Insights from Past Lives of Decision Analysis Practioners: Decisions Analysis and Game Theory

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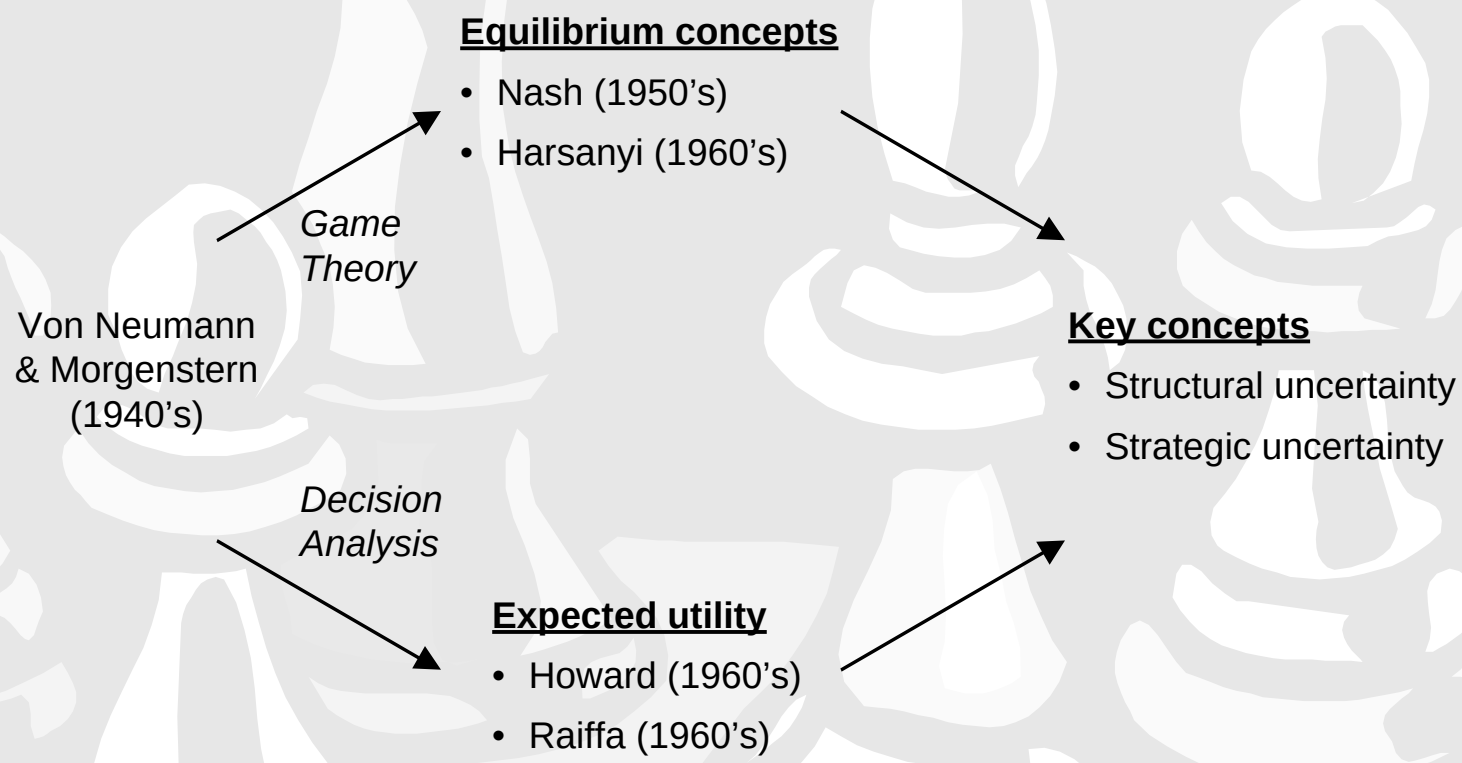
Background

- How did I get here today?
  - My background is that I have a Ph.D. in Economics
    - My thesis was in international trade and labor standards
    - The dissertation employed a great deal of game theory
  - Currently, I'm working at SDG/ Navigant Consulting
    - I've become a practitioner of Decision Analysis to guide strategy decisions
  - Although there is a great deal of overlap between economics and DA, I was intrigued that there is little employment of game theory
    - In Economics, any discussion of strategy would involve game-theory considerations.

In this presentation, we will further investigate the differences between DA and Game Theory.

- By examining some very simple game structures, we can elucidate circumstances where DA and Game Theory may give differing strategic directions.
- From these examples, we gain some insight on the fundamental differences between Game Theory and DA practice.
- We will also explore some possible methods for incorporating Game Theoretic considerations into DA analysis.

Both Decision Analysis and game theory are based on the same principles.



Can we apply game-theoretic considerations to Decision Analysis practice?

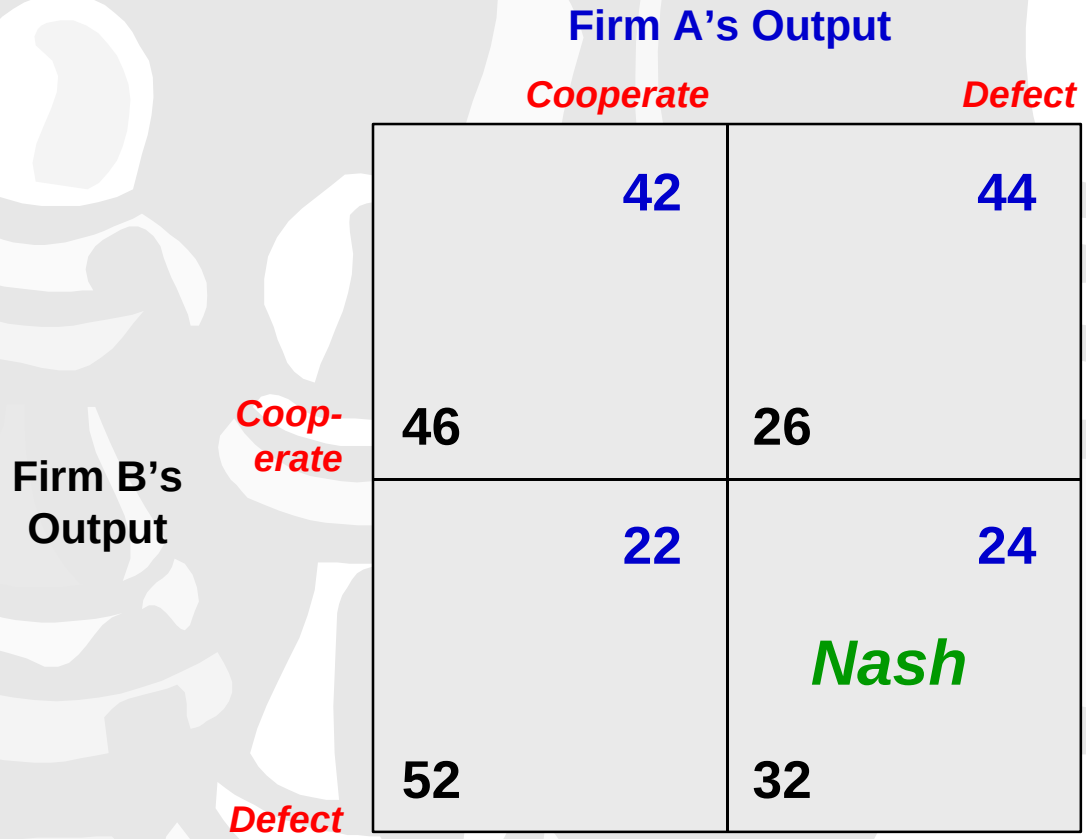
From an economics point-of-view, there are two critical differences between DA and Game Theory.

- Decision Analysis does not explicitly incorporate the payoffs to a competitor.
  - Instead, a probability assessment is made over the possible actions of a competitor.
  - These may be informed by some consideration of the competitor's payoffs.
- Decision Analysis does not incorporate an equilibrium concept which will "solve" the problem.
  - Instead the tree is "rolled back" to determine the highest valued alternative.

As I further researched this topic, I found that there is a growing literature addressing these differences.

We first examine the Prisoner's Dilemma or Duopoly Game as an example of how Game Theory and DA are similar.

The simplest way to analyze the game is to view it in "standard form".

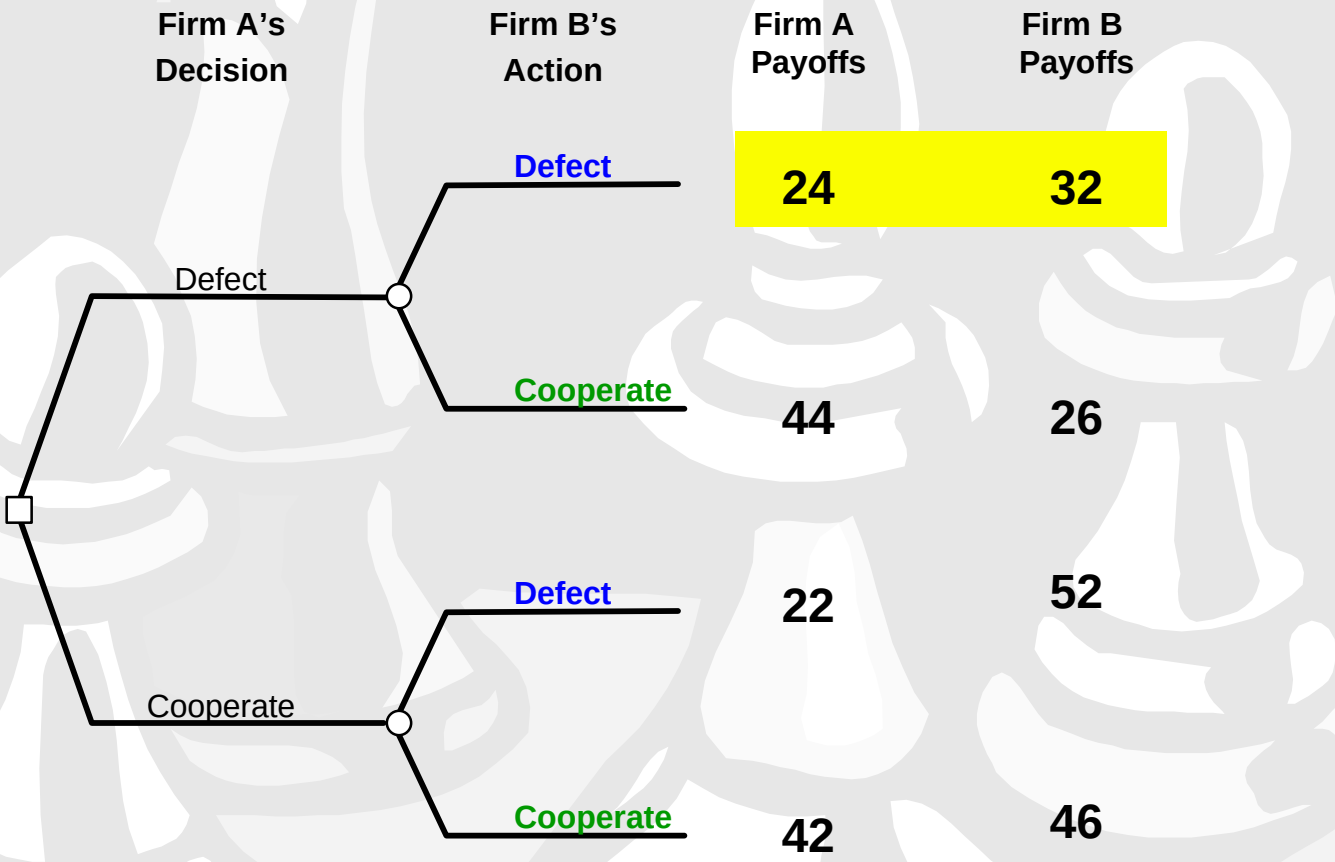


The dominant strategy for each player is to "defect."

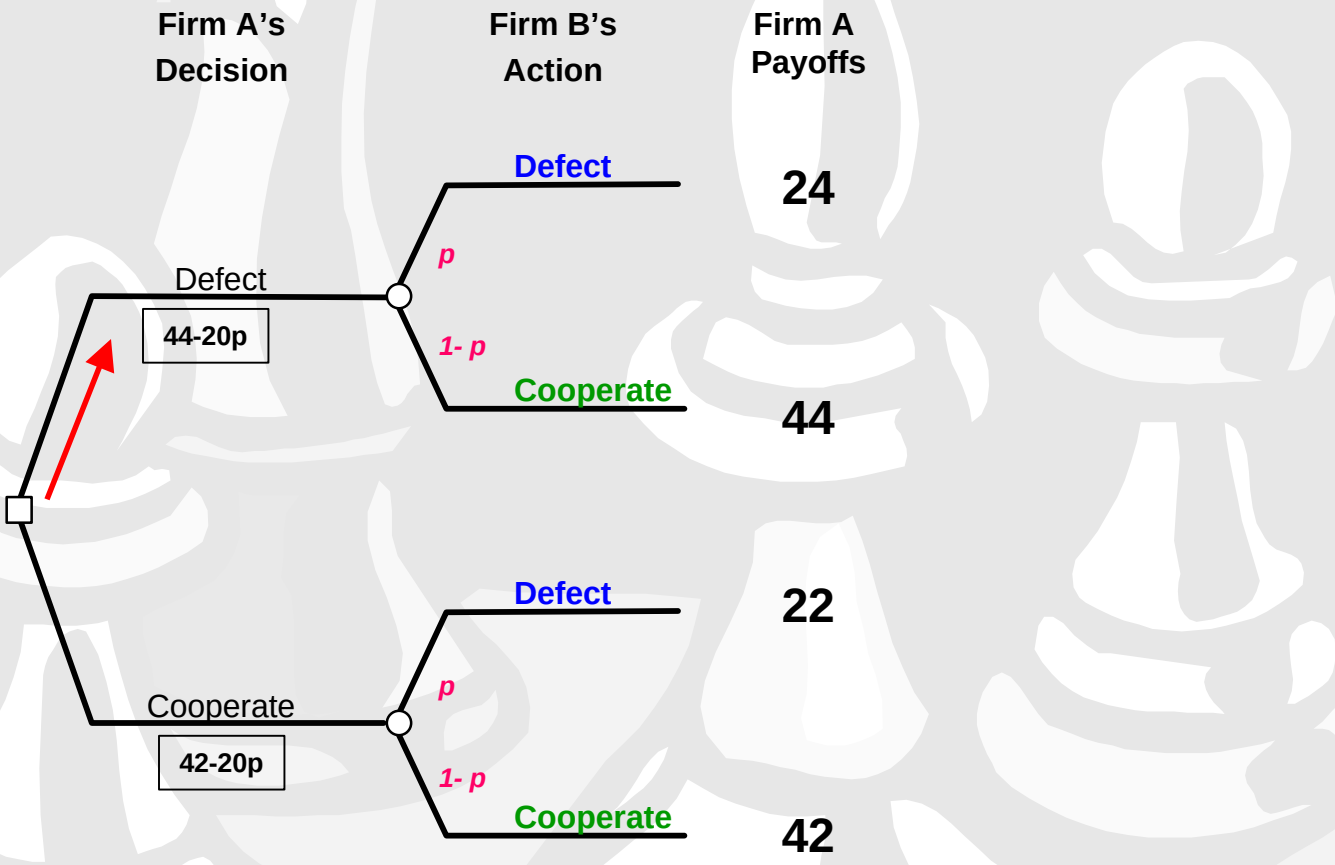
The solution to this game is the pure-strategy Nash where both parties "defect," even though everyone is better off by cooperating.

We can convert this example into a DA framework.

First, we present the game in its extensive form.



We can convert this example into a DA framework.



For any probability distribution, the optimal choice for Firm A remains the same, given this payout structure.

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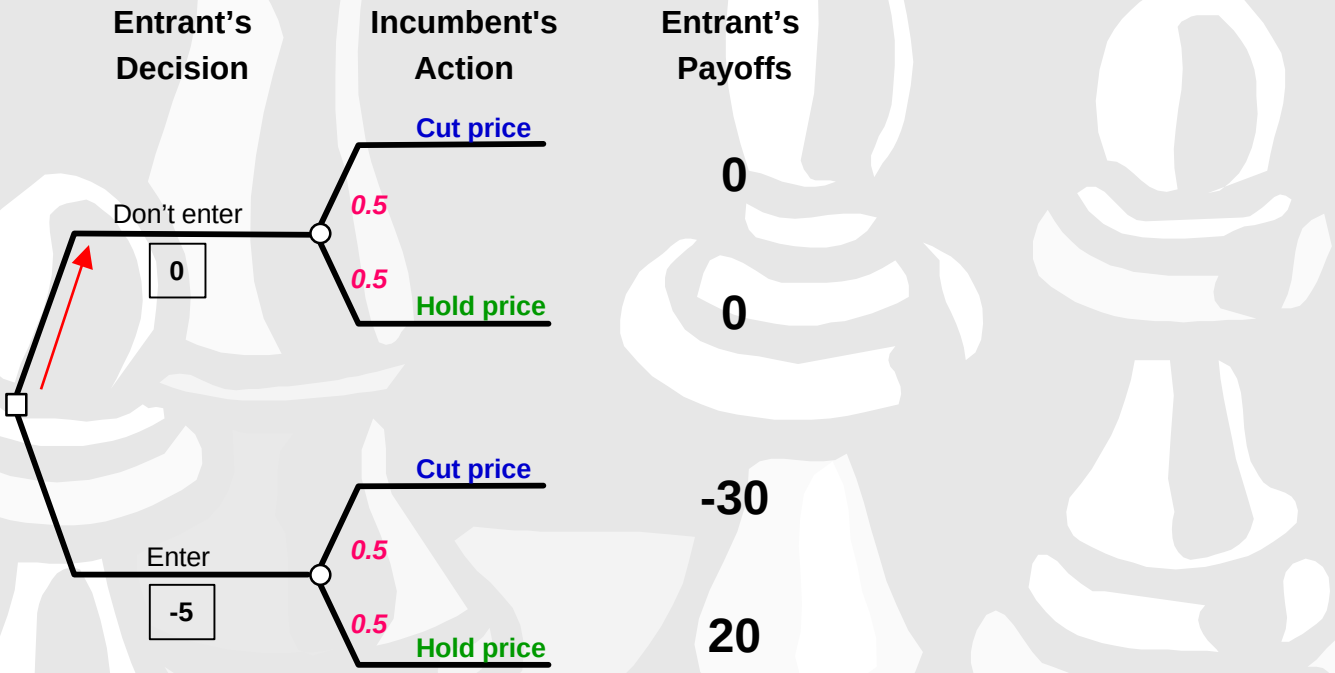
In this simple game, both DA and Game Theory provide the same answer.

- Because the game contains a dominant strategy, we get this strong result.
  - Since the game is simultaneous, the probability placed on the competitor's actions does not depend on our own actions.
  - Even if we changed the game to a sequential game, we would still achieve the Nash equilibrium.
- In this case, knowing what the other person's payoff will be is irrelevant to our optimal strategy.
- In most games, we will not get this coincidence in answers.

If we change the payoffs to the same game, we alter the result dramatically.

The structure of the game is similar but the context is different.



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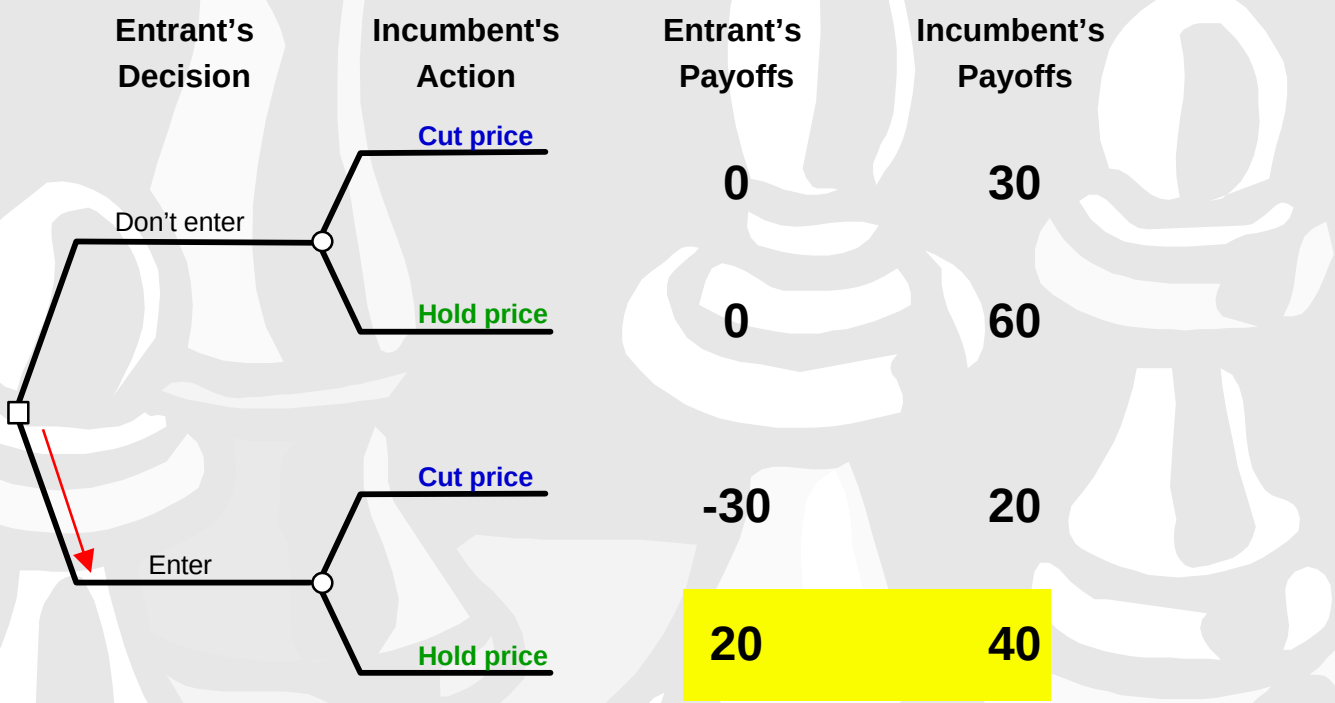

Knowledge of the competitor's payoffs is critical to getting the right strategy recommendation.

The equilibrium is the more robust outcome because no matter what information is revealed, the optimal strategy choice does not alter.

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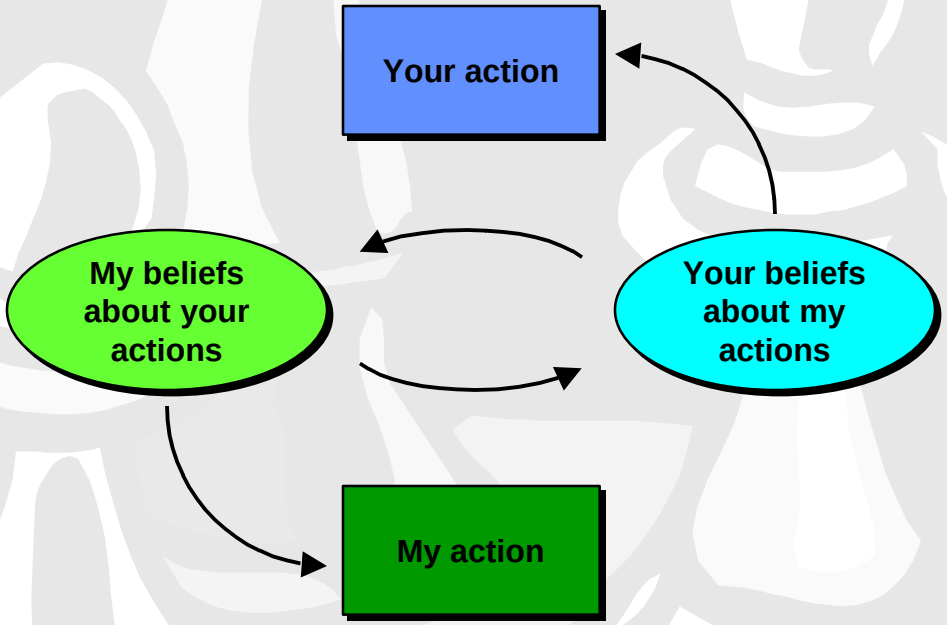
What is the cause for this discrepancy?

In these games there are two types of uncertainty:

- Structural uncertainty: uncertainty surrounding the parameters of the game, e.g., industry-specific factor, economy-wide factors.
  - Game theory distinguishes between games with “complete information” and “incomplete information.”
  - Decision Analysis incorporates these uncertainties into uncertainty nodes.
- Strategic uncertainty: uncertainty surrounding the purposeful behavior of players.
  - Game theory places very little importance on this uncertainty.
  - Decision Analysis places this uncertainty at center stage.

Why does game theory place such little importance on strategic uncertainty?

Game theory assumes that there exists common knowledge between the players of the game.



Decision Analysis is more restrictive on allowing infinite circular reference.

Theoretically, strategic uncertainty can be treated as any other uncertainty.

- The theory builds on the notion of a "Bayesian-Nash Equilibrium" introduced by John Harsanyi (1967).
  - In games of incomplete information, players can create a probability distribution over their beliefs of the "type" of competitor they are facing.
- Recently, this concept has been extended to incorporate strategic uncertainty as one kind of uncertainty around type.
  - In the game theory literature, this ability to incorporate has been called "interactive belief system" [1]

[1] *Aumann & Brandenburg*

Why would game-theoretic considerations be important to DA practice?

- An equilibrium concept is important because it indicates a stable outcome to the game.
  - Even after the results of the game are revealed, no player would want to change their strategy, given other players reactions.
- The quality of the decision is improved by placing oneself in the “shoes” of the competitor.
- Many “Good Decision, Bad Outcome” scenarios would be avoided.
  - An unexpected action by the competitor does not occur.
- There are a number of business situations where this approach would be applicable:
  - contract negotiations
  - bidding situations
  - mergers and acquisitions
  - situations where a client interacts with another company

How can we apply these Game Theory concepts to DA practice?

- As a first pass, as always, we should consider a competitor's potential payoffs when assessing the likelihood of a particular action.
- We should also attempt to explicitly model an opponent's payoff in order to eliminate possible alternatives that are internally inconsistent for the opposing company.
- In addition, this may lead to possible alternatives of the client that could also be discarded.
- In this way, we can use game theory and logical deduction to reduce uncertainty about a competitor's actions.

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