

- I. Introduction to game theory
- II. Repeated games
- III. Sequential games
  - A. Look ahead and reason back
  - B. Strategic moves
  - C. Credibility

## I. Introduction to game theory

Simple economic models of oligopoly are not very useful to management students because they fail to give robust conclusions on basic pricing and output decisions. Game theory was designed to examine the behavior of two or more parties facing a limited set of options. It can deal with a wide range of issues, including foreign policy, bargaining, sports, and relationships – not just oligopoly. Here are some key issues we want to understand:

- When does your decision depend on the choices made by your rival?
- How can two parties reach decisions that are in their best mutual interests?
- How do “rules of the game” influence outcomes?
- Most importantly: how can firms make decisions today to limit their opponent’s (or their own) future options, and thus get higher returns?

### A. Dominant strategies

Best illustrated by an example. Time and Newsweek compete on subscriptions and newsstand sales. The former is a steady source of income, so it is very critical for success to come up with a cover story each week that will generate the most sales on newsstands.

Next week the two biggest stories are likely to be Sam Alito and the new *Harry Potter* movie. Flash polling numbers indicate that 70% of likely buyers are more interested in Harry Potter and 30% are more interested in Alito. If both magazines run the same cover, they split the market 50-50. If they run different covers, there is complete sorting – moviegoers all buy one mag and Supreme Court followers buy the other. (Attribution: this and many other examples are adapted from an excellent book on game theory at an introductory level: *Thinking Strategically* by Avinash Dixit and Barry Nalebuff.)

In this situation, Time’s optimal strategy is to go with Potter. It gets higher market penetration when it runs that story than with the Alito story, no matter what Newsweek does. If Newsweek goes with Potter, Time gets more sales by going with Alexander (35) than with Alito (30). If Newsweek goes with Alito, Time gets more sales by going with Potter (70) than Alito (15). As it turns out, Newsweek also will go with the Potter story because it always does the best with that story, no matter what Time does. These are both examples of *dominant strategies*: strategies that are best for one player no matter what his opponent does.

A dominant strategy is a special case of a Nash equilibrium. In a dominant strategy, one party is doing the best no matter what the other parties are doing (vs. what they are doing right now).

Not every game has a dominant strategy as a solution. Let's change the game slightly, so that whenever the two magazines have the same cover, Time gets a 60% market share. In this situation, Time still has a dominant strategy – the Potter story. But Newsweek does better with Alito than with Potter if Time goes with the Potter. What does Newsweek do? If they have looked through the game from Time's perspective, they know that Time will go with the dominant strategy of the Potter story and will thus counter-punch with Alito. (But then again they might run something on the economy!)

The opposite of dominant strategy is a *dominated strategy*, i.e., a choice that always leads to outcomes which are inferior to those associated with at least one other choice. In a game with only two options on each side, there always is a dominated strategy whenever there is a dominant strategy. In a game with three or more options, it is possible to have a dominated strategy without having a dominant strategy.

The next slide gives an example where both parties have a dominated strategy even though neither have a dominant strategy. How does the concept of a dominated strategy become useful? It allows you to rule out options and lets you focus on the more attractive choices. In this case (borrowed from another textbook) Honda and Toyota are facing a choice of what size plant to build (payoffs are in millions of dollars per year). There is no clear strategy choice looking across all three options: build a large plant, build a small plant, or don't build any plants. But the choice of building a large plant is clearly dominated by the other two and this is true for both Honda and Toyota. Once this choice gets scrapped, it becomes clear that each side now has a dominant option – build a small plant. Often when you rule out the dominated strategies, the Nash equilibrium becomes clearer!

## B. Prisoner's dilemma

Let's start with a business example, and then show what the general problem is. Suppose United and American both service the New York-Boston route. If they both charge \$100 each way, they each get monthly profits of \$81 thousand. If they both charge \$200 each way, they get monthly profits of \$112 thousand. If United (American) charges \$100 and American (United) charges \$200, then United's (American's) profits are \$123 thousand and American's (United's) profits are \$58 thousand.

There is a dominant strategy in this game for each airline. American always is better off charging the lower fare, no matter what United does. Ditto for United. So the Nash equilibrium is (\$100 for American, \$100 for United).

Bottom line: unless American and United collude (which could be problematic given our antitrust laws), they will always end up charging the lower price and getting lower profits

This game is one example of a more general situation that has come to be known as the *prisoner's dilemma*. Here is the way the tale is usually told: the KGB arrests Popov and Chekhov and charges them with being American spies. Each is put in a separate cell and told that if he confesses and rats on the other one, he will get a light sentence and the other one has a long stay in a Siberian work camp coming. But the KGB has no

evidence at all and since in the new Russia the KGB is trying to develop a new image, the sentence would be relatively light if neither confesses. The payoff matrix illustrates the choices.

Again, each has a dominant strategy: Popov will confess and rat on Chekhov and Chekhov will confess and rat on Popov. The parallel to oligopoly is as follows: firms have to decide whether to actively compete on price and markets or whether to cooperate by engaging in fairly passive, noneffective forms of competition. Both are better off if they agree to cooperate, but as in the cartel situation, each has an incentive to compete.

Going back to the airline pricing example, what options do United and American have? Here are two tricks of the game theory trade:

1. Since this is a game that will be repeated ad infinitum, engage in a *tit-for-tat* strategy along the following lines: "American starts with a high price which it maintains as long as United keeps its price high. If United charges the lower price, American matches it." In this situation the strategy is never announced, but since the game is repeated each side can figure out what the other is doing fairly quickly.
2. One airline or the other makes a public statement that they will always match the lowest price on that route. This sends a clear message on the consequences of price competition, making it much less likely

(Aside: But how do they keep Southwest from entering?)

## II. Repeated games

In the prisoner's dilemma game each side is guaranteed the least favorable outcome if they act individually but each side can achieve the best outcome by working together. This view of the world makes sense when we are looking at one time situations, such as the arrest of Popov and Chekhov, but it does not make sense when dealing with firms that are engaged in the same rivalry every day (e.g., American vs. United). In these *repeated games* firms have the ability to develop more sophisticated strategies to avoid the least favorable outcome. Here are two common solutions that we touched on last time, both of which involve punishing the other party if it starts down the path leading to unfavorable outcomes:

- In cases involving prices, one firm could start advertising a policy of matching or beating (by a token amount) the price of any competitor. This is enforceable as long as all firms have comparable cost levels. All firms now realize that price competition is self-destructive and this greatly reduces the odds of it happening.
- Another possibility we mentioned last time is a "tit-for-tat" strategy, where each party agrees to "do unto others as they have done unto you" (not quite equivalent to the biblical version). In pricing, if they keep their prices high, you keep yours high as well. This has a number of nice properties: it is clear and simple, it is nice (you never start price wars), it is provokable (cheating never goes unpunished), and forgiving (you stop price war if they stop). In Axelrod's study where game theorists played each other 150 times in a prisoner's dilemma situation, he found that this approach was most effective because those using the tit-for-tat strategy never got into prolonged, disastrous wars. Nonetheless there can be problems with tit-for-tat in the

real world (as opposed to computer simulations played by game theorists), e.g., Hatfields and McCoys, protestants v. Catholics in N. Ireland, shifts in demand or cost conditions. Simple misperceptions or poor communications can lead to round after round of warfare (that can only end when one side mistakenly thinks the other side has given up). Dixit and Nalebuff suggest the following revised approach: (1) begin cooperating, (2) continue cooperating, (3) keep count of the number of times the other side has cheated while you have cooperated, (4) reciprocate when that count reaches beyond an acceptable level. The text also mentions that tit-for-tat becomes less viable as the number of firms in the market increases.

### III. Sequential games

#### A. Look ahead and reason back

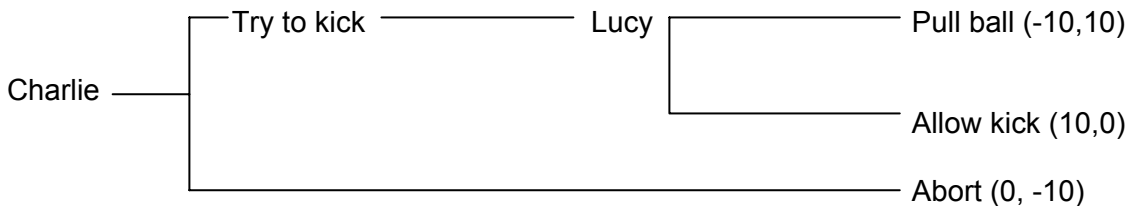
It is a beautiful fall day. Charlie Brown is playing in the leaves with Snoopy. Here comes Lucy Van Pelt with a football. "Charlie," she says, "I will gladly hold the football for you if you want to kick it."

As we all know, Charlie gets great satisfaction from kicking a football, but since Snoopy lacks opposable thumbs, he needs Lucy's help. But Charlie also knows that Lucy gets great satisfaction from taking the ball away at the last nano-second and watching Charlie fall down. Here is the payoff matrix:

|         |                     | Lucy           |                  |
|---------|---------------------|----------------|------------------|
|         |                     | Pull ball away | Let Charlie kick |
| Charlie | Try to kick         | -10, 10        | 10, 0            |
|         | Abort @ last second | 0, -10         | 0, 0             |

Q: does either Charlie or Lucy have a dominant strategy in this case?

But this is not really a situation where both parties can make simultaneous decisions. Once Charlie is running at full speed, he gets so excited that he forgets to keep an eye on Lucy. It is more realistic to look at this as a *sequential game* where Charlie is committed once Lucy tees the ball up.



Viewed this way, Charlie's choice is quite clear. He should anticipate Lucy's response before running toward the football. He should realize that as soon as he commits to running toward the ball, she is going to have control of the situation and will always pull the ball away. So Charlie is always better off not taking Lucy up on her offer. The basic rule here is quite simple:

Look ahead and reason back.

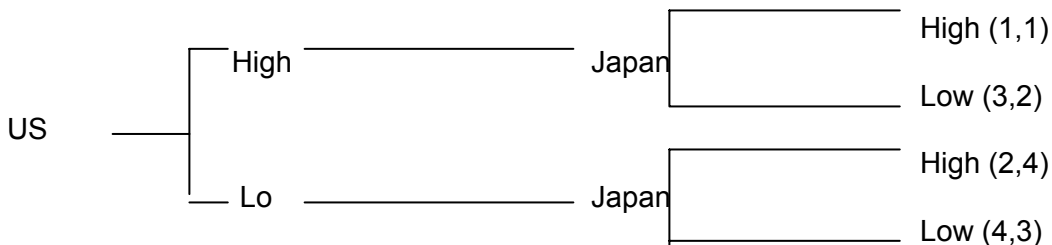
## B. Strategic moves

Now let's turn to a business example. A few years ago the US and Japan were both working on high-definition television technologies. At the time the US had large budget deficits and limited opportunity to support such research, but the US has a technological edge. A high effort-high effort solution is worst for both sides. For the US it is bad because of the cost and for the Japanese it is worst because they are more likely to lose. Each side's second worst outcome is going low effort while the other side is going high. The best situation for the Japanese is where the US has low effort and they have high effort – this makes it most likely that they will dominate HDTV as they have other consumer electronics. The best for the US is where both parties have low effort because the US is still likely to win, but does so at low cost. Here is the payoff matrix:

|    |             | Japan      |             |
|----|-------------|------------|-------------|
|    |             | Low effort | High effort |
| US | Low effort  | 4,3        | 2,4         |
|    | High effort | 3,2        | 1,1         |

Q: what is dominant strategy for US? Japan? If one side has a dominant strategy, what will the other do?

The US can turn this situation around if it has the ability to move first. This changes the table into a tree (a unique feat of reverse engineering!):



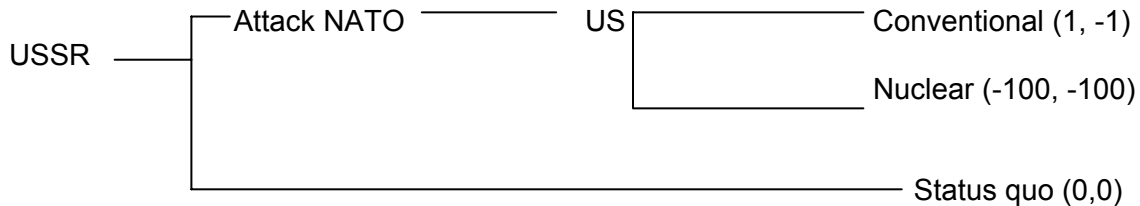
By committing to the high effort strategy, the US locks Japan into a low effort strategy and this guarantees a better outcome for the US (3) than the dominant strategy in the simultaneous game above (2). This is an example of a *strategic move*, defined by Tom Schelling as “one that influences the other person’s choice in a manner favorable to one’s self, by affecting the other person’s expectations of how one’s self will behave.” It also illustrates that in many games, *there is a clear advantage to moving first*.

Natural question to ask is why should Japanese believe the US has committed to the high effort strategy. After all, if all the US does is make an announcement, it still has an incentive to talk high effort but walk low effort (to get the highest possible payoff if the Japanese are bluffed into low effort themselves). To make the Japanese believe the US is committed, Congress and the President would have to agree to an aggressive, multiyear spending plan on HDTV and then actually let contracts.

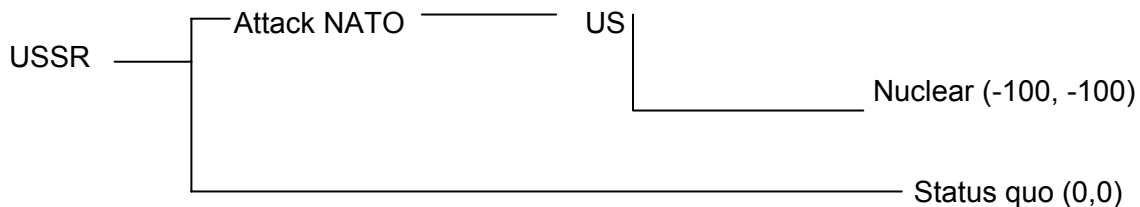
Is moving first the only key to strategy? Not really. Another way to get strategic advantage is by developing (and sticking to) a *response rule*. These rules can be either threats (I will punish you if you do that) or promises (I will reward you if you do that). For instance, if your child announces that he will not eat his spinach, what can a fretful

parent do? Threaten no meals for a week? Not very credible, plus it could invite a visit from the county welfare office. Threaten no dessert? Much more credible! (But keep an eye out and make sure he does not slip the spinach to the pooch.)

Here is an example of how threats can influence an opponent's behavior. NATO countries were very concerned in the 1950s through the 1980s about a conventional ground and air attack from the Soviet Union. Their concerns were based on the following decision tree:



They saw the USSR as being in a position of being able to attack by ground and air, knowing that the likely response of the US would be to respond in kind. To turn things around, the US had to make a credible threat that it would respond with nuclear force if there were an attack. This changes the game to:



Now the Soviets would be motivated to stick with the status quo, given the dire alternative. Fortunately, we never got to see how this game actually played out, but many believe the US deterrent was critical in the 1950s to keeping Western Europe free.

### C. Credibility

We have noted before that talk is pretty cheap, so how can you make sure that your statements about intended responses are believed? Here are some ways to make your threats/promises credible and receive the desired response:

1. Develop a reputation and use it. Examples include Kennedy's decision to airlift supplies to Berlin in 1961, Israel's policy (until a few years ago) of not negotiating with terrorists, pledges to match the lowest price of any competitor
2. Burn your bridges behind you. Cortes burned or disabled all but one of his ships after landing in Mexico, so that his troops knew that they had no option but to fight their best to survive (and so that natives knew that too and would retreat when his troops advanced). In business a good example of this strategy is Polaroid (until recently at least), which has put all of its eggs in one basket – instant photography. They have to do it better than everyone else, because they have no fallback position.