Decision Analysis and Game Theory: Competition or Complementarity?

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The insights decision analysis (DA) can bring to situations with great uncertainty are profound. As a result, a plethora of companies and consulting firms use DA and it has been applied effectively in many industries to help decision-makers make a wide range of important business decisions. However, DA cannot deal effectively with interactive, multi-party decisions – those in which the decisions of different parties can or should influence one another. To analyze such situations, another tool from the decision science family, game theory, should be used. Game theory should be seen as another tool in an analyst's toolkit, and one that is complementary to DA. While game theory is different than DA in subtle but profound ways, it is also a tool that can build on and be seen as an extension of DA.

Some DA practitioners ask me, "Why can't I just use DA for such interactive problems?" This article will attempt to explain why DA should not be used for interactive influence issues. Indeed, I hope to show that such questions are akin to a handyman saying, "Why can't I just hammer in a screw rather than use a screwdriver?" If analysts expect to help decision-makers make good decisions in an interdependent environment, they must add game theory to their toolkit. Game theory is not in competition with DA. It is a tool that is both complementary to and compatible with DA principles and techniques and one that can help analysts address issues they would otherwise avoid or treat poorly. Indeed, game theory applied smartly can be an extension of DA. Bringing game theory into the toolkit is, in fact, an opportunity for intellectual and professional growth for DA practitioners that will also enable the decision-makers they serve to become more savvy strategists and negotiators.

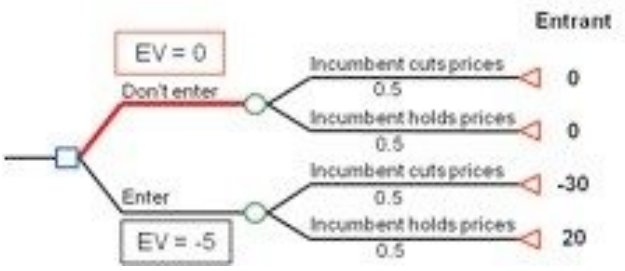
The Illogic of DA for Interdependent Decision-Making

In DA we cannot model moves by other players in a tractable or sensible fashion. For one, decision trees require that we assign probabilities at every possible node for moves by other players. Obviously, this can easily lead to a highly subjective and arduous process, especially as the decisions for other players in an action-reaction environment increase.

Second, even if we are inclined to assign probabilities at nodes for other players' moves, doing so encodes what we know or imagine today. As such, it blocks our ability to learn anything from analysis about others' motivations and incentives.

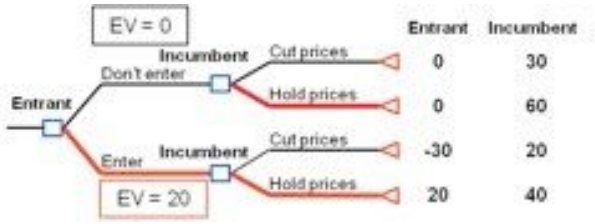
Third, assigning probabilities to others' moves is inconsistent with the action-reaction, chess-type of logic that businesses are actually engaged in (or should be in), when determining what the best course of action is. No one playing a game of chess asks themselves what probability their opponent will move a rook, a knight, or a bishop. Instead, chess players attempt to think about how their possible moves may best be countered by their opponents, and in so doing try to think ahead several moves and analyze how the game could unfold. Game trees, by treating all players' decisions as choices and incorporating each player's payoffs, can help us capture the logic of chess, for we are able in game theory to look forward and reason back, much as we would try to do in a game of chess.

In part for each of these reasons, using DA will provide a far less reliable answer than game theory would. To illustrate, consider this simple example about a common business question, market entry. Below we see that a potential market entrant has a decision to enter a market or not, and using DA we would assign probabilities to whether the incumbent should cut prices or hold them. Based on the 50-50 probability assigned here, we find the expected value (EV) of entering is negative, and so the entrant should not enter.



Using game theory to analyze the question, we treat the incumbent's decision as a decision, not an uncertainty, and consider what the payoffs would be for the incumbent as well as for the entrant. The tree thus looks like what is below, and we get a much different answer. By looking forward and reasoning

back, what is called backwards induction in game theory, we see that the incumbent would always prefer to hold prices. As a result, the entrant should prefer to enter the market, for it can get 20.



For the reasons elucidated above, no one in academic economics or social sciences circles would use decision theory for an interactive issue, and no one has for a very long time. 2005 Nobel Prize winner Thomas Schelling made the argument most cogently in his 1960 classic, *The Strategy of Conflict,* when he wrote that it was "retarded" to think about international political-military strategy (e.g., nuclear deterrence) without adopting an interactive approach. To Schelling, a game-theoretic approach was essential because of its focus on understanding how an individual's best course of action depends on his or her expectations of what others will do. Using game theory (that is not zero-sum), Schelling argued, was essential and insightful for analyzing what he called "mixed-motive" or "bargaining" games, in which there is "a mix of mutual dependence and conflict, of partnership and competition." Although he was not writing about business, many business situations involve competitive-cooperative dilemmas that are perfectly analogous to the political-military world with which he was concerned.[5]

In announcing the 2005 award, the Royal Swedish Academy of Sciences pointed to Schelling's book in particular as helping to make game theory "the dominant approach" to understanding conflict and cooperation in international affairs, economics, and throughout the social sciences.[6] Indeed, game theory is now widely considered in academia to be "the science of strategic thinking."[7] In fact, as a former academic who long studied international relations, I know of no significant piece of work in the past 30 years that used decision theory rather than game theory to address issues involving multiple parties in the international arena.

Yet when it comes to the science and practice of business strategy, game theory has had little traction. Business strategy is much like international strategy was fifty years ago, when Schelling's path-breaking book was published. There are several reasons why, which I won't go into here, but the point is, DA practitioners and decision-makers need to understand that game theory is an important tool for understanding issues around competition and cooperation that are commonplace in the business world. DA is not the only tool, and should not be a hammer used for all types of problems. If game theory can be practical to business problems, not simply an academic tool, it should be added to the toolkit.

Applying Game Theory in Business

Two questions need to be addressed: When should game theory be used? How can game theory be applied effectively?

The diagnostic question is a critical first step. Just as it would be imprudent to use a hammer to nail in a screw, it would be inappropriate to apply game theory to some business problems.

In short, game theory is appropriate for business strategy when companies need to gain insight into interactive situations with influence potential—i.e., one's actions can affect the choices others will make, and vice versa. Without such influence potential, DA (or a "real options" variant) is generally applicable to situations with great uncertainty. At times, DA is about evaluating big bet decisions. But DA can also, in what some would call real options, address how the choices we make today can affect the choices and information we have in the future. Such analysis incorporates the value that comes from anticipated learning and the flexibility to take advantage of it through downstream decisions. Whether the problem is of the big bet variety or has learning events, decision

[5] Thomas C. Schelling, *The Strategy of Conflict*, (Cambridge, MA and London: Harvard University Press), 1960/1980.

[6] The Royal Swedish Academy of Sciences, "Press Release: The Bank of Sweden Prize in Economic Sciences in Memory of Alfred Nobel 2005," October 10, 2005.

[7] See Avinash K. Dixit and Barry J. Nalebuff, *Thinking Strategically: the competitive edge in business, politics, and everyday life* (New York: Norton), 1991.

trees are typically used to map out a company's choices over time and key "chance event" uncertainties, and analysts are able to quantify value and risk, compare strategic alternatives, and systematically focus on the factors that truly drive value.

As another branch in the decision sciences, game theory has many similarities, but also some powerful differences. As discussed above, other players' moves are treated as uncertainties in decision trees, though in practice they are often ignored altogether, while game trees explicitly model other players' choices as decisions. Game theory requires consideration of the payoffs (value) to each of the players in the game tree, not just to one company, as is done in decision analysis and real options. Meanwhile, all the chance event uncertainties prominent in decision analysis and real options work can be incorporated in game trees and associated economic models. Thus, game theory is most appropriate whenever there are influence issues, whatever the nature of the uncertainties. Hence, game theory can extend DA, incorporating all the types of uncertainties we would find in DA models, but treating other players as decision-makers and enabling a rigorous examination of chess-like action-reaction dynamics.

The key to applying game theory effectively is to address five basic questions drawn from game theory:

1. Who are the key players?
2. What choices do they have?
3. In what sequence do they make these choices?
4. What are the key uncertainties?
5. What are the payoffs to each player for each possible outcome?

I have not seen these five questions in any game theory text, or anywhere else. Nonetheless, they are the core of game theory models and the key to making game theory practical in the business world. These five questions underpin the Strategic Gaming process I developed and that my firm applies regularly in business to use game theory.[8]

[8] For an extensive discussion of Strategic Gaming, see my book, *Game Theory for Business: A Primer in Strategic Gaming* (Probabilistic Publishing, 2010).

In incorporating uncertainties and developing economic models that provide the payoffs for each player, Strategic Gaming models draw extensively from DA principles and techniques—tornado diagrams, s-curves and the like all can figure prominently in such work. DA is taken to another level though, enabling us to think carefully about others' perspectives as well as our own, gaining valuable strategic and tactical insights. By drawing on basic game theory principles and methods, as well as DA, Strategic Gaming helps executives, managers, and negotiators gain clarity about what the "game" that they are playing looks like, and how to best move and influence others at both the strategic and tactical level over time and across potential contingencies.

By forcing a focus on the interdependence of choices between players in a practical way, Strategic Gaming helps make the science and practice of business strategy smarter. In dozens of applications for small and large companies in various industries, it has enabled analysts, strategists and negotiators to efficiently and effectively tackle a wide range of business strategy questions in which competitive-cooperative dilemmas are a central concern, from deal-making to competitive risk and partnering strategy. These applications have enabled strategists and negotiators to capture or save billions of dollars of value by gaining clarity about complex interactions and puzzling competitor behaviors, and by finding opportunities and commercial risks they had not seen previously. Executives have come away with a great capacity for shaping and playing "the game" to gain strategic advantages and avoid being blindsided by competitors, partners, suppliers, governments, and other players.

Time to Move Forward

Game theory and decision theory are in the same decision science family, and Strategic Gaming and DA are valuable, practical applications of game theory and decision theory respectively. They should not be seen in competition. Analysts have a choice about which tool should be used for a given situation, and decision professionals should use the appropriate tools for the situation at hand. Where there are significant uncertainties, but influence issues are not present, DA or its real options variant are useful. If there are influence issues, game theory is generally applicable and Strategic Gaming is a practical application of game theory that extends DA.

DA practitioners and advocates should see this as an opportunity to add another tool to their toolkit, to grow intellectually and professionally, and to serve decision-makers more ably on a wider range of difficult and interesting business strategy issues. While game theory and Strategic Gaming are fairly straightforward, the learning involved to add to the toolkit is not trivial, but seldom is anything of value.

For DA practitioners who choose to enter the learning curve, I have found two words of advice —"immerse yourself"—to be particularly useful. Those who have tried to learn a foreign language know that if they try to translate everything into their native language rather than immerse themselves, learning is much slower and more painful. Similarly, even though game theory looks very similar to DA and is in the same family, one should not try to translate what they are learning about game theory into a DA language or mindset. To a large degree, DA is designed with an engineering mindset. Game theory requires a somewhat different way of thinking, what I would call an economist's mindset, to model and draw out useful insights. Given the different thinking required, I typically advise long-time DA practitioners who are learning game theory to immerse themselves, as if they are learning a foreign language. Those who have immersed themselves have learned it well and been able to use game theory to great effect.

Though learning is involved, and the mindset of game theory is somewhat different than DA, game theory should be seen as another tool in an analyst's toolkit and one that is complementary to DA. Though different than DA in subtle but profound ways, game theory is also a tool that can build on DA principles and techniques. It is a tool that will also enable its users and consumers to rigorously evaluate a wider range of strategy issues and enable savvier strategizing and negotiating.

Society of Decision Professionals

By Hilda Cherekdjian, Column Editor

The SDP was launched a year ago by the community of decision professionals and has reached a membership of about 200. Members are from around the world, the public and private sector including students as well as seasoned professionals. A newly elected board of directors took office on July 1st 2011. The SDP board is comprised of global decision professionals from both the public and private sectors. This diversity ensures that SDP will continue to benefit from a set of diverse experience, knowledge, and skills.

Elected officers are Carl Spetzler, President; Frank Koch, Vice President; William Leaf-Hermann, Secretary; and Tony Manzella, Treasurer. Elected as board members are Jay Andersen, Eric Bickel, Ellen Coopersmith, Jim Felli, Eric Johnson, Jack Kloeber, Larry Neal, Greg Parnell, and Katherine "Trina" Weller.

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SDP Learning Exchange

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1. "**Ordered or Unordered? – A different angle from which to look at the complex issue of resource sustainability"** presented by *Patrick Leach, SDP Fellow*
2. "**Rethinking VOI: How the Game Changes Things"** presented by *Paul Papayoanou, PhD*

Please note SDP is proudly sponsoring an upcoming learning exchange webinar - a "Best Technical DAAG 2011" presentation:
The "Discretization, Simulation and Swanson's (Inaccurate) Mean" Featured speaker *Eric Bickel*
Wednesday, September 14, 2011 at 8:30 a.m. PDT