How to apply game theory to buying your Christmas presents

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Credit: AI-generated image (disclaimer)

According to Sheldon from The Big Bang Theory, if someone is buying you a Christmas gift then the "essence of the custom is that I now have to go out and purchase for you a gift of commensurate value and representing the same perceived level of friendship as that represented by the gift you've given me".

But if you, like Sheldon, are having trouble deciding who to buy presents for this Christmas, and what to buy, then the mathematics of Game Theory can help.

If we imagine two people (players 1 and 2) who are deciding whether to buy each other a gift or not, then each person has two options (or strategies): they can either buy a gift, or not. If they receive a gift, then they get some enjoyment from that "E" and if they give a gift then there is a cost "C", which could be partially financial and partially based on effort.

We can represent the possible outcomes of this game in something called a payoff matrix, in which each of the entries is made up of two parts, the payoff for player 1, followed by the payoff for player 2:

$$\begin{array}{lll} & & \text{Player 2} \\ & & \begin{array}{cc} \textit{Give} & \textit{Receive} \end{array} \\ \text{Player 1} & \begin{array}{l} \textit{Give} \\ \textit{Receive} \end{array} & \begin{pmatrix} E_1 - C_1, E_2 - C_2 & -C_1, E_2 \\ E_1, -C_2 & 0, 0 \end{pmatrix} \end{array}$$

This says that if both players buy each other a present, then they both get a payoff which is the enjoyment they get from receiving a present minus the cost of the present they bought. If one of them buys and the other does not, then one person gets enjoyment and no cost and the other gets cost and no enjoyment. Finally, if neither of them buy a present, then there is no cost and no enjoyment and so the payoff is zero for each player.

If E>C for both players then this game is known as the Prisoner's Dilemma, a well-known game which was first formulated in 1950 by Merrill Flood and Melvin Dresher and has taken many forms over the years. For example, the final round of the television quiz show Goldenballs was a Prisoner's Dilemma – a particularly fine example can be seen here:

This game is counter-intuitive because it seems like it is in both players' best interests to cooperate by buying each other gifts – because, in our case, E-C is a positive payoff. If one player knows that the other one is going to cooperate, however, then it would be better for them to defect and not buy a present – that way they receive the present at no cost. Of course, if they both defect then they both end up with nothing.

In fact, for the game presented here, mathematics tells us that it is always better not to exchange gifts as this is a so-called Nash equilibrium – a situation where we cannot better our circumstances by changing our actions.

Last Christmas, I gave you my heart

However, the result given above assumes that we are only playing the game once. If we are playing against someone who we will spend many Christmases with and who will remember what we have done in the past, then we are faced with the more complex Iterated Prisoner's Dilemma.

In 1984, Robert Axelrod produced a book called The Evolution of Cooperation which looked at the Iterated Prisoner's Dilemma. He found that greedy strategies tend to do worse in the long run while more generous strategies do better. In fact, the winning strategy in this iterated game was proposed by Anatol Rapaport and is called "tit for tat".

In this strategy, you cooperate for the first year and after that do whatever your opponent did last time. In our game, that would mean giving a present this year and then seeing what your friend does and then do the same as them next year.

Of course, some people have difficulty deciding what other people would enjoy and there can be disasters when people give gifts which are not well received. For small children, for example, there is usually huge enjoyment in whatever they receive and that can be achieved for a relatively small cost. Teenagers are more tricky, almost everything they want is more expensive and although they might enjoy them the joy of receiving is diminished – if only because the size and quantity of the presents is much smaller.

Socks are always going to be a tricky proposition: the cost is relatively low, but people do not necessarily appreciate them. Vouchers on the other hand, as long as they are for the correct retailer, should always be a winner since their "value" is clearer.

The joy of giving?

The game changes completely, however, if you include the joy of giving "J" in your payoff. If your payoff when you buy someone a present changes from –C to J-C, and this is positive, then the winning strategy is always to buy gifts as that becomes the Nash equilibrium.

So, how did Sheldon solve the problem? He bought several gift baskets of varying value and decided he would give the one closest in value to Penny's gift. Penny gave Sheldon a napkin containing "the DNA of

Leonard Nimoy" and while the monetary value of the gift was small, the value placed on it by Sheldon was sufficiently high that he gave her all the gift baskets he had bought.

So, what can we conclude from the mathematics? Well, generosity is best, especially when the joy of giving is deemed the most important part of Christmas. (By the way, if our families and friends are reading, we don't want Leonard Nimoy's DNA this year!)

Source: The Conversation

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