the Attacker's best responses?
    - If the Defender chooses to Threaten, the Attacker prefers to Attack (3 >-2).
    - If the Defender remains Silent, the Attacker again prefers to Attack (5 >0).
3. *Last*, we observe whether there is an outcome that corresponds with a best response for both actors. If there is such an outcome, this is the *equilibrium*.

- In this case, there is an outcome that is produced by both actors making decisions according to their best responses: *Deterrence Failure* because regardless of the Defender's choices, the Attacker attacks and, when that heppens, the Defender matches the attack with a threat.

From solving this game, we can say that this crisis will inevitably end in war because the Defender will be unable to deter the Attacker.

Explaining Cooperation & Conflict Through Strategic Games

Indeed, this deterrence game —- where conflict is the inevitable result — is one in a class of strategic games called *Deadlock* games. If we replace the words "Silent" and "Back Down" with "Cooperate," and the words "Threaten" and "Attack" with "Defect," we find one explanation for why peaceful cooperation is sometimes difficult to achieve in international relations. Sometimes, when states rationally pursue their interests, their actions will not produce peace because there is no individual or mutual benefit to cooperation.

This is not to say that acting in one's strategic self interest is *selfish* or that it *inevitably* leads to conflict. The key thing to remember about interests and preferences in the context of game theory is that the game does not tell us *why* actors have those preferences, only that preferences exist and that they may be ranked. Game theory tells us which outcomes are likely to occur, given that actors attempt to take actions that correspond with their preferences. In contrast to *Deadlock* games, there is another class of games, *Harmony* games, that demonstrate how cooperation can result when it is in both actors' self interest. For example:

		Actor 2	
		Cooperate	Defect
Actor 1	Cooperate	3, 3	2, 1
	Defect	1, 2	0, 0

In this case, Cooperation is a mutual best response because there are individual and mutual benefits to cooperation.

Deadlock and Harmony games, arguably, describe a great deal of cooperation and conflict in international relations (Oye 1985; Wagner 1983), however, they are not theoretically interesting. In the cases of Harmony, the mutual gains observed from cooperation are merely the result of each actor pursuing its self-interest, regardless of its counterpart's choices. In other words, there is no

cooperation in a real sense. In contrast, Deadlock games are not consistent with other rationalist explanations for conflict — notably, the assumption that because fighting is costly, states would be better off finding peaceful settlements that fall within their bargaining range.[2] To model this type of puzzle — where actors are better off by cooperating but, nonetheless, fight — game theorists have developed other strategic games: the Prisoner's Dilemma, Chicken, and the Stag Hunt. Other games that also explain conflicts of interest include the Battle of the Sexes and the Matching Pennies games.

The following exercise will cover each of these games (Prisoner's Dilemma, Chicken, Stag Hunt, Matching Pennies, and Battle of the Sexes) in the context of international relations phenomena in order to illustrate the explantory power of game theory for global politics.

[2] See Fearon (1995).

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Solving International Relations Games

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Directions: This exercise covers five strategic games in the context of international relations. Each exercise describes a game scenario. You are asked to find each game's equilibrium solution. In some cases, there may be only one equilibrium. In other cases, there may be multiple equilibria or no equilibria. Last, you should interpret the equilibrium result to explain what will happen in the scenario.

Exercises

1. **Prisoner's Dilemma**

   Two suspects in a major crime are brought in by the police for questioning. Each suspect is held in a separate room for questioning. There is enough evidence to convict each suspect with a minor offense, but there is not enough to convict them of the major crime — unless they are willing to testify against their partner in crime. The suspects are given the choice: remain silent or testify. If both remain silent, they are both convicted of the minor crime and spend 2 years in prison. If one of the suspects testifies while the other remains silent, the prosecutor is willing to cut a deal to let the testifying suspect go free and convict the silent suspect of the major crime, which carries a sentence of 4 years. If both suspects testify, then each suspect receives 3 years in prison.

   Assume that the suspects would prefer to spend as little time in prison as possible.

   (a) Solve for the equilibrium.

		Suspect 2	
		Stay Silent	Testify
Suspect 1	Stay Silent	3, 3	0, 4
	Testify	4, 0	2, 2

(b) Interpret the solution: Will the suspects remain quiet?

2. **Treaty Compliance**

Two countries, Ferelden and Orlais, have recently reached a peace agreement to resolve their long-standing territorial dispute. The agreement divides the disputed territory evenly between the two rivals. Once the agreement is signed, the leaders will return to their capitols and determine whether they will follow-through with its terms. If both countries countries comply with the agreement, the terms will hold. However, if either country reneges, the defiant country captures the entire territory, but Nevarra, the country that mediated the settlement, will impose sanctions equal to roughly one-quarter of the country's value for the territory. The compliant country in this case loses its share of the territory and receives nothing. If both countries renege, then they both lose control of their share of territory and the both receive sanctions for non-compliance.

(a) Solve for the equilibrium.

		Orlais	
		Comply	Defy
Ferelden	Comply	2, 2	0, 3
	Defy	3, 0	-1, -1

(b) Interpret the solution: Will the parties comply with the settlement?

3. **Eradicating a Global Epidemic**

The World Health Organization has been alerted to a highly contagious disease, like zombieism (Drezner 2011), which is threatening to become a global epidemic. Coalitions representing developed major powers and developing countries are negotiating between two options to address impending health crisis. One option is to invest in the WHO, which will dispatch a coordinated response. This option will eradicate the disease, but requires cooperation from both coalitions. The second option is for all countries to pursue their own local responses. This will treat and prevent the spread of disease within each country, but it will not cure it.

If the coalitions cannot agree on an option, the group that responds locally will be able to treat the disease, but not prevent future exposure. This is because the group that, instead, invests in the WHO will not receive any treatment (too few resources committed to the response), which allows the disease to thrive and spread.

(a) Solve for the equilibrium.

		Developing Countries WHO	Local
Major Powers	WHO	10, 10	-5, 1
	Local	1, -5	3, 3

(b) Interpret the conclusion: Will the disease be eradicated?

4. **Civil War Targeting**

A government, embroiled in civil war, is planning an attack on the challenging insurgent group.

The insurgents are known to hide in two locations: a heavily populated urban city and the mountains near the country's border. The core of the insurgency is only in one location at a time, so the government can quell the rebellion by targeting the correct location. If the government targets the wrong location, the insurgents gain a victory over the state and the government loses more domestic support.

For the government, targeting the mountains is less costly than targeting the city because an attack in the city results in civilian casualties. For the insurgents, hiding inside the city is easier than retreating to the remote mountains.

The insurgents only know that the government will target one of their locations and that they have enough time to settle into either. The government does not know, in advance of their attack, at which location the insurgents will be.

(a) Solve for the equilibrium.

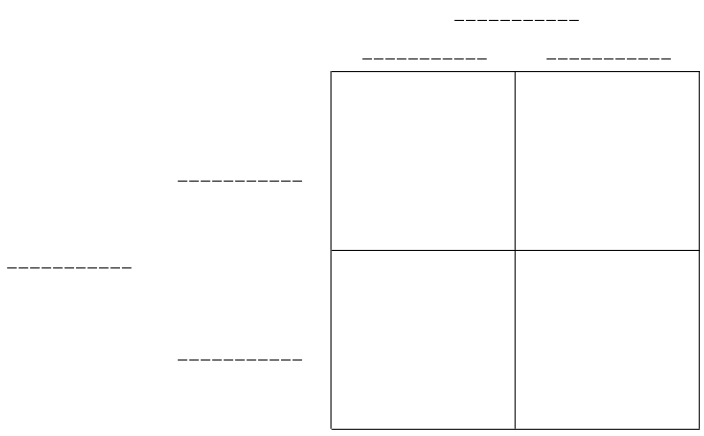
		Insurgents City	*Insurgents* Mountains
Government	City	5, -3	-10, 2
	Mountains	-3, 5	10, -5

(b) Interpret the conclusion: Will the government end the insurgency?

5. **Bonus Question (+5 points)**

Two friends are planning to see a movie at an odd theater. The theater is odd because only two movies are showing, both documentaries: *Murderball* and *The King of Kong: A Fistful of Quarters*. One of the friends prefers the action of *Murderball* while the other friend prefers the comedy of *The King of Kong*. The friends would prefer to agree and go to the same movie, but they cannot communicate to the other which movie they will show up at. If they go to different movies, they are equally unhappy viewing either documentary.

(a) In the following table, complete the strategic game.



(b) Solve for the equilibrium and interpret the conclusion. Will the friends find each other at the same movie?

(c) Describe an international relations scenario that fits with this theory. You should specify the actors and their actions. Also, explain how the actors' preferences over those actions would be consistent with the preference orderings necessary to produce the equilibrium.

Hint: Is there another game that you have already studied that this is similar to? How is this game the same? How is it different? Based on that, what kinds of international relations events might be like this?

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