

Game Theory and Probabilistic Decision Analysis

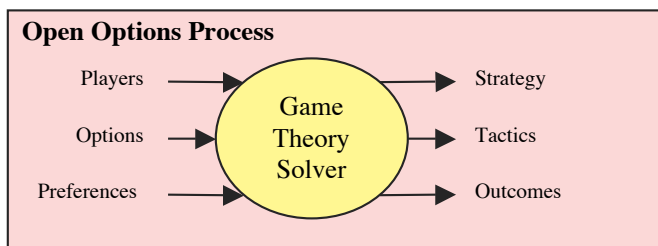
Background

The issue of fit between quantitative, probabilistic decision analysis processes and game theoretical analysis arises frequently. This note attempts to outline how the two processes fit together and can be used in a synergistic and integrated process. This note focuses on decision techniques to deal with distinct and temporary issues, not the development of policies or frameworks to guide the ongoing operations of a firm.

Game Theory

The value of the game theory is in understanding the likely outcomes of a business issue when the outcome is dependent on actions taken by other parties with potentially conflicting interests. In Game Theory we assume that every party acts rationally and takes action based on their preferences.

The inputs to the game theory process are the



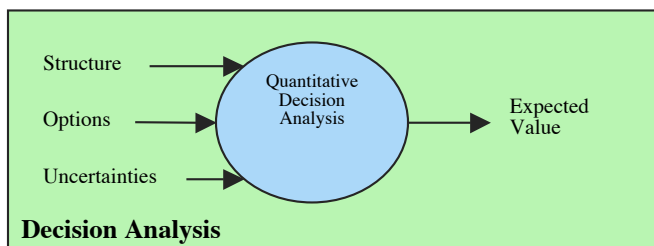
listing of players (the parties involved in the issue), the options (or actions) available to them and the preferences they have. A typical game theory project would consider 20 – 25 different options.

The output of the process is a set of outcomes – one is called the “Natural Outcome”, resulting from all players following their natural self interest. Another is the “Best Attainable Outcome” (for the client), resulting from the client also taking subtle and possibly counter-intuitive actions.

Decision Analysis

Probabilistic decision analysis processes have high value in cases where the value of different

outcomes is highly dependent on quantifiable external uncertainties that are not determined by actions taken by identifiable players. Examples of such uncertainties could be the weather, the foreign exchange rate, and the future price of oil. Uncertain future events are represented as decision trees or probability distributions.



The input of a decision analysis process is the structure of an issue (influence diagram or decision tree), with identified external uncertainties and decision variables.

Typically, a decision analysis would handle two to four actions (or decisions). The outcome of a formal decision analysis is a recommended or preferred set of decisions for the client.

Commonalities

Although the analysis processes and tools are quite different, success of a project using either methodology is quite dependent on participation by the right individuals from the client company and skilful facilitation of the process. A strong knowledge elicitation methodology is essential to either process and several facilitation tools can be applied equally well.

Secondly, organizations that are receptive to objective and structured decision-making processes tend to like both processes, whereas purely intuitive decision cultures are not receptive.

Differences

Game Theory has advantages in situations where the best course of action is dependent on actions by other players. It is easier to apply where there are multiple value measures (where a single decision criteria such as expected Net Present Value is not feasible). A typical Game Theory project can be done in a little over a week, with 10 hours of client team involvement. Last, the Game Theory process is strong when there are too many outcomes to allow financial analysis (a typical case has 20 options, or $2^{20} = 1$ Million outcomes).

Decision Analysis is advantageous in cases where the decision uncertainty is caused primarily by quantifiable uncertainties (e.g. the probability of success of a technology, the price of a commodity, an exchange rate), not dependent on the choices made by other players. Decision Analysis requires the issue to be condensed into a small number of outcomes and two or three decisions. Last, decision analysis provides a financial result (Expected Value), which is often necessary to justify an investment.

How to choose the right methodology?

Both methodologies have their own application areas. In some cases, both could be used together.

For issues where the critical driver is actions and preferences of other players, Game Theory is the preferred choice. For issues where the critical driver is a few quantifiable uncertain variables, quantitative decision analysis is the preferred choice.

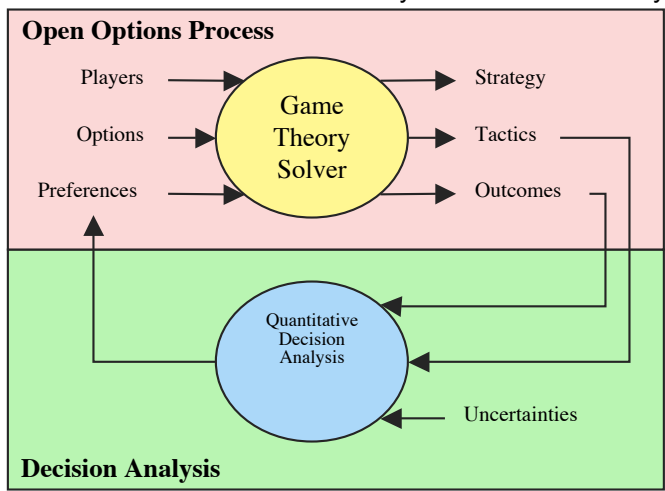
The diagram on the left shows how both can be used in certain cases.

A critical input for a game theory case is the preferences of the various players, including the

client company. The preferences are elicited from the client team. If the client has undertaken quantitative analysis, taking into account uncertainties, than this quantitative analysis influences the client's preferences. However, it must be recognized that a client team will always have a set of preferences, whether they've done formal analysis or not. Then the

game theory analysis will show what the possible outcomes will be.

Where feasible, we recommend that the Natural Outcome and the Best Attainable Outcome be further analyzed using a Decision Analysis process. This may or may not result in a revised set of preferences.



An Example

Let's assume that in a labour relations case, management has preferences for (in order of priority): (1) cutting wages; (2) downsizing and (3) limiting early retirement. A game theory analysis shows that the most likely outcome is a strike. Subsequent Decision Analysis shows that the cost of the strike is very high (exceeding the benefits of the wage cut). It also shows that early retirement is very expensive. As a result, management revises its preferences to: (1) limiting early retirement; (2) downsizing and (3) **not** cutting wages. (Wage cuts end up very low on the preference listing).

In this case, game theory was used to narrow the cases that needed to be analyzed. It also provided a clear perspective on the likelihood of a strike. Then Decision Analysis was used to get a good handle on the expected value of the alternative courses of action.

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