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Forecasting games: can game theory win?

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Abstract

I present evidence to suggest that studying the use of game theory in prediction is a legitimate area of research and suggest ways in which game theory might be used to make or support predictions. Green's study predominately assesses the accuracy of predictions by game theorists (who *may* have made informal use of game theory concepts) rather than predictions obtained from formal game theory models. I argue that the accuracy of predictions derived from such models is likely to be contingent on the characteristics of the conflict and provide a partial taxonomy of these characteristics, together with their hypothesised effects. I also argue that it would be worth investigating the potential use of game theory as an aid to obtaining probabilistic predictions.

1. Introduction

The paper by Green (2002) deals with a fascinating and important area, namely the prediction of outcomes of conflicts. The paper extends earlier work, reported in Armstrong (2001), which has shown that the use of role playing to predict the outcomes of conflicts leads to forecasts that are significantly more accurate than those obtained through unaided expert judgment. In the current paper, the focus is on the relative accuracy of forecasts obtained through role-playing and game theory. This commentary addresses four questions: (i) Is it legitimate to study the use of game theory for prediction? (ii) Is game theory being assessed in the study, or game theorists? (iii) To what extent can we draw practical inferences from the results of the study. (iv) Where should future research effort be directed?

2. Game theory and prediction

A key question underlying the paper is: *should game theory be used for prediction* or is it essentially a prescriptive tool designed to aid decision-makers who have to make strategic choices under conditions of conflict? There are close parallels with decision analysis here. Much evidence suggests that *unaided* decision-makers do not make choices consistent with those suggested by decision analysis (Goodwin & Wright, 1998). Allais's paradox (Allais, 1953) where people violate the prescriptions of utility theory, is a famous example of this.

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Factors like habit, the inability of decision makers to process all of the information associated with a decision, and the consequent use of mental heuristics (Goodwin & Wright, 2001; Tversky & Kahneman, 1974), are all likely to lead to discrepancies between what people choose and what normative methods say they should choose. Indeed, the *raison d'etre* of a prescriptive technique is that the unaided decision maker would make a different (inferior) decision to that prescribed by the technique.

However, two factors suggest that the use of game theory in forecasting *is* a legitimate area for investigation. First, I selected a convenience sample of six introductory textbooks on game theory and found that two of these suggest that the technique does have value as a forecasting method. For example, Dixit and Skeath (1999), in their book 'Games of Strategy', state:

> The second use (of Game Theory) is in prediction. When looking ahead to situations where multiple decision makers will interact strategically, we can use game theory to foresee what actions they will take and what outcomes will result.

Indeed, as Hargreaves, Heap, and Varoufakis (1995) point out, regarding game theory as merely a prescriptive technique would: ''greatly undermine [its] attraction since the arresting claim of game theory is that it can be used to explain social interactions''. Explanation is, of course, a necessary precursor of insightful prediction.

Second, game theory *is being used* as a predictive technique in practical contexts. For example, Decision Insights Inc. of New York, who claim to work with Fortune 500 companies, government institutions and investment banks, amongst others, state on their website (www.diiusa.com) that they:

> . . . develop practical game theory models . . . to [inter alia] forecast the outcome of political events that influence business activity.

3. Game theory or game theorists?

The second main question about the paper is: *is game theory being assessed or game theorists*? To consider this, it may be instructive to consider the possible approaches a game theorist might adopt when faced with the task of prediction. The 'purest' approach would involve the exclusive use of a game theory model to derive the prediction. To achieve this the game theorist would, ideally, need to obtain information on factors such as the number of players, the strategies available to the players, and the players' utilities (which are likely to be multiattributed) for all strategy combinations. In addition to this, information on the type of game would be required. For example, do the players determine their moves sequentially or simultaneously; do all the players have full information or is some information known only to certain players; can the rules of the game be manipulated; are agreements enforceable? While modern game theory is capable of handling a diverse range of game types, much of this information may be difficult to obtain. For example, determining players' multi-attribute utilities will be dependent on having knowledge of their value systems and attitudes to risk. When this knowledge is not available, approximations or assumptions will be required. For example, a multiattribute utility function might be approximated by ranks designed to reflect the relative attractiveness of a game's outcomes to a given player. Sensitivity analysis may be useful in situations like this to determine the robustness of predictions to changing assumptions. Nevertheless, inadequate models may still lead to erroneous predictions. For example, in ex-

perimental studies, the failure of game theory models to predict accurately players' strategies in simple games involving monetary outcomes has been attributed not to game theory per se, but to the fact that the models did not include the players' tendency to reject outcomes which were perceived as being grossly unfair to the other player (Thaler, 1988; Cameron, 1995).

In view of these difficulties the game theorist might, instead, use a game theory model to clarify his or her thinking, but then make a judgmental adjustment to the model's prediction to try to compensate for the deficiencies of the model. In this approach, the game theory model is being used as a forecasting support system. While in both approaches the model will reflect the subjective perceptions and skill of the game theory expert, in the second approach the judgmental adjustment is not formally based on game theory.

Finally, the game theory expert might not employ game theory explicitly at all, but simply make a judgmental prediction of the outcome of a dispute. The rationale for employing a game theorist here would be that being an expert in a discipline leads to the concepts associated with that discipline becoming ingrained in one's thinking, even when the method is not being explicitly used. Some people argue that this may be the case. For example, the Nobel laureate, Paul Samuelson has written ''To know game theory is to change your lifetime way of thinking'' (see Dixit & Skeath, 1999). However, if game theorists do predict in this mode it is useful to distinguish between their use of game theoretic thinking and the possibility that they may simply be drawing on their experience of studying a large number of conflict situations.

Green asked the game theorists in his study how they arrived at their predictions and he has helpfully provided details of their responses on the Internet (at http://decision.co.nz/approach.pdf). There is little evidence in these responses that most of the experts were formulating game theory models of the situations—either to produce their forecasts directly, or as a basis for subsequent judgmental prediction (an impression supported by the five independent raters who studied the game theorists' explanations). This suggests that most of their forecasts were purely judgmental. However, since the game theorists were significantly more accurate in their predictions than unaided judges it appears that either their 'ingrained game-theoretic thinking' or their experience as students of conflict situations, or both, were acting to their advantage. Unfortunately, it is not possible to discriminate between these possibilities on the basis of the explanations provided.

4. Practical inferences?

The next question is: *to what extent can we draw inferences from the results of the study for practical forecasting*? In the early stages of research in a new area there is always a temptation to draw unconditional conclusions from results. Later research often reveals that conclusions are contingent upon particular circumstances. How might conditions in conflict situations vary, and are there any conditions where the use of game theory might be expected to lead to accurate predictions?

Raiffa (1982) has constructed a partial classification of conflict situations (he admitted that it was impossible to obtain a complete taxonomy of all possible disputes). This classification has been used as a starting point for the list of characteristics shown in Table 1. Hypotheses about whether the characteristics will be detrimental or favourable to accurate prediction by game theory are also given in the table. The hypotheses are based mainly on the extent to which the conditions mean that outcome of the conflict is likely to be predictable or whether the

Table 1
Characteristics of disputes and their likely effect on game theory forecast accuracy

	Characteristic
Favourable:	
Low uncertainty	Good knowledge of payoffs by parties
	Option sets clearly defined and known by parties
	Rules of game known by parties
	Honesty and openness in negotiations
	Third party intervention possible
	Monolithic parties
Reduced complexity	Use of decision aid by at least one party
Learning	Repetitive negotiations
Professionalism	Skilled experienced negotiators
Unfavourable:	
Bounded rationality	Payoff dependent on more than one attribute
	More than two parties
	Large number of options
	Linkage between issues
	Time constraints on deal
High uncertainty	Negotiators need ratification
	Creative/flexible negotiators
	Contract not binding
Emotional factors	Parties subject to emotional influences

Source: adapted from Raiffa (1982).

conditions are consistent with the three key assumptions of game theory (Hargreaves et al., 1995). These are that parties in the conflict:

1. are instrumentally rational;
2. have common knowledge of this rationality;
3. know the rules of the game.

These assumptions essentially imply that the parties in a conflict will be utility maximisers who also know that the other parties are utility maximisers. These parties will also know: (i) all the possible actions available to themselves and the other parties, and (ii) the payoffs that will accrue to each party contingent on combinations of these actions being chosen (although some of this information may be held in probabilistic form). Despite these core assumptions, it should be acknowledged that game theory can embrace *some* situations where there is uncertainty and incomplete information, even when this uncertainty relates to the sets of available strategies and the rationality, or otherwise, of an opponent (Dixit & Skeath, 1999, p. 35).

How robust are the key assumptions of game theory likely to be across a variety of conflict situations? Simon's (1955) concept of bounded rationality suggests that, as the complexity of the game increases, the decision making parties will lack the mental capacity to process all of the information needed to maximise utility. As indicated in Table 1, this suggests that game theory will be less effective in forecasting their actions. Departures from utility maximisation as a result of emotional factors will have a similar effect. For example, in a series of negotiations, parties who feel they have behaved badly in earlier disputes may be more amenable to yielding concessions in subsequent negotiations to compensate for their behaviour. Similarly,

conflicts where the parties have poor quality information about the available sets of options, or the contingent payoffs, are also likely to lead to outcomes that deviate from the predictions of game theory. Indeed, the actions of creative negotiators who *invent* mutually attractive options during the negotiating process (Raiffa, 1982; Goodwin & Wright, 1998) will be particularly difficult to predict.

In contrast, there is some experimental evidence that after several *repetitions* of playing relatively *simple* games, which each have a unique Nash equilibrium, with different opponents, people do learn to play the Nash equilibrium strategies predicted by game theory (Davis & Holt, 1993). Observations of baseball and tennis players also suggests that experience of playing games repeatedly can lead to the use of strategies that are consistent with Nash equilibria (Dixit & Skeath, 1999, p. 215). Similarly, the Ghemawat and McGahan (1998) study, cited by Green, found that repeated games between electricity generators were forecast relatively accurately through game theory, when they involved a small number of players. In addition, there is some, albeit limited, evidence from experiments that professional negotiators may behave more consistently with the predictions of game theory than non-professionals do (Potters & Van Winden, 2000).

Some of the factors in Table 1 will be more important than others, depending on the context of the dispute, and there are also likely to be interactions between the factors. For example, research suggests that repetitive games involving single attribute payoffs may be amenable to accurate game theory predictions, but repetitive games, which involve the need for the parties to use probabilities, because of uncertainty in information, are less amenable (Davis & Holt, 1993). Clearly, other factors could be added to Table 1. For example, it also seems likely that whether the negotiations are held in public or private will effect the outcome, but it is difficult to anticipate the effect of this on the value of game theory as a predictive tool.

5. Suggestions for further research

Table 1 considers how the characteristics of conflict situations may affect the accuracy of game theory predictions. However, it does not consider the accuracy of these predictions *relative* to those of other methods, like role-playing. For example, some of the characteristics that are favourable to game theory may also favour other methods, possibly because they simply make the conflict inherently easier to predict. Further research will be needed to discover whether there are characteristics that uniquely favour prediction by game theory.

It is also worth noting that, in the experiments described by Green, the participants were faced with a choice from a fixed set of pre-determined options. In real-time negotiations new options and opportunities may emerge and environmental factors and pressures on negotiators may change (e.g., an initially supportive public may tire of the disruption caused by a trade union's dispute). Clearly, the true test of the relative power of the methods discussed in the Green study is whether the outcomes of current, hitherto unresolved, disputes can be accurately predicted.

Finally, it is surely worth investigating probabilistic prediction (e.g., an estimate that there is a 0.3 probability that the outcome will be x and a 0.7 probability that it will by y)—Brier scores, or similar approaches, could be used to evaluate the forecasts. Probabilistic predictions would seem to be a natural way of addressing the uncertainty inherent in the outcomes of conflicts. They convey more information than simple predictions of the most likely outcome and they would be a necessary input to some normative decision models (e.g., decision tree models based on expected utility) where a

decision maker needs to take into account the possible outcomes of a conflict. It should not be forgotten that game theory itself often prescribes that parties should select strategies in a probabilistic manner through the device of mixed strategies. Surprisingly, although probabilistic prediction was available to the game theory experts in the Green study, only one respondent adopted it for just one of the predictions.

6. Concluding comments

There are a number of ways in which game theory *might* be useful in forecasting the outcomes of conflicts. Green's study has predominantly investigated the accuracy of the judgmental forecasts by game theory experts and found this to be inferior to the accuracy obtained through role playing, but superior to unaided forecasts produced by students. However, the use of formal game theory models to support judgment, and the use of the models in their own right, also appear to be worth investigating. In using such models there are likely to be two main sources of possible forecast error: incompleteness in the information available to the modeler and the failure of disputants to behave consistently with the assumptions of game theory. This suggests that some types of conflicts may be more amenable to predictions involving formal models than others. Further research effort could be directed into identifying these situations, while the use of game theory to produce probabilistic predictions is also worth investigating.

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