Chapter 1

Introduction

1.1 What is Game Theory?

We, humans, cannot survive without interacting with other humans, and ironically, it sometimes seems that we have survived despite those interactions. Production and exchange require cooperation between individuals at some level but the same interactions may also lead to disastrous confrontations. Human history is as much a history of fights and wars as it is a history of successful cooperation. Many human interactions carry the potentials of cooperation and harmony as well as conflict and disaster. Examples are abound: relationships among couples, siblings, countries, management and labor unions, neighbors, students and professors, and so on.

One can argue that the increasingly complex technologies, institutions, and cultural norms that have existed in human societies have been there in order to facilitate and regulate these interactions. For example, internet technology greatly facilitates buyer-seller transactions, but also complicates them further by increasing opportunities for cheating and fraud. Workers and managers have usually opposing interests when it comes to wages and working conditions, and labor unions as well as labor law provide channels and rules through which any potential conflict between them can be addressed. Similarly, several cultural and religious norms, such as altruism or reciprocity, bring some order to potentially dangerous interactions between individuals. All these norms and institutions constantly evolve as the nature of the underlying interactions keep changing. In this sense, understanding human behavior in its social and institutional context requires a proper understanding of human interaction.

Economics, sociology, psychology, and political science are all devoted to studying human behavior in different realms of social life. However, in many instances they treat individuals in isolation, for convenience if not for anything else. In other words, they assume that to understand one individual's behavior it is safe to assume that her behavior does not have a significant effect on other individuals. In some cases, and depending upon the question one is asking, this assumption may be warranted. For example, what a small farmer in a local market, say in Montana, charges for wheat is not likely to have an effect on the world wheat prices. Similarly, the probability that my vote will change the outcome of the U.S. presidential elections is negligibly small. So, if we are interested in the world wheat price or the result of the presidential elections, we may safely assume that one individual acts as if her behavior will not affect the outcome.

In many cases, however, this assumption may lead to wrong conclusions. For example, how much our farmer in Montana charges, compared to the other farmers in Montana, certainly affects how much she and other farmers make. If our farmer sets a price that is lower than the prices set by the other farmers in the local market, she would sell more than the others, and vice versa. Therefore, if we assume that they determine their prices without taking this effect into account, we are not likely to get anywhere near understanding their behavior. Similarly, the vote of one individual may radically change the outcome of voting in small committees and assuming that they vote in ignorance of that fact is likely to be misleading.

The subject matter of game theory is exactly those interactions within a group of individuals (or governments, firms, etc.) where the actions of each individual have an effect on the outcome that is of interest to all. Yet, this is not enough for a situation to be a proper subject of game theory: the way that individuals act has to be strategic, i.e., they should be aware of the fact that their actions affect others. The fact that my actions have an effect on the outcome does not necessitate strategic behavior, if I am not aware of that fact. Therefore, we say that game theory studies *strategic interaction* within a group of individuals. By strategic interaction we mean that individuals know that their actions will have an effect on the outcome and act accordingly.

Game theory studies strategic interactions

Having determined the types of situations that game theory deals with, we have to now discuss how it analyzes these situations. Like any other theory, the objective of game theory is to organize our knowledge and increase our understanding of the outside world. A scientific theory tries to abstract the most essential aspects of a given situation, analyze them using certain assumptions and procedures, and at the end derive some general principles and predictions that can be applied to individual instances.

For it to have any predictive power, game theory has to postulate some rules according to which individuals act. If we do not describe how individuals behave, what their objectives are and how they try to achieve those objectives we cannot derive any predictions at all in a given situation. For example, one would get completely different predictions regarding the price of wheat in a local market if one assumes that farmers simply flip a coin and choose between $1 and $2 a pound compared to if one assumes they try to make as much money as possible. Therefore, to bring some

rules of the game

discipline to the analysis one has to introduce some structure in terms of the rules of the game.

The most important, and maybe one of the most controversial, assumption of game theory which brings about this discipline is that individuals are *rational*.

We assume that individuals are rational.

Definition. An individual is *rational* if she has well-defined objectives (or preferences) over the set of possible outcomes and she implements the best available strategy to pursue them.

Rationality implies that individuals know the strategies available to each individual, have complete and consistent preferences over possible outcomes, and they are aware of those preferences. Furthermore, they can determine the best strategy for themselves and flawlessly implement it.

✍ If taken literally, the assumption of rationality is certainly an unrealistic one, and if applied to particular cases it may produce results that are at odds with reality. We should first note that game theorists are aware of the limitations imposed by this assumption and there is an active research area studying the implications of less demanding forms of rationality, called *bounded rationality*. This course, however, is not the appropriate place to study this area of research. Furthermore, to really appreciate the problems with rationality assumption one has to first see its results. Therefore, without delving into too much discussion, we will argue that one should treat rationality as a limiting case. You will have enough opportunity in this book to decide for yourself whether it produces useful and interesting results. As the saying goes: "the proof of the pudding is in the eating."

The term strategic interaction is actually more loaded than it is alluded to above. It is not enough that I know that my actions, as well as yours, affect the outcome, but I must also know that you know this fact. Take the example of two wheat farmers. Suppose both farmer A and B know that their respective choices of prices will affect their profits for the day. But suppose, A does not know that B knows this. Now, from the perspective of farmer A, farmer B is completely ignorant of what is going on in the market and hence farmer B might set any price. This makes farmer A's decision quite uninteresting itself. To model the situation more realistically, we then have to assume that they both know that they know that their prices will affect their profits. One actually has to continue in this fashion and assume that the rules of the game, including how actions affect the participants and individuals' rationality, are common knowledge.

A fact X is *common knowledge* if everybody knows it, if everybody knows that everybody knows it, if everybody knows that everybody knows that everybody knows it, an so on. This has some philosophical implications and is subject to a lot of controversy, but for the most part we will avoid those discussions and take it as given.

We assume that the game and rationality are common knowledge

In sum, we may define game theory as follows:

Definition. *Game theory* is a systematic study of strategic interaction among rational individuals.

Its limitations aside, game theory has been fruitfully applied to many situations in the realm of economics, political science, biology, law, etc. In the rest of this chapter we will illustrate the main ideas and concepts of game theory and some of its applications using simple examples. In later chapters we will analyze more realistic and complicated scenarios and discuss how game theory is applied in the real world. Among those applications are firm competition in oligopolistic markets, competition between political parties, auctions, bargaining, and repeated interaction between firms.

1.2 Examples

For the sake of comparison, we first start with an example in which there is no strategic interaction, and hence one does not need game theory to analyze.

Example 1.1 (A Single Person Decision Problem)**.** Suppose Ali is an investor who can invest his \$100 either in a safe asset, say government bonds, which brings 10% return in one year, or he can invest it in a risky asset, say a stock issued by a corporation, which either brings 20% return (if the company performance is good) or zero return (if the company performance is bad).

	State	
	Good	Bad
Bonds	10%	10%
Stocks	20%	0%

Clearly, which investment is best for Ali depends on his preferences and the relative likelihoods of the two states of the world. Let's denote the probability of the good state occurring p and that of the bad state $1-p$, and assume that Ali wants to maximize the amount of money he has at the end of the year. If he invests his \$100 on bonds, he will have \$110 at the end of the year irrespective of the state of the world (i.e., with certainty). If he invests on stocks, however, with probability

p he will have \$120 and with probability $1-p$ he will have \$100. We can therefore calculate his average (or expected) money holdings at the end of the year as

$$p \times 120 + (1-p) \times 100 = 100 + 20 \times p$$

If, for example, $p = 1/2$, then he expects to have \$110 at the end of the year. In general, if $p > 1/2$, then he would prefer to invest in stocks, and if $p < 1/2$ he would prefer bonds.

This is just one example of a *single person decision making problem*, in which the decision problem of an individual can be analyzed in isolation of the other individuals' behavior. Any uncertainty involved in such problems are exogenous in the sense that it is not determined or influenced in any way by the behavior of the individual in question. In the above example, the only uncertainty comes from the performance of the stock, which we may safely assume to be independent of Ali's choice of investment. Contrast this with the situation illustrated in the following example.

A single person decision problem has no strategic interaction

Example 1.2 (An Investment Game)**.** Now, suppose Ali again has two options for investing his \$100. He may either invest it in bonds, which have a certain return of 10%, or he may invest it in a risky venture. This venture requires \$200 to be a success, in which case the return is 20%, i.e., \$100 investment yields \$120 at the end of the year. If total investment is less than \$200, then the venture is a failure and yields zero return, i.e., \$100 investment yields \$100. Ali knows that there is another person, let's call her Beril, who is exactly in the same situation, and there is no other potential investor in the venture. Unfortunately, Ali and Beril don't know each other and cannot communicate. Therefore, they both have to make the investment decision without knowing the decisions of each other.

We can summarize the returns on the investments of Ali and Beril as a function of their decisions in the table given in Figure 1.1. The first number in each cell represents the return on Ali's investment, whereas the second number represents Beril's return. We assume that both Ali and Beril know the situation represented in this table, i.e., they know the rules of the game.

Figure 1.1: Investment Game.

		Beril	
		Bonds	Venture
Ali	Bonds	110, 110	110, 100
	Venture	100, 110	120, 120

The existence of strategic interaction is apparent in this situation, which should be contrasted with the one in Example 1.1. The crucial element is that the outcome of Ali's decision (i.e., the return on the investment chosen) depends on what Beril does. Investing in the risky option, i.e., the venture, has an uncertain return, as it was the case in Example 1.1. However, now the source of the uncertainty is another individual, namely Beril. If Ali believes that Beril is going to invest in the venture, then his optimal choice is the venture as well, whereas, if he thinks Beril is going to invest in bonds, his optimal choice is to invest in bonds. Furthermore, Beril is in a similar situation, and this fact makes the problem significantly different from the one in Example 1.1.

So, what should Ali do? What do you expect would happen in this situation? At this point we do not have enough information in our model to provide an answer. First we have to describe Ali and Beril's objectives, i.e., their preferences over the set of possible outcomes. One possibility, economists' favorite, is to assume that they are both expected payoff, or utility, maximizers. If we further take utility to be the amount of money they have, then we may assume that they are expected money maximizers. This, however, is not enough for us to answer Ali's question, for we have to give Ali a way to form expectations regarding Beril's behavior.

One simple possibility is to assume that Ali thinks Beril is going to choose bonds with some given probability p between zero and one. Then, his decision problem becomes identical to the one in Example 1.1. Under this assumption, we do not need game theory to solve his problem. But, is it reasonable for him to assume that Beril is going to decide in such a mechanical way? After all, we have just assumed that Beril is an expected money maximizer as well. So, let's assume that they are both rational, i.e., they choose whatever action that maximizes their expected returns, and they both know that the other is rational.

Is this enough? Well, Ali knows that Beril is rational, but this is still not enough for him to deduce what she will do. He knows that she will do what maximizes her expected return, which, in turn, depends on what she thinks Ali is going to do. Therefore, what Ali should do depends on what she thinks Beril thinks that he is going to do. So, we have to go one more step and assume that not only each knows that the other is rational but also each knows that the other knows that the other is rational. We can continue in this manner to argue that an intelligent solution to Ali's connundrum is to assume that both know that both are rational; both know that both know that both are rational; both know that both know that both know that both are rational; ad infinitum. This is a difficult problem indeed and game theory deals exactly with this kind of problems. The next example provides a problem that is relatively easier to solve.

Example 1.3 (Prisoners' Dilemma)**.** Probably the best known example, which has also become a parable for many other situations, is called the Prisoners' Dilemma. The story goes as follows: two suspects are arrested and put into different cells before the trial. The district attorney, who is pretty sure that both of the suspects are guilty but lacks enough evidence, offers them the following deal: if both of them confess and implicate the other (labeled C), then each will be sentenced to, say, 5 years of prison time. If one confesses and the other does not (labeled N), then the "rat" goes free for his cooperation with the authorities and the non-confessor is sentenced to 6 years of prison time. Finally, if neither of them confesses, then both suspects get to serve one year.

We can compactly represent this story as in Figure 1.2 where each number within each cell is the number of free years that will be enjoyed by each prisoner in the next six years.

Figure 1.2: Prisoners' Dilemma.

		Player 2	
		C	N
Player 1	C	$-5,-5$	$0,-6$
	N	$-6,0$	$-1,-1$

For instance, the best outcome for the player 1 is the case in which he confesses and the player 2 does not. The next best outcome for player 1 is (N,N), and then (C,C) and finally (N,C). A similar interpretation applies to player 2.

How would you play this game in the place of player 1? One useful observation is the following: no matter what player 2 intends to do, playing C yields a better outcome for player 1. This is so because (C,C) is a better outcome for him than (N,C), and (C,N) is a better outcome for him than (N,N). So, it seems only "rational" for player 1 to play C by confessing. The same reasoning for player 2 entails that this player too is very likely to play C. A very reasonable prediction here is, therefore, that the game will end in the outcome (C,C) in which both players confess to their crimes.

And this is the dilemma: wouldn't each of the players be strictly better off by playing N instead? After all, (N,N) is preferred by both players to (C,C). It is really a pity that the rational individualistic play leads to an inferior outcome from the perspective of both players.

You may at first think that this situation arises here only because the prisoners are put into separate cells and hence are not allowed to have pre-play communication. Surely, you may argue, if the players debate about how to play the game, they would realize that (N,N) is superior relative to (C,C) for both of them, and thus agree to play N instead of C. But even if such a verbal agreement is reached prior to the actual play of the game, what makes player 1 so sure that player 2 will not backstab him in the last instant by playing C; after all, if player 2 is convinced that player 1 will keep his end of the bargain by playing N, it is better for her to play C. Thus, even if such an agreement is reached, both players may reasonably fear betrayal, and may thus choose to betray before being betrayed by playing C; we are back to the dilemma.

> ☞ What do you think would happen if players could sign binding contracts?

Even if you are convinced that there is a genuine dilemma here, you may be wondering why we are making such a big deal out of a silly story. Well, first note that the "story" of the prisoners' dilemma is really only a story. The dilemma presented above correspond to far more realistic scenarios. The upshot is that there are instances in which the interdependence between individuals who rationally follow their self-interest yields socially undesirable outcomes. Considering that one of the main claims of the neoclassical economics is that selfish pursuit of individual welfare yields efficient outcomes (the famous invisible hand), this observation is a very important one, and economists do take it very seriously. We find in prisoners' dilemma a striking demonstration of the fact that the classical claim that "decentralized behavior implies efficiency" is not necessarily valid in environments with genuine room for strategic interaction.

✍ Prisoners' dilemma type situations actually arise in many interesting scenarios, such as arms-races, price competition, dispute settlements with or without lawyers, etc. The common element in all these scenarios is that if everybody is cooperative a good outcome results, but nobody finds it in her self-interest to act cooperatively, and this leads to a less desirable outcome. As an example consider the pricing game in a local wheat market (depicted in Figure 1.3) where there are only two farmers and they can either set a low price (L) or a high price (H). The farmer who sets the lowest price captures the entire market, whereas if they set the same price they share the market equally.

Figure 1.3: Pricing Game.

		Farmer B	
		L	H
Farmer A	L	1,1	4,0
	H	0,4	2,2

This example paints a very grim picture of human interactions. Indeed, many times we observe cooperation rather than its complete failure. One important area of research in game theory is the analysis of environments, institutions, and norms, which actually sustain cooperation in the face of such seemingly hopeless situations as the prisoners' dilemma.

Just to illustrate one such scenario, consider a repetition of the Prisoners' Dilemma game. In a repeated interaction, each player has to take into account not only what is their payoff in each interaction but also how the outcome of each of these interactions influences the future ones. For example, each player may induce cooperation by the other player by adopting a strategy that punishes bad behavior and rewards good behavior. We will analyze such repeated interactions in Chapter 9.

Example 1.4 (Rebel Without a Cause)**.** In the classic 1955 movie *Rebel Without a Cause*, Jim, played by James Dean, and Buzz compete for Judy, played by Natalie Wood. Buzz's gang members gather by a cliff that drops down to the Pacific Ocean. Jim and Buzz are to drive toward the cliff; the first person to jump from his car is declared the chicken whereas the last person to jump is a hero and captures Judy's heart. Each player has two strategies: jump before the other player (B) and after the other player (A). If they jump at the same time (B,B), they survive but lose Judy. If one jumps before and the other after, the latter survive and gets Judy, whereas the former gets to live, but without Judy. Finally, if both choose to jump after the other (A,A), they die an honorable death.

The situation can be represented as in Figure 1.4.

Figure 1.4: Game of Chicken.

		Buzz	
		B	A
Jim	B	$2,2$	$1,3$
	A	$3,1$	$0,0$

The likely outcome is not clear. If Jim thinks Buzz is going to jump before him, then he is better off waiting and jumping after. On the other hand, if he thinks Buzz is going to wait him out, he better jumps before: he is young and there will be other Judys. In the movie Buzz's leather jacket's sleeve is caught on the door handle of his car. He cannot jump, even though Jim jumps. Both cars and Buzz plunge over the cliff.[1]

Game of chicken is also used as a parable of situations which are more interesting than the above story. There are dynamic versions of the game of chicken called the *war of attrition*. In a war of attrition game, two individuals are supposed to take an action and the choice is the timing of that action. Both players desire to be the last to take that action. For example, in the game of chicken, the action is to jump. Therefore, both players try to wait each other out, and the one who concedes first loses.

Example 1.5 (Entry Game)**.** In all the examples up to here we assumed that the players either choose their strategies simultaneously or without knowing the choice of the other player. We model such situations by using what is known as *Strategic (or Normal) Form Games*.

In some situations, however, players observe at least some of the moves made by other players and therefore this is not an appropriate modeling choice. Take for example the *Entry Game* depicted in Figure 1.5. In this game Pepsi (P) first decides whether to enter a market curently monopolized

[1] In real life, James Dean killed himself and injured two passengers while driving on a public highway at an estimated speed of 100 mph.

Figure 1.5: Entry Game

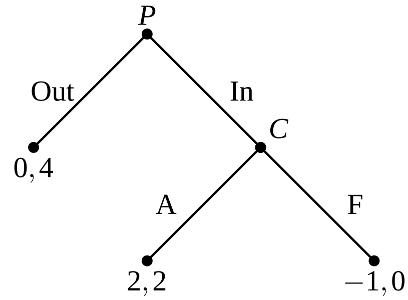


Table 1.1: Voters' Preferences

voter 1	voter 2	voter 3
A	B	S
S	A	A
B	S	B

by Coke (*C*). After observing Pepsi's choice Coke decides whether to fight the entry (F) by, for example, price cuts and/or advertisement campaigns, or acquiesce (A).

Such games of sequential moves are modeled using what is known as *Extensive Form Games*, and can be represented by a game tree as we have done in Figure 1.5.

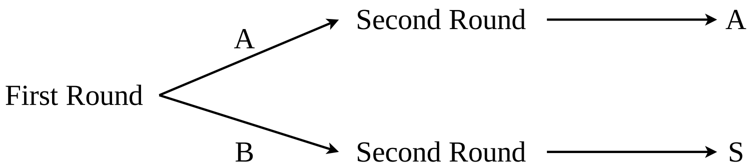
In this example, we assumed that Pepsi prefers entering only if Coke is going to acquiesce, and Coke prefers to stay as a monopoly, but if entry occurs it prefers to acquiesce; hence the payoff numbers appended to the end nodes of the game.

☞ What do you think Pepsi should do?
☞ Is there a way for Coke to avoid entry?

Example 1.6 (Voting)**.** Another interesting application of game theory, to political science this time, is *voting*. As a simple example, suppose that there are two competing bills, A and B, and three legislators, voters 1, 2 and 3, who are to vote on these bills. The voting takes place in two stages. They first vote between A and B, and then between the winner of the first stage and the status-quo, denoted S. The voters' rankings of the alternatives are given in Table 1.1.

First note that if each voter votes truthfully, A will be the winner in the first round, and it will also win against the status-quo in the second round. Do you think this will be the outcome? Well, voter 3 is not very happy about the outcome and has another way to vote which would make him

Figure 1.6: Voting Game



happier. Assuming that the other voters keep voting truthfully, she can vote for B, rather than A, in the first round, which would make B the winner in the first round. B will lose to S in the second round and voter 3 is better off. Could this be the outcome? Well, now voter 2 can switch her vote to A to get A elected in the first round which then wins against S. Since she likes A better than S she would like to do that.

We can analyze the situation more systematically starting from the second round. In the second round, each voter should vote truthfully, they have nothing to gain and possibly something to lose by voting for a less preferred option. Therefore, if A is the winner of the first round, it will also win in the second round. If B wins in the first round, however, the outcome will be S. This means that, by voting between A and B in the first round they are actually voting between A and S. Therefore, voter 1 and 2 will vote for A and eventual outcome will be A. (see Figure 1.6.)

Example 1.7 (Investment Game with Incomplete Information)**.** So far, in all the examples, we have assumed that every player knows everything about the game, including the preferences of the other players. Reality, however, is not that simple. In many situations we lack relevant information regarding many components of a strategic situation, such as the identity and preferences of other players, strategies available to us and to other players, etc. Such games are known as *Games with Incomplete (or Private) Information*.

As an illustration, let us go back to Example 1.2, which we modify by assuming that Ali is not certain about Beril's preferences. In particular, assume that he believes (with some probability p) that Beril has the preferences represented in Figure 1.1, and with probability $1-p$ he believes Beril is a little crazy and has some inherent tendency to take risks, even if they are unreasonable from the perspective of a rational investor. We represent the new situation in Figure 1.7.

Figure 1.7: Investment Game with Incomplete Information

		Beril	
		Bonds	Venture
Ali	Bonds	$110, 110$	$110, 100$
	Venture	$100, 110$	$120, 120$

Normal (p)

		Beril	
		Bonds	Venture
Ali	Bonds	$110, 110$	$110, 120$
	Venture	$100, 110$	$120, 120$

Crazy ($1-p$)

If Ali was sure that Beril was crazy, then his choice would be clear: he should choose to invest in the venture. How small should p be for the solution of this game to be both Ali and Beril, irrespective of her preferences, investing in the venture? Suppose that "normal" Beril chooses bonds and Ali believes this to be the case. Investing in bonds yields $110 for Ali irrespective of what Beril does. Investing in the venture, however, has the following expected return for Ali

$$p \times 100 + (1 - p) \times 120 = 120 - 20p$$

which is bigger than $110 if $p < 1/2$. In other words, we would expect the solution to be investment in the venture for both players if Ali's belief that Beril is crazy is strong enough.

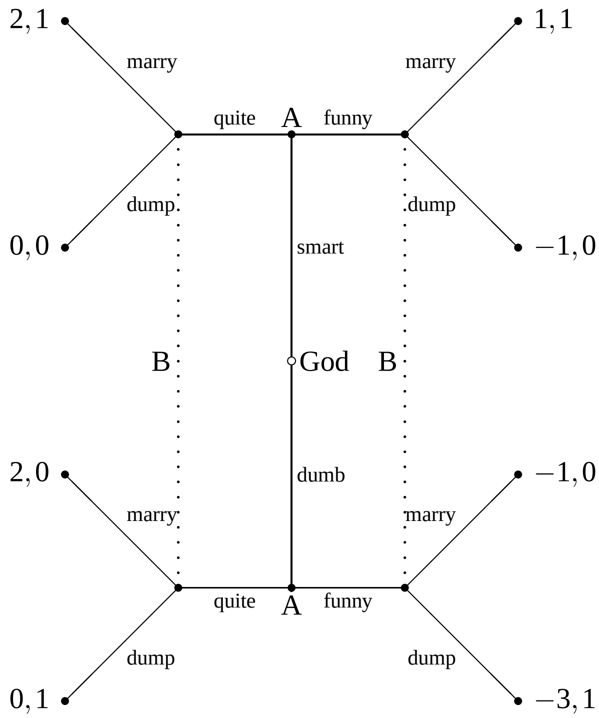
Example 1.8 (Signalling)**.** In Example 1.7 one of the players had incomplete information but they chose their strategies without observing the choices of the other player. In other words, players did not have a chance to observe others' behavior and possibly learn from them. In certain strategic interactions this is not the case. When you apply for a job, for example, the employer is not exactly sure of your qualities. So, you try to impress your prospective boss with your resume, education, dress, manners etc. In essence, you try to *signal* your good qualities, and hide the bad ones, with your behavior. The employer, on the other hand, has to figure out which signals she should take seriously and which ones to discount (i.e. she tries to *screen* good candidates).

This is also the case when you go out on a date with someone for the first time. Each person tries to convey their good sides while trying to hide the bad ones, unless of course, it was a failure from the very beginning. So, there is a complex interaction of signalling and screening going on.
Suppose, for example, that Ali takes Beril out on a date. Beril is going to decide whether she is going to have a long term relationship with him (call that marrying) or dump him. However, she wants to marry a smart guy and does not know whether Ali is smart or not. However, she thinks he is smart or dumb with equal probabilities. Ali really wants to marry her and tries to show that he is smart by cracking jokes and being funny in general during the date. However, being funny is not very easy. It is just stressful, and particularly so if one is dumb, to constantly try to come up with jokes that will impress her. Figure 1.8 illustrates the situation.

What do yo think will happen at the end? Is it possible for a dumb version of Ali to be funny and marry Beril? Or, do you think it is more likely for a smart Ali to marry Beril by being funny, while a dumb Ali prefers to be quite and just enjoys the food, even if the date is not going further than the dinner?

Example 1.9 (Hostile Takeovers)**.** During the 1980s there was a huge wave of mergers and acquisitions in the Uniter States. Many of the acquisitions took the form of "hostile takeovers," a term used to describe takeovers that are implemented against the will of the target company's manage-

Figure 1.8: Dating Game



ment. They usually take the form of direct tender offers to shareholders, i.e., the acquirer publicly offers a price to all the shareholders. Some of these tender offers were in the form of what is known as "two-tiered tender offer."

Such was the case in 1988 when Robert Campeau made a tender offer for Federated Department Stores. Let us consider a simplified version of the actual story. Suppose that the pre-takeover price of a Federated share is \$100. Campeau offers to pay \$105 per share for the first 50% of the shares, and \$90 for the remainder. All shares, however, are bought at the average price of the total shares tendered. If the takeover succeeds, the shares that were not rendered are worth \$90 each.

For example, if 75% of the shares are tendered, Campeau pays \$105 to the first 50% and pays \$90 to the remaining 25%. The average price that Campeau pays is then equal to

$$\begin{aligned} p &= 105 \times \frac{50}{75} + 90 \times \frac{25}{75} \\ &= 100 \end{aligned}$$

In general, if s percent of the shares are tendered the average price paid by Campeau, and thus the price of a tendered share, is given by

$$p = \begin{cases} 105 & \text{if } s \leq 50 \\ 105 \times \frac{50}{s} + 90 \times \frac{s-50}{s} & \text{if } s > 50 \end{cases}$$

Notice that if everybody tenders, i.e., $s = 100$, then Campeau pays \$97.5 per share which is less than the current market price. So, this looks like a good deal for Campeau, but only if sufficiently high number of shareholders tender.

- ☞ If you were a Federated shareholder, would you tender your shares to Campeau?
- ☞ Does your answer depend on what you think other shareholders will do?
- ☞ Now suppose Macy's offers \$102 per share conditional upon obtaining the majority. What would you do?

The actual unfolding of events were quite unfortunate for Campeau. Macy's joined the bidding and this increased the premium quite significantly. Campeau finally won out (not by a two-tiered tender offer, however) but paid \$8.17 billion for the stock of a company with a pre-acquisition market value of \$2.93 billion. Campeau financed 97 percent of the purchase price with debt. Less than two years later, Federated filed for bankruptcy and Campeau lost his job.

1.3 Our Methodology

So, we have seen that many interesting situations involve strategic interactions between individuals and therefore render themselves to a game theoretical study. At this point one has two options. We can either analyze each case separately or we may try to find general principals that apply to any game. As we have mentioned before, game theory provides tools to analyze strategic interactions, which may then be applied to any arbitrary game-like situation. In other words, throughout this course we will analyze abstract games, and suggest "reasonable" outcomes as solutions to those games. To fix ideas, however, we will discuss applications of these abstract concepts to particular cases which we hope you will find interesting.

We will analyze games along two different dimensions: (1) the order of moves; (2) information. This gives us four general forms of games, as we illustrate in Table 1.2.

Table 1.2: Game Forms

		Information	
		Complete	Incomplete
Moves	Simultaneous	Strategic Form Games with Complete Information *Example 1.2*	Bayesian Games *Example 1.7*
	Sequential	Extensive form Games with Complete Information *Example 1.5*	Extensive form Games with Incomplete Information *Example 1.8*