Prisoner's Dilemma

The Prisoner's Dilemma is a famous model of game theory. In this model the decisions of a particular firm depend on what it thinks the others will do. It is called the Prisoner's Dilemma because it is based on a scenario in which two thieves are arrested. Each one is interviewed separately and has to decide whether to confess or not to the crime; their decision depends on what they think the other one is going to do. Ideally they would both deny the charges and the police would not be able to prove anything but what if the other one decides to confess to get lenient treatment; in which case the police would come down heavily on you? So should you confess as well?

In the economics version of this scenario there are two firms X and Y operating in a market. Each firm can decide to produce at a high level of output and sell it at a low price or it can sell a low level of output at a high price. If they both restrict output this is most desirable because the limited amount available generates high prices and profits for both. However each firm will be worried that if it holds back the other one will flood the market and win all the sales at a lower price. This suspicion is likely to lead both firms to flood the market because of their fear of what the other will do. The result is the market price ends up extremely low and both do badly. If only they could trust each other and collude they would do much better.

	Firm Y OUTPUT		
Firm X OUTPUT		HIGH	LOW
	HIGH	£1m £1m	£3m £0
	LOW	£0 £3m	£2m £2m

The matrix above shows the financial results of each possible outcome; the left hand figure is the outcome for X and the right hand figure is the outcome for Y. If they both produce high levels of output they will gain £1m each; if they both restricted output they could earn £2m each.

The interesting question here is how could the firms agree to collude. One factor may be the track record of the different firms- have they stuck to their promises in the past? Secondly is there a way of getting a commitment up front to show that they really want the agreement to work?

Game theory developed

Example 1

	Firm X's price		
Firm Y's price		£2	£1
	£2	A. £10,000 each	B. £6000 for Y £13,000 for X

	£1	C. £13,000 for Y £6000 for X	D. £7000 each

Imagine two firms are competing in a market and are charging £2 each. They each make a profit of £10,000.
They now independently consider changing their price to £1.

Imagine you are firm X and you are naturally cautious. You are considering the worst possible outcomes whatever you do. If you cut your price, Y might follow in which case you end up with £7,000 or firm Y might not follow in which case you would get £13,000. The worst that can happen is therefore that you end up with £7,000. If, however, you were firm X and you kept your price at £2, then the worst that can happen is that Y cuts its price to £1; in this case you would be left with £6,000. Comparing the two alternatives the cautious firm would cut its price to £1- this is the best of the worst outcomes. This is known as a "maximin" approach: maximizing the minimum outcomes.

Alternatively a firm may be optimistic and look for the best possible outcomes. If X sets the price at £2 the best outcome is if Y charges £2 as well. They both earn £10,000. If X sets the price at £1, the best possible outcome is if Y keeps the price at £2 as X would earn £13,000. On this basis a firm that maximizes the best results (a maximax strategy) would choose to charge £1.

In this scenario both the minimax and the maximax have led to the same outcome: a cut in price. This is known as a "dominant strategy" game because both approaches lead to the same result.

Interestingly both X and Y will be tempted to cut price in which case they end up with £7,000 each. If they had colluded and trusted each other they could have earned £10,000 each.

Example 2

		Firm X's price	
Firm Y's price		£2	£1
	£2	A. £10,000 each	B. £6,000 for Y £13,000 for X
	£1	C. £13,000 for Y £6000 for X	D. £4,000 each

In the case above:
- the maximin strategy for X is to charge £2
- the maximax strategy for X is to charge £1

In this case there is no dominant strategy.

Game theory highlights the importance of considering competitors' responses and how this might affect a firm's strategies. However in the real world in which there are many possible competitors and many possible reactions trying to estimate possible responses and outcomes can be very difficult.