Prisoners’ dilemma exercises

In chapter 15 of *Smart Thinking* we considered the significance of the prisoners’ dilemma. On the face of it this might appear to be an interesting problem, which obviously has important implications for the big issues facing the world, like the stockpiling of nuclear weapons and climate change, but is not significant enough for you to consider in the decisions you have to make. However, it does, in fact, enter into the decisions we all have to make in our private and professional lives.

Slimming products, makeup and personal appearance

Advertisers use it as they promote the sales of a whole range of products. Do you compete in the appearance game which advertisers exploit, or do you co-operate and save yourself money? Do you ask yourself, how do I compare with others? Do you consider losing a few pounds to become more attractive? Excluding individuals with serious health problems deriving from obesity, those who buy dieting products and dieting publications are now part of a huge multi-million pound market. Although the advertising industry might not have created the competitive mechanism that drives this, it certainly takes advantage of it. The same goes for other products that affect our personal appearance, like the millions spent on women’s makeup, even non-health-related hygiene products, like deodorants, shaving products and razors.

Pirating CDs, DVDs and computer software

Then there are those decisions we make largely beyond the influence of others. We photocopy textbooks, we copy CDs, DVDs and computer software. Each time we do this we have to make the decision, do I co-operate by buying the original product or do I exploit the opportunity for my own personal gain? If you co-operate by buying the product, the manufacturer can co-operate by keeping prices low and, as a result, many more can afford it. However, if you decide not to co-operate and copy it instead of purchasing it, either the price will rise for the people who co-operate or the company will go out of business and everybody will lose.

Academic work

In our academic lives, we face similar decisions. You might be given a group project to complete. You can either co-operate by working hard on the project, or you can defect, let others do the hard work and share in the benefits of the good grade that they have achieved. Of course, if everyone took this decision and defected like you, the project would either get a poor grade or not get done at all, and everyone would fail.

Society

The more you think about it, the more you realise the prisoners’ dilemma affects almost every aspect of our lives. We live in societies that are maintained by laws and regulations. When we break these we are usually punished, but still there is always the opportunity to defect, rather than co-operate. Fly tipping household waste and unwanted articles, like broken washing machines and building materials, in the countryside is a cheap and easy way of solving a problem, but our failure to co-operate with the laws governing disposal of these items destroys the attractiveness of the countryside. As a result, families can no longer enjoy it and the rest of us have to pay the bill for cleaning up the mess you have created.

Sport

Those engaged in competitive sports have the choice whether to defect on their agreement to compete fairly and take performance-enhancing drugs to boost their performance, or co-operate with others by not taking them and compete on a level playing field. If they take them, others are more likely to follow suit, neutralising the advantage they had gained and, ultimately, ruining their sport as fair competition.

Prices

In contrast to the other examples so far, this is perhaps the most obvious way in which co-operation works *against* the interests of all of us as consumers. There are many large, unregulated markets in which there are just a few competitors. If they decide to co-operate with each other and reduce competition by keeping prices high, they reap the benefits of high monopoly profits. Of course, they all realise that they can individually gain an advantage by defecting from the agreement and reducing their prices. But they are all too aware of the dangers: the rest will have to follow suit and they will all see a significant drop in their profits.

The environment

It takes the earth 15 months to regenerate what we use up in 12 months. We harvest trees faster than they can regrow; we deplete fish stocks faster than they can restock; we take nutrients from the soil faster than they can replenish; and we emit CO₂ into the atmosphere faster than nature can absorb it. Tackling these problems effectively calls for international co-operation. If one country defects from this, say by fishing more frequently, then soon there will be no resources left for anyone.

The Prisoners’ Dilemma – how does it work?

In chapter 15 of *Smart Thinking* we examined the implications of the prisoners’ dilemma by looking at the following table.

B

Confess Not confess

Confess 5 yrs/5 yrs Go free/20 yrs

A

Not confess 20 yrs/Go free 1 yr/1 yr

(A’s payoffs are listed first in each cell.)

We found that the best strategy is to co-operate with each other and refuse to confess. But we argued that if you found yourself in this position, your decision would depend on what you think your friend will do. You might believe there is no way you can trust him not to defect, confess his part in the crime, implicate you and walk away free, while you’re sentenced to 20 years. You also realise that he is probably thinking exactly what you’re thinking, that you too will not be able to resist confessing in the expectation that you will go free. This showed that,

1. If B confesses, A should confess too, otherwise he will go to jail for 20

years.

2. If B does not confess,

either A will go free if he confesses,

or go to jail for one year if he too decides not to confess.

3. Therefore, whatever B does A should confess.

This is known as the ‘dominant strategy’. Whenever there is an option that beats any other option that the other player has, as in this case, this is the dominant strategy. And whenever there is an outcome in which both players play their dominant strategy, this is the Nash equilibrium. It does not mean that it is the outcome that would be better for both players. As you can see in this case, if they both confess, they get between them 10 years, whereas if they were both to refuse to confess they would get just 2 years between them.

You can also see from this that in any problem that resembles a prisoners’ dilemma there are certain requirements that must be met. First, there is a **reward** payoff (1 year) for mutual co-operation that both parties want more than the **punishment** payoff (5 years), which both would get for not co-operating. However, both of them are attracted to the **temptation** payoff (Go free), the highly desirable outcome of a single defection, even more than the reward. Both of them also have doubts about whether they can trust the other person and fear being the one who gets the **sucker** payoff (20 years) as a result of being the one who doesn’t defect.

R = Reward for co-operation

T = Temptation to defect in the hope you will get away with it

S = Sucker’s payoff when one of the players co-operates and the other defects

P = Punishment for both players when they both defect

In the case we examined on pages 244-5 of *Smart Thinking* the value of each of these was as follows:

R = 1 year

T = Go free

S = 20 years

P = 5 years

B

Defect Co-operate

Defect P/P T/S

A

Co-operate S/T R/R

If you think about the relationship between these terms, it means that for a situation to be a prisoners’ dilemma the reward payoff must be greater than the average of the sum of the temptation and sucker payoffs. Or to put it another way, twice the reward payoff must be greater than the sum of the temptation and sucker payoffs.

R > T + S

2

or

2R > T + S

The interesting thing about the prisoners’ dilemma and the relevance it has for us as we make our decisions lies in the fact that the common good can be served by co-operation, while the players deny their own advantage by defecting. The important thing for us to learn is how to identify situations in which these conditions prevail; when we can promote our own interests by co-operating with one another, rather than by competing.

Exercises

Exercise 1:

Marketing

In the following problem identify the elements, plot them in a matrix and decide on the best solution and the dominant strategy.

The DIY market in a small town is dominated by two companies: company A and company B. Each one has an income of £1 million and an advertising budget of £100,000. They both realise that the effectiveness of their advertising is partly determined by the advertising undertaken by the other company. If they both decide to invest the same amount in a year, then their respective promotions will cancel themselves out: their income will remain on the same level and their costs will increase as a result of the costs of advertising.

Equally, they both realise that they would benefit from reducing their advertising budget. At the moment they both have a net income of £900,000, but if they could both agree to do no advertising this would increase to £1 million. However, if company A were to advertise, while company B decided not to, company A’s income would rise to £1.4 million, leaving it with a net income, after deducting the advertising costs, of £1.3 million. In contrast, company B’s would fall to £400,000 with no advertising costs.

Answer:

The elements:

R = Net income increases to £1 million – an extra £100,000

T = Net income increases to £1.3 million – an extra £400,000

S = Net income falls to £400,000 – a loss of £500,000

P = Net income stays at £900,000 – a missed opportunity to save £100,000

B

Defect Co-operate

Defect Missed opport

of £100k/£100k 400K/loss 500K

A

Co-operate loss 500K/400k 100K/100K

From this we can compare the reward payoff compared to the sucker and temptation payoffs. The force of the prisoners’ dilemma lies in the fact that the common good can be served by co-operation, while the players deny their own advantage by defecting. In this case, knowing how loss averse we tend to be, the threat of losing £500,000 (the sucker’s payoff) or gaining £400,000, set against the missed opportunity of gaining just £100,000, suggests that the **dominant strategy** is to defect.

Of course, the **best solution** would have been to co-operate. This would have resulted in a gain for each company of £100,000 compared with the average of the sum of the temptation (a loss of £500k) and sucker (a gain of £400k) playoffs of a loss of £50k.

R > T + S

2

£100k > loss of £500k + £400k

2

£100k > – £500k + £400k

2

£100k > – £100k

2

£100k > – £50k

Exercise 2:

Teacher offering higher marks

Since 2008 Professor Dylan Selterman at the University of Maryland has been allowing his class to choose how many extra credit points they want to add to their final paper grade. He presents them with the following proposition:

Select whether you want 2 points or 6 points added onto your final paper grade. But there's a small catch: if more than 10 per cent of the class selects 6 points, then no one gets any points. Your responses will be anonymous to the rest of the class, only I will see the responses.

What would you do?

Answer:

Professor Selterman's students are in the same position as the prisoners. All would benefit from two additional points on their final papers, if they can co-operate and avoid the temptation of the six additional points. If they give in to this temptation, no one will get extra credit. In fact, Professor Selterman reports that of all the classes that have considered this proposition since 2008 only one has successfully received an extra two points each.

Exercise 3:

Saving water

If I don’t save water and nobody else does either, then my decision not to save water makes no difference. If I don’t save water and everybody else does, my decision will still make no difference. Either way it makes no sense for me to save water. Is my reasoning sound?

Answer:

It is not difficult to see that this is similar to the problem of climate change. If you save water and nobody else does, you have co-operated and everybody else has defected, leaving you with the sucker’s payoff. Alternatively, as the statement makes clear, if you choose not to save while everyone else saves, you benefit from the temptation payoff. The question is how great is the sum of the sucker and temptation payoffs compared with the reward payoff? In terms of the formula above, this would have to be greater than twice the reward payoff of the security of the supply of water for all. This doesn’t appear to be the case, but I will leave it to your judgement.

Exercise 4:

Iterated Prisoners’ Dilemma

This exercise helps you to see how different strategies can solve competitive situations through collaboration. To complete it you will need a group of friends. On pages 246-8 of *Smart Thinking* I examine this more complex form of collaboration: the iterated form of prisoners’ dilemma. It replicates much more accurately the sort of extended relationships we develop between each other in real life.

The important aspect of this is that, as in real life, we learn about each other: we’re able to decide whether to co-operate or defect on the basis of what had taken place in previous decisions. As I explained in *Smart Thinking*, if you are not going to see the person in front of you again, defection makes the obvious rational choice. But, if you know you will be meeting them regularly in the future, you will want to create a good reputation, one that people can trust. Likewise with this game: each side will need to build a reputation that can be trusted.

*Step 1:*

The group is divided into two equal teams: A and B. The teams cannot communicate with each other, except when told to by the teacher (Step 3 below).

The teams are told that they can play the ‘Red’ or ‘Blue’ strategy. Each word is written on cards and each team given one of each. They are told that the objective is to get maximum points.

*Step 2:*

In each round the teams will discuss among themselves whether they will play the red or blue strategy. After their discussion the teacher will tell each team to hold up the card they have agreed on.

*Step 3:*

After each round the scores are recorded for each team:

1. If both teams choose red, they both score 2 points.

2. If both teams choose blue, they both score 1 point.

3. If one chooses blue and the other chooses red, blue scores 3 points and red scores 0.

The game is played over ten rounds. After round five the teams can meet to negotiate, but this is optional.

*Step 4:*

After round ten the final score is counted and both teams are debriefed.[[1]](#endnote-1)1

There are, of course, different ways of approaching this game. On pages 247-8 of *Smart Thinking* I discussed the iterated form of the prisoners’ dilemma and the two computer tournaments that were held to see which was the most successful strategy. In both of the tournaments this turned out to be the ‘tit-for-tat’ strategy. In this game, at the beginning, both teams may decide to choose red to maximise their scoring, until one group decides to break ranks and choose blue. Then, of course, much will depend on the reaction of the other group. The maximum one team can get is 30, if the other gets nil. The maximum aggregate score of both teams is 40, if both play red each time.

1. 1 From J. William Pfeiffer & John E. Jones, *A Handbook of Structured Experiences for Human Relations Training* (Pfeiffer & Co., 1981). [↑](#endnote-ref-1)