Worth Noting

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Robert Aumann and Thomas Schelling recently won the 2005 Nobel Prize in Economics for their work on game theory and how game theory can be used to resolve conflicts. Game theory has been used extensively by experts to predict and solve problems in situations where conflicts arise: business & management, international politics and even behaviour at a dinner party.

It is obviously beyond us here to go through the theories Aumann and Schelling put forward which catapulted them to international intellectual acclaim. What we thought we might do in this edition of ***Worth Noting*** is to look at a few examples of game theory models and how they can help us make better decisions either as a game player or as a system builder in any context that conflict might arise (which basically means every human activity that involves two or more people.)

In particular, we will look a few basic models/scenarios dealing with the problem of cooperation.

The essence of game theory

The essence of game theory deal with models that predict the likelihood that hypothetical players will or will not cooperate, how they will behave (whether they are competing, cooperating or indifferent), and therefore the likely outcomes from any given hypothetical situation.

Game theory only works if we assume that participants try to make rational means-ends decisions. In other words, the models generally assume that participants seek to maximize their desired outcome by choosing what they believe to be the best decision (i.e., means). Depending on the context, this might be defined in many ways such as maximizing money, power, friends, market share and so on.

This does not mean that all participants will actually behave rationally and in fact much of the value in game theory is to account for why a participant will choose irrationally even though they might be trying to be rational. This is why game theory models have been useful in predicting which outcomes are probably, and where individual choices and collective outcomes are sub-optimal, why this has been the case and whether it is possible to eliminate the reasons for poor outcomes.

Game theory examples

A. The Prisoner's Dilemma

One of the most common uses of game theory is to demonstrate the difficulties of cooperation in any system. The Prisoner's Dilemma is one of the best know simple game theory models used to demonstrate this.

Imagine two criminals arrested under the suspicion of having committed a crime together. However, the police do not have sufficient proof in order to have them convicted. The two prisoners are isolated from each other, and the police visit each of them individually to offer a deal: the one who offers evidence against the other one will be freed (if they themselves are not implicated by the other). If none of them accepts the offer, they are in fact cooperating against the police, and both of them will get only a small punishment because of lack of proof. They both gain.

However, if one of them betrays the other one, by confessing to the police, the defector will gain more, since he is freed; the one who remained silent, on the other hand, will receive the full punishment, since he did not help the police, and there is sufficient proof given the testimony of the other. If both betray each other, both will be punished, but less severely than if they had refused to talk.

The dilemma resides in the fact that each prisoner has a choice between only two options – to spill the beans on the other or to remain silent, but cannot make a good decision without knowing what the other one will do. The idea is that each player gains when both cooperate, but if only one of them cooperates, the other one, who defects, will gain more. If both defect, both lose (or gain very little) but not as much as the "cheated" cooperator whose cooperation is not returned.

The individual prisoner **A** is faced with the following possibilities.

i. If **A** gives evidence against **B,** and **B** does not give evidence against **A**, **A** gets out of jail. **B** received 10 years in jail.
ii. If **A** gives evidence against **B**, and **B** also gives evidence against **A**, both **A** & **B** receive 8 years jail.
iii. If **A** does not give evidence against **B**, but **B** gives evidence against **A**, then **A** received **10** years jail for not cooperating with police while **B** goes free.
iv. If both **A** & **B** do not give evidence against the other, they will be both given two years each on much lesser charges.

The Prisoner's Dilemma

Action of A \ **Action of B**	**Testify**	**Remain Silent**
Testify	8/8	0/10
Remain silent	10/0	2/2

This simple model demonstrates that there can sometimes be a contradiction between individual and collective rationality. Individual rationality here means that each prisoner is trying to reduce their own jail time. Collective rationality is the objective of reducing the total jail time for both prisoners.

What would you do? At first glance the correct strategy appears obvious. No matter what **B** does, you'll be better off "defecting" (confessing) as this would avoid you the maximum jail term and there is even the possibility that you might be released. The individual prospect of either receiving 8 years or 0 years jail by testifying (SCORE = -8) is more rational than remaining silent and having the prospect of receiving either 10 years or two years jail (SCORE = -12).

However, **B** would realize this as well, and if **B** used the same rationality, you would both end up getting eight years – by far the worse collective outcome.

If you had both "cooperated" with each other (refused to testify), you would both be much better off individually and collectively. The collective jail-years would only be a maximum of 10 and a minimum of 4 (compared to a maximum of 16 and a minimum of 10 if at least one person testifies.) However, the individual rationality of participants would tend to be against cooperation (i.e., remaining silent).

The problem is that if both actors are rational, both will decide to defect, and none of them will gain anything. However, if both "irrationally" decide to cooperate, both would gain. Game theorists call this seeming paradox the principle of sub-optimization. The prisoner’s dilemma payoff structure makes it very difficult for everyone to be well off, and introduces massive risks to players willing to chance cooperation. It presents a world where rational people perceive that they could be better off under some cooperative arrangement, but that there is no course of action that they can safely pursue to achieve that state of affairs.

Obviously, one needs to know when to correctly apply different game theory models to real-life situations. The Prisoner’s Dilemma clearly does not apply to all actual situations since not all actual situations penalize participants in the same form for cooperation or non-cooperation.

This is obviously a very simple model with only two participants and two choices available. Game theories become more complicated as real life situations become more complicated and the models used by Aumann and Schelling are mind-blowing in their sophistication. They take into account not only greater numbers of choices and outcomes but also take into account elements such as individual, group and system level behaviour, learning by participants as they become more involved in the game and the subsequent learning of different levels of rational behaviour, entry of outsiders with different objectives (i.e., different rationalities), impact of slow and quick learners within the model, participants that might value the same outcome different … The list is endless as is the mathematics involved.

B. The Stag Hunt

Many game theories have been developed based on the simple problem within a scenario posed by philosopher Jean-Jacques Rousseau as follows.

In earlier societies, people formed alliances in order to hunt deer. Each hunter had their role. If even one person in the group did not help with the hunt, the deer would be lost. The hunters were sometimes tempted to leave the hunt by seeing rabbits which were plentiful, but they preferred deer to rabbit.

However, only one person was needed to catch a rabbit. From a game theory perspective, the best strategy for maximum outcome is to hunt the deer, but people may decide to hunt the rabbit because they believe others may defect from the hunt also.

This might seem like a simple representation but the point is to look at a different kind of problem regarding cooperation. In the Prisoner’s Dilemma, the main principle is to point out the difference between individual and collective rationality and why following our individual rationality can lead to collective sub-optimal outcomes.

In the Stag Hunt, the principle introduced is slightly different. Temptation to defect arises only when you believe that others will defect. For this reason the dilemma is most acute when one has reason to doubt the rationality of the other player, or in groups large enough that, given the vagaries of human nature, some defections are likely.

This basic scenario gives rise to countless models in the same way that the Prisoner's Dilemma is the basis for much more complex and multi-varied game theory models.

C. The free rider

The free rider problem is simple to understand. Imagine that there are one hundred people rowing a large boat, fifty on each side. Each rower is in an enclosed compartment so they cannot see each other.

If one rower stops rowing, the boat speed will be reduced but at less than one percent of full capacity. In other words, a reduction of one percent in rowing power produces less than one percent in a reduction in speed.

The self-interested individual is rationally tempted to stop rowing since the speed reduction will be negligible. Obviously, if all one hundred rowers are similarly self interest and imbued with the same 'rationality', the boat will stop moving.

Substantial efforts by game theorists have been made to look at the freerider problem and devise models that discourage the individual rationality to freeride. Some game theorists would even claim that the great advantage of capitalism (in principle anyhow) is the success in reducing the amount of systemic free-riding since the individual within the larger system is more likely to define rational action (i.e., their self interest) as being productive (rather than freeriding within a more collective form of production.)

Legislation and enforcement is obviously a direct way to prevent freeriding but there are many things that cannot be legislated and enforced by law. Hence, game theories are produced to help established systems that voluntarily discourage freeriding by participants.

Application of game theory

Critics might consider that game theory is too abstract or simplistic an approach to help describe and prescribe action for participants who have free will and different priorities.

This criticism fails to appreciate the pervasiveness of game theory and the almost infinite capacity for game theories to develop and adapt proportional to the level of complexity of human behaviour.

It is not an exageration to say that almost every system we implement in modern, Western style societies (of which we are one) is founded on game theory models. Welfare systems, taxation systems, corporate strategies, population policies, health policies and so on all depend heavily on game theories. We are all unwitting participants in these models every time we pay taxes or receive welfare or go to the doctor. You would be surprised how predictable our behaviour actually is.

Even everything from the arms race during the Cold War to disarmamant to Non-Nuclear Proliferation agreements to World Trade Organisation rules have a solid basis in game theory.

When Aumann and Schelling won the Nobel Prize, they did so because their theories have been used to accurate describe and predict behaviour in instances such as price wars, arms races, trade wars and even how international crime syndicates will and do actually behave.