Game theory in marketing science
Uses and limitations

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This paper reviews some major concepts in game theory and indicates how they may apply to marketing science. The theory of games provides a framework for addressing problems of competitive strategies and of buyer–seller interactions. These issues are important in studying industrial markets where there are a small number of buyers as well as for studying how to incorporate knowledgeable, active competitors into consumer marketing mix models.

Few marketers have seen much benefit in the past from developments in game theory. This is partly because of the historical preoccupation of game theorists with complete information, zero sum games. The richer area of games of incomplete information may have much more to offer the marketing scientist.

In this paper we review how game-theoretic approaches (interactive models) differ from most previous approaches, which are optimizing and asymmetric. We then look at how these alternative approaches apply to two problem areas – competitive entry and bargaining. Then we review potential applications of game theory in marketing and the value of applying marketing science approaches in game theory. We conclude with a perspective on future developments in this field.

1. Introduction

Recently, there has been a revived interest among marketing scientists in the use of game theory as a tool for analyzing problems of competition and negotiation in marketing. This has led to major survey articles by Moorthy (1984), which introduces and summarizes new developments in game theory and by Eliashberg and R. Chatterjee (1984), which examines models of competition in marketing in an implicitly game-theoretic framework.

Game theory has also become an increasingly frequent mode of analysis in economic theory, where the preoccupation with models of perfect competition is giving way to discussions of more interesting market and information structures. (The previously cited papers by Moorthy and Eliashberg and R. Chatterjee discuss some of these approaches.)

Despite this surge of interest among theorists, marketing practitioners often remain dubious about the usefulness of game theory. Their views may be summarized in the following statement in Wagner’s (1975) popular operations research textbook:

‘In practicing operations research we have found that game theory does not contribute any managerial insights into real competitive and cooperative decision-maker behavior that are not already familiar to the church-going poker player who regularly read the Wall Street Journal.’ (p. xi)

Lazer and Thomas (1974: 578–592) also regard it as ‘(...) highly unlikely that game theory will be used to solve any practical marketing problems’. On the other hand, Henderson (1984: 5) says:

‘The emergence of grand strategy concepts for business has been severely handicapped by the lack of a comprehensive general theory of dynamic competition. Only in game theory has a systematic and methodical approach been developed.’

The critics of game theory have usually concentrated their criticism on the rationality and informational requirement of the theory – notably the assumption that the payoffs of

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The authors wish to acknowledge the assistance of Eunsang Yoon.

Intern. J. of Research in Marketing 3 (1986) 79–93
North-Holland

all competitors from any choice of strategies are common knowledge. Work in game theory following Harsanyi (1967, 1968a, b) has substantially relaxed this troubling assumption and has thus brought the theory more in line with the real world. However, there still remain doubts about the underlying assumptions and the value of the results of a game-theoretic analysis to a marketing practioner.

This paper examines the potential value of and possible pitfalls in applying game theory and we hope that the nature of the remaining doubts will be clarified in the course of the discussion.

In the next section we will analyze how game-theoretic models differ from previous marketing models. Our answer, in brief, will be that the earlier models were primarily optimizing, and asymmetric, taking the point of view of a single decision-maker, while game-theoretic models are interactive, seeking to determine an equilibrium among several active decision-makers. The equilibrium, however, is not the competitive equilibrium that appears in economic theory, though for large numbers of economic agents the two notions could approximately coincide (see Debreu (1952), and Wilson (1978)).

The following two sections will then illustrate the advantages and disadvantages of each approach in two different application areas. In the first application area, that of competitive entry, we shall discuss the papers of Hauser and Shugan (1980), Eliaishberg and Jeuland (1982), and Saloner (1982) as illustrations of different approaches to competitive entry problems.

The second area, that of bargaining, discusses the papers of Neslin and Greenhailgh (1983) and the approach advocated by Raiffa (1982) as well as the formal game-theoretic models with incomplete information that have appeared recently.

In the final section, we offer concluding comments.

This paper does not aim to be an exhaustive survey of marketing applications or to be a tutorial on game theory. The choice of illustrations reflects the interests of the authors, but we hope that they throw some light on the uses and limitations of game theory in marketing.

2. Optimizing and interactive models

2.1. Optimizing (asymmetric) models

Most of the marketing decision models that appear in the literature (see, for example, those discussed in Lilien and Kotler (1983)) adopt the point of view of a single, active decision maker. Competitors are either assumed not to react or the decision maker subjectively assesses what the reaction could be. Given this mode of handling competition, the model than helps the decision-maker choose one or more elements of the marketing mix in order to optimize some objective function (to maximize profits or sales response, for example). We shall refer to such asymmetrically prescriptive models as 'optimizing' models.

These models use a variety of techniques. When the environment is known (that is, under certainty), mathematical programming or its dynamic version, optimal control theory, are the tools frequently employed. For example, see, Little and Lodish (1969) for media scheduling, Lodish (1980) for broadcast spot pricing, and Sethi (1973) for advertising spending.

Under uncertainty, the appropriate framework is that of Bayesian decision analysis, where the decision-maker chooses a decision or sequence of decisions to maximize his subjective expected utility and learns from observation using Bayes' theorem. The proponents of Bayesian decision theory often do not distinguish between natural uncertainty (for example the uncertainty associated with tomorrow's weather) or strategic uncertainty
(uncertainty about the actions of competitors). In their view, then, the analysis of competition could proceed in the framework of an optimizing, decision-analytic model with the appropriate subjective probability distributions on the competitors' possible choices. This point of view is expressed forcefully by Kadane and Larkey (1982). To them, the essential task is collecting normally highly diffuse market data about the behavior of competitors and, in general, other decision makers, to be able to assess a 'good' probability distribution. Thus:

'(...) the empirical data (...) support the conclusions that opponents tend to be "actually or potentially irrational" and hence we attach urgency to further psychological research on actual behavior of people making decisions in game situations.' (Kadane and Larkey (1982:124))

This is appropriate in situations where the actions of competitors are decoupled from one's own actions and where such data is normally available. Highly diffuse markets with little concentration of market share, in which the indifferent competitor-weaker buyer paradigm is appropriate, fit this framework. However, many non-consumer markets are characterized by a small number of buyers, each of whom may yield significant power. In these markets, the competition tries to guess what any major firm may be doing and to optimize against that set of actions. Competitors' likely actions may not, therefore, correspond to their past behavior on which data may be available, but may be based on rational optimizing behavior. Paradoxically, it seems that only firms with a relatively minor market share position can expect competitive strategies to be decoupled from their own strategies.

2.2. Interactive models

The potential inadequacy of the asymmetric, optimizing framework is therefore its lack of interactive considerations - the fact that one's opponent is also using an optimizing model. Game theory provides solution concepts that take into account this mutual interaction of optimizing models. The most popular and frequently used one is that of non-cooperative (Nash) equilibrium. This concept will be discussed shortly. However, we should point out that, in our view, the asymmetric decision-analytic approach has a number of strengths. It is simple to use and it can generate a large number of explicit recommendations to problems too complex to be analyzed by game theory. Naive application of this kind of model may be dangerous, but sophisticated application (with a strong dose of formal or informal game theoretical insights thrown in) may, in fact, be the best option for a manager.

Since Moorthy (1984), among others, has expanded on the equilibrium notion in detail, we shall not do so here. We do include a brief discussion of the basics of game theory in order to make this paper self-contained.

Our concern is with non-cooperative game theory since this seems particularly appropriate for a discipline focused on competition. The crucial difference between a non-cooperative and a cooperative situation is that, in the former situation, agreements between decision-makers have to be self-enforcing. That is, each decision-maker must find it in his best interest to choose the action recommended in the agreement, since binding contracts are not permitted or not enforced.

The 'best interest' of a decision-maker is represented by a von Neumann-Morgenstern (cardinal) utility function. Every decision-maker is assumed to have one and, in games of complete information, all these utility functions are common knowledge. The cardinality of the utility scale is needed for the use of randomized strategies, which we shall mention briefly later. The interested decision-makers are called players; each has a set of possible strategies (or decision sequences) which is usually assumed to be convex, com-
pact and (one hopes) non-empty. If environmental uncertainty is present, then another 'player', chance, is added. Chance 'chooses' a resolution of the uncertainty in accordance with some commonly-known probability distribution.

The normal form of the game (as the decision-making context is labelled) specifies the outcome (in terms of the payoffs in expected utility to each player) corresponding to a choice of strategy by each player and by chance. Note that in calculating the normal form, players are assumed to choose their strategies simultaneously in a one-shot game. This is not a real restriction, since we can model a sequence of moves and counter-moves (known as an extensive form of the game) in this framework by defining a strategy suitably. Notice we defined a strategy as a decision sequence, not as a decision; a strategy specifies a decision at every distinguishable move. For details, see Luce and Raiffa (1957), which still remains the most lucid exposition of the basics of game theory.

Formally, the notion of Nash equilibrium defined with reference to the normal form asks us to look for a n-tuple of strategies (if there are n decision-makers) consisting of strategies that are best responses to one another. In a two-player game, if we find a pair of strategies such that player A's strategy is optimal for A given B's strategy and moreover B's strategy is optimal for B given A's strategy, we are at an equilibrium. Neither player can gain by a unilateral switch to a non-equilibrium strategy. (However, as the Prisoner's Dilemma game shows — see Luce and Raiffa (1957) — this does not mean that both cannot improve by a joint deviation.)

The notion of equilibrium is, in some sense, an interactive extension of an associated (implied) asymmetric decision analytic model. Suppose A develops an expectation of what B is likely to do. Suppose that A's conjecture of B's strategy is, in fact, B's equilibrium strategy. In that case, A could do no better than choose his own equilibrium strategy (using an optimizing model with a single-point probability assessment of B's strategy). Similarly, if B makes the 'right' conjecture about A's choice of an equilibrium strategy, B's optimizing model will yield his equilibrium strategy as a response.

The choice of the right conjecture thus enables the two separate optimizing models to be linked. The question arises, can one expect one's opponent to choose the equilibrium conjecture? (The question becomes more acute if there are multiple equilibria which we shall not consider here.) This is where the frequently criticized concept of game-theoretic rationality enters. A rational player will be able to calculate the equilibrium and see that the pair of conjectures entailed by it is mutually consistent. Moreover, he will never underestimate his opponent and will assume him to be rational as well.

In his reply to Kadane and Larkey (1982), Harsanyi (1982: 125) states:

'(...) game theory (...) is essentially a question of how to act in game situations against highly rational opponents (...) this line of inquiry actually is, and always has been, the main intellectual attraction of game theory... No psychologist studying how people perform arithmetic computations can develop a realistic descriptive theory of computing behavior without knowing arithmetic, i.e., without knowing the normative theory of correct computations — for he must explain any given computation move either as the correct move prescribed by normative arithmetic, or as a psychologically understandable deviation from the current arithmetic procedure. Likewise, a psychologist trying to explain a move by a given player in a game must explain it either as a move justified by normative gametheoretical rationality or as a psychologically understandable deviation from it.'

Other recent work on the equilibrium notion has proceeded to attempt to reduce the number of equilibria that could be considered reasonable outcomes of a game. The most promising of these refinements is the concept of perfectness in the extensive form (Selten (1975), Kreps and Wilson (1982)). This is discussed in Moorthy (1984) so we shall not give a detailed exposition. The main idea is
that an equilibrium in the normal form may, in fact, be unreasonable if it involves a player making threats that would be irrational for him to carry out if it becomes necessary to do so. If the threat is believed, it may sustain an equilibrium, but there is no reason for it to be believable. This does not imply that threats will not be made or that bluffs will not be used. It simply means that a player must pay attention to the credibility of the threat and that the analyst must see that threats that are made are credible. The notion is used in the papers in the next section.

2.3. Mixed strategies

The normal form game in table 1 does not have a pure strategy equilibrium. However, since it is a game with a finite number of pure strategies for each player, it does have mixed strategy equilibrium. For example, Player A should play \( a_1 \) with probability 12/17 and \( a_2 \) with probability 5/17. Marketers and decision analysts in general have always needed convincing about the value of mixed strategies. It is not easy for a subordinate to tell a superior that a decision should be based on the spin of a roulette wheel.

The rationale game theorists give for mixed strategies is that of maintaining secrecy. One's opponent is assumed always capable of going through every link in the most intricate chain of reasoning but cannot be expected to foresee the outcome of a random event. Randomization is then a way to prevent one's strategy choice from being fully anticipated and countered.

Since a mixed strategy would never need to be used in an asymmetric decision analytic model, it is one of the features that distinguishes the interactive equilibrium solution concept from the optimizing one. In our opinion, a key insight from the potential use of mixed strategies is that, if using a pure strategy communicates private information perfectly, it may be optimal to behave 'as if' the information is less precise than it actually is. The more competitive the market-situation, the more one expects to see this phenomenon occur.

2.4. Incomplete information

The game-theoretic model is capable of being extended to incorporate incomplete information about payoff functions. Harsanyi (1967, 1968a, b) introduced the idea, which was to model player A's uncertainty about player B's payoff by a chance move at the beginning of the game tree. The resolution of the uncertainty is then supposed to be communicated to player B and not to player A who knows only a commonly known probability distribution over the possible payoff functions for player B. The equilibrium concept is extended to this kind of game by defining a strategy as a mapping from a player's information to his decision, rather than as the decision itself.

The use of incomplete information models often, paradoxically, makes formal analysis more tractable in addition to making it more realistic. This is because a pure strategy equilibrium becomes more likely. (A player's uncertainty about the other player's payoff function mimics a roulette wheel.) Incomplete information models in bargaining also reduce the number of equilibria or provide focal equilibria that are more likely to be picked by the players.

We shall not discuss here the nuances of Harsanyi's formulation. The interested reader
is referred to the clear exposition in Myerson (1983).

2.5. Summary

In this section we contrast asymmetric optimizing models with formal interactive models with respect to the solution concepts that each type of model employs. We have also provided a brief discussion of various criticisms of game-theoretic notions and possible resolutions.

3. Handling competitive response in marketing models

Most marketing models use the consumer packaged good paradigm as a model of the marketplace: several sellers and a very large number of buyers. Operationally-oriented marketing modelers have traditionally handled competitive behavior in one three ways: (1) by ignoring it; (2) through a judgmental model approach (Little (1975), Buzzell (1964), General Electric Company (1980), Kotler (1965), Simon (1978)); or (3) through the reaction matrix approach (Lambin, Naert and Bultez (1975), Bensousson, Bultez and Naert (1978), Lambin (1976), Schultz and Hanssens (1976), Hanssens (1980)). These models/approaches have, deterministically or probabilistically, assumed the nature of competitive response (via a decision theory/judgmental model approach) or have tried to infer the nature of response from market data (the reaction-matrix approach).

Models based on axiomatic frameworks describing the marketplace have been appearing in recent years both in marketing and in economics. We shall discuss three of these: Hauser and Shugan (1980), Eliashberg and Jeuland (1982), and Saloner (1982). These papers are not directly comparable since they deal with somewhat different problems, but the choice of problem is often an indication of the power of the methodology. Our examination of these papers is in terms of three modelling features, namely:

(i) static models versus dynamic models,
(ii) optimizing versus equilibrium models, and
(iii) complete versus incomplete information models.

Hauser and Shugan (1983) concern themselves with the optimal response of an existing firm to a competitive new product entry. They adopt the framework of Lancaster (1971, 1980) in treating a product as a point in attribute space with consumer tastes being distributed over this space. At the time of the new entry, there are several existing brands in the market (occupying different points in attribute space). If the new entry is 'competitive' in the sense of competing for the same group of consumers, an existing firm may respond optimally by changing its price, its advertising, its distribution or the positioning of its product. None of the other existing brands is assumed to respond at all, and the effect of any changes in the focal firm's marketing mix is summarized through exogenously given response functions.

Given this framework, the authors derive several interesting results about the direction of change of price or advertising expense, for example, in an optimal response. An optimal response could be, for example, to decrease price or decrease distribution expense.

We shall not go into the results in detail, but will confine ourselves to commenting about the model. Many of our comments are anticipated by Hauser and Shugan themselves in their introductory remarks.

First, the model is a static model in that time does not enter in any essential way. As a result the model does not discuss any responses the new entrant might make to the existing firm's optimal response.

Second, the model optimizes for a given
firm assuming that all other brands remain passive. There is also no attempt to expand the problem description to incorporate the viewpoint of the entrant who should, presumably, be able to predict the optimal response derived in the paper and be able to position his product in an optimal way. (This would be akin to deriving a Nash equilibrium in a Stackelberg formulation of the game.) Operationally, this last piece of missing analysis might be especially useful, since a product manager could then be able to predict the attribute configuration of a possible entrant and contemplate possible preemptive strategies. (One preemptive strategy is briefly mentioned by Hauser and Shugan on page 337.)

On page 321 the authors express the hope that their model "is an important step towards a multiproduct equilibrium." However, noting that Lane (1980) had failed to obtain explicit analytical results beyond proving existence of equilibrium, the authors justify the strong assumptions about competition made in their model. To some extent, this is a justification many optimizing models in different areas can claim. The sequence of conjectures followed in reaching an equilibrium may render calculation of that equilibrium particularly intractable. We might then have a very general model with nothing to say. The asymmetric optimizing model, on the other hand, is capable of generating advice for managers. This theory has been extended and marketed under the name of Defender by Management Decision Systems, as a "new model and measurement system to determine the best response to a competitive new product introduction (cf. Klein (1984: 20))."

A third characteristic of this paper is that it is basically an analysis under complete information (though consumers may not be aware of some brands). There is no learning about firm characteristics either by other firms or by consumers. There is no explanation given, and this holds for the other models we shall discuss as well, why a particular firm should choose to enter the market or why it should enter earlier than any other firm. Consumers are also not modeled as learning about the available products through use, since the model is a static one.

The Eliashberg-Jeuland (1982) paper is also a complete information model, although it does incorporate dynamic features and does consider a duopolistic phase. The problem these authors address is essentially one of pricing policy over time in a dynamic model where one firm enters first and a second firm enters (with certainty) a specified period of time later. Once again, the entry decision is exogenous to the model; firms are not allowed to enter before or after the specified length of time. In the duopoly phase, which occurs after the second firm has entered, the change in market share of a firm is linearly related to the price difference between the two firms. This is exogenous to the model and could be contrasted with the Bertrand oligopolistic story in which the firm with the lower price gets the whole market if its capacity is sufficient. For a homogeneous commodity in a world without search costs and incomplete information, this relation is difficult to justify in equilibrium. However, product differentiation and incomplete information enables the model to use this framework in a reasonable way.

The Eliashberg-Jeuland paper thus uses the equilibrium notion in a competitive marketing analysis. The authors obtain appealing results but on a smaller range of issues than the Hauser-Shugan article discussed earlier in this section. However, in the duopolistic phase, the advice a manager would receive from Eliashberg-Jeuland would be contingent on assumed equilibrium behavior by the adversary firm as well as on the special features of the model.

As a final sample of the game-theoretic models that have appeared recently, we con-
sider the work of Saloner (1982). This is closely related to the papers of Matthews and Mirman (1983) and Milgrom and Roberts (1982). Saloner considers an existing monopolist trying to deter potential entry by its market behavior (for example, by 'limit pricing'). Potential entrants are, however, uncertain about the monopolist's costs structure and cannot infer it exactly by observing the price. (This is accomplished in Saloner's paper by exogenous market uncertainty.) Based on the observed price, a potential entrant makes probabilistic inferences (using Bayesian learning) about the monopolist's true cost and chooses whether to enter or not. Saloner shows that a 'trigger-price' strategy is followed—that is the entrant chooses to go into the market if the price is higher than some cut-off value. The monopolist's market behavior anticipates and optimizes against the potential entrant's strategy.

This model is dynamic, contains incomplete information and uses (Bayesian Nash) equilibrium as the solution concept. As compared with the Eliashberg-Jeuland paper, with which its subject matter has some similarity, it does not exogenously specify the time of entry independently of the monopolist's behavior. On the other hand, Eliashberg-Jeuland are able to get stronger explicit characteristics of the pricing strategy of the monopolist over time.

We note that as we move from the purely optimizing model to the explicitly interactive ones with uncertainty, the scope of the model becomes narrower and answers to complex problems difficult to obtain. The interactive analysis, however, is valuable in providing insights into competitive behavior that cannot be obtained by treating other decision-makers as passive.

4. Bargaining and negotiation models

An area largely ignored in the marketing models literature deals with bargaining and negotiation. We noted earlier that the typical consumer marketing paradigm includes a set of powerful, knowledgeable active sellers dealing with a large number of relatively weak, passive buyers. But many marketing situations, especially in the institutional or industrial area, deal with a single buyer and seller with some common interests and some opposing ones, attempting to reach a common, cooperative goal of agreement (if it is mutually beneficial) as well as the non-cooperative goal of seeking to maximize an individual payoff. The most typical marketing example deals with negotiation over price and quantity of some product to be purchased by the buying firm from the selling firm, although such agreements usually entail complications related to quality, delivery, future prices, renewal options, competitive restrictions and the like.

Unfortunately, formal analysis of the strategic process of bargaining in these settings often proves analytically intractable. A possible approach, advocated by Kadane and Larkey (1982), Raiffa (1982), and carried out partially in Chatterjee and Ulvila (1982), is to combine an asymmetric decision analytic model with empirical studies of the strategies used by likely bargaining adversaries. Since few negotiations are open for outside observers to study, empirical data on the actual process of negotiation is often hard to obtain. (An exception is Sebenius (1984), which contains a detailed case study of the Law of the Sea negotiations.) The data must usually be collected in a laboratory setting.

Several recent studies in bargaining have reported experimental results: Roth and Malouf (1979), Roth and Murnighan (1982), Roth and Schoumaker (1983), Chatterjee and Lilien (1984), Neslin and Greenhalk (1983), and Eliashberg, LaTour, Stern and Rangaswamy (1984). None of these papers contains explicit efforts to determine what strategies bargainers use in given contexts. Roth and Malouf (1979) and Roth and Murnighan
(1982) attempt to test the validity of the assumptions leading to the famous Nash bargaining solution (Nash (1950,1953)). These assumptions are often interpreted as informal principles governing the process of bargaining in complete information situations where the status quo point and the utility–possibility set of agreements are common knowledge. One of the results of these experiments is of potential importance for the asymmetric decision analytic program (Kadane and Larkey (1982)) – namely the observation that bargainers often go beyond utility information to the physical monetary values involved. However, to translate this into a strategy that one's opponents will use is not trivial.

Neslin and Greenhailgh (1983) and Eliashberg et al. (1984) are concerned explicitly with outcomes of the bargaining rather than the strategic process. Each paper explores a particular solution concept as a predictor of the expected outcome and analyses deviations from it in terms of bargaining skill, situational considerations and (in the Eliashberg et al. paper) the completeness of information. While these studies are valuable in their own right, they do not help carry out the asymmetric decision analytic program that is needed to close a model with strategic uncertainty.

Roth and Schoumaker (1983) conduct experiments on the role of reputation. Their result, that it pays a bargainer to establish a clear preference for some particular outcome, does have strategic implications. Chatterjee and Lilien (1984) look at ‘mechanisms’ rather than outcomes and study the efficiency of various mechanisms, that is, various bargaining processes. Their results throw some light on the bargaining procedures an individual might elect to follow rather than on the strategies a bargainer should choose given a procedure. However, since many of the procedures they study have theoretically determined equilibria it is possible to use their results to cast doubt on Bayes equilibrium as a predictor of an individual’s actions.

Given the paucity of work in fulfilling the empirical requirement of the decision analytic program, it is useful to consider the theoretical process modeling that has gone on recently in game theory.

Most classical models of bargaining use the concept of complete information, resulting in predictions of behavior that often seem far from reality. Indeed, we have all observed bargaining situations that have resulted in disagreement (strikes, for example) although outside observers may easily point out that a mutually beneficial agreement could have been reached. Although such issues of disagreement may be explained by psychological or behavioral factors, it is interesting to note that they can often be explained by assuming incomplete information.

Bargaining under incomplete information deals with situations where each party has private information (about preferences, costs, reservation prices, etc.) that is unavailable to the other side. The research on bargaining under incomplete information has led to the important result that pareto-inefficient outcomes (outcomes that allow each party to improve its position) can be shown to persist in equilibrium; the most striking such outcome is the existence of disagreement even when mutually beneficial agreements exist.

This result has generally appeared in single-stage models in which the bargaining is over one issue. There has also been a fair amount of interest recently in multi-stage models in which the phenomenon of inefficient bargaining expresses itself through delayed agreement in an environment where time costs money. (See table 2 for a summary of these models.)

The bargaining literature, notably the work of Myerson (1983), for example, has also generated new notions of efficiency while proving the impossibility of attaining efficiency in the classical sense. The focus in this work is not on the efficiency of the outcome ob-
Table 2
Strategic models of bargaining under incomplete information
(source: Chatterjee (1984)).

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<th>Models</th>
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<tr>
<td>1. Binmore (1981)</td>
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<td>2. Chatterjee and Samuelson (1983)</td>
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<td>5. Fudenberg and Tirole (1983)</td>
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<td>6. Fudenberg, Levine and Tirole (1983)</td>
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<td>7. Rubinstein (1983)</td>
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<td>8. Sobel and Takahashi (1983)</td>
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<tr>
<td>9. Wilson (1982)</td>
<td>x x x x</td>
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* In some of their models, these authors include this feature.
1. Two-sided incomplete information.
2. Continuous probability distributions.
3. Both parties make offers.
4. Sequential information transmission incorporated in model.
5. Bargaining on more than one dimensions.
6. Explicit consideration of alternatives to current bargain.
7. Many buyers and sellers in market.
8. Bargainers uncertain before bargaining of the size of gains from trade.

maintained in bargaining, but on the efficiency of the mechanism or process used in arriving at the outcome. The non-cooperative equilibria of such mechanisms are compared with one another and principles laid down for choosing a mechanism based on the properties of its equilibrium payoffs.

The recent research in bargaining, though much of it is arcane, has provided several important insights. From the point of view of both bargainers, the theory suggests that it might be desirable to set time limits on the bargaining, even perhaps to limit it to one offer from each side. (See Cramton (1983b) for results on how much bargainers collectively lose by not being able to enforce this commitment.)

From the point of view of the individual bargainer, the theory prescribes how he should use his private information optimally against another rational bargainer. It lays down for instance, how aggressive he should be (the most aggressive bargainers end up not doing too well) and under what conditions making concessions over time is optimal as against a 'take it or leave it' strategy. The interesting conclusion in some of these models is that the 'take it or leave it' strategy could be optimal if you could get your opponent to believe that you meant to stick to your offer, but not otherwise.

These insights could prove of assistance to marketing scientists in constructing operational models that purchasers engaged in negotiation might profitably use.

From this brief overview certain needs seem clear. First, more empirical work in realistic business contexts is needed to drive the search for both normative and descriptive theory of bargaining and negotiation. Such a cycle of empirical observation leading to new theory could well lead to models and guidelines that can improve the bargaining and negotiation process. Indeed, this area appears to be quite a fruitful one for further development and application.

5. Game theory and marketing: Match or mismatch?

Several points emerge in our discussion. First, the problem of competition is important in the marketing area and is often handled in an unsatisfactory manner. Second, game-theoretic concepts offer a framework for directly addressing competition. Third, game-theoretic models frequently make assumptions about available information, about the descriptive nature of market equilibria or about the objectives of competitive rivals that bear little resemblance to real marketing situations.

We believe that a cross-fertilization is needed. Game theory can provide an approach for addressing some marketing prob-
lems that the more conventional tools of the marketing scientist do not address. And the empirical focus of marketing science can help provide the tests that are required for the game theorist to evaluate alternative concepts of equilibria and to assess the descriptive soundness of game-theoretic models. We elaborate below.

5.1. Applications of game theory in marketing

As with most methodologies, game theory is being first applied in marketing to those situations where it best demonstrates its value.

Industrial marketing applications of bargaining. The bulk of the marketing science literature focuses on situations where there is ample data for analysis and where the number of buyers, at least, is large. According to Hill, Alexander and Cross (1975: 83) however, 'most major purchases by business, private institutions and numerous government agencies and departments are probably negotiated'. They go on to note, 'The buyer must be cognizant of the cost situation of his own firm as well as that of suppliers (...) [he] must seek every advantage (...) to which his company is entitled' (1975: 84). This quote makes several points that focus on the game-theoretic nature of industrial marketing negotiations. First, the buyer is cautioned to be aware of the cost situation of his firm and that of his suppliers. This awareness permits the buyer to assess the value of a contract to him and to his supplier. The value-analysis concept (Lee (1978)), a seminal idea in the industrial marketing area, teaches the seller how to determine the value of a product to the buyer. Here symmetry exists to have both parties calculate contractual equilibria.

Second, the stress on 'seeking every advantage' points strongly toward joint evaluation of contractual benefits. Cases like Air and Gas Compressors, Inc. (Corey (1976)) demonstrate how buyers and sellers use information about each others' costs and objectives to develop fair and profitable relationships.

The benefit of using game theory in such situations is that it (a) focuses attention on information that must be collected (costs/value functions of bargainers) as well as (b) suggesting fair solutions (e.g., identification of a pareto frontier). Tools to perform such analyses are currently under development (see e.g., Eliashberg (1985)).

Measurement market efficiency. In many commodity markets, competition exists among a small number of sellers, with one of those sellers acting as a price leader. Due to the undifferentiated nature of the product, competition in those markets incorporates elements such as assurance of supply that are closely related to a selling firm's share of industry capacity. Many chemicals, metallic products and electrical components are examples of products that compete in such a manner.

One example is titanium dioxide. Over the past 20–25 years, the titanium dioxide market has been characterized by periodic over-expansion followed by under-capacity. The mechanism during this vicious cycle seems to be a view that competition will remain static while each (active) firm independently decides whether or not to add capacity. The result is that when demand rises, all firms consider adding capacity. Most do, and periodic overcapacity results (Lilien and Yoon (1985)).

Improvements in profitability of up to 60% are shown to be possible for a firm that operates more efficiently in this market. There appear to be major inefficiencies associated with asymmetric decision-making of this type. A game theoretic market analysis has the potential to improve overall market efficiency materially in the market. Such a tool might also provide a case for information-sharing to produce such efficiency.
This situation is an example where game theory has a diagnostic or auditing function. The approach can identify market situations that are inefficient and suggest the type of markerter-educator (use of applied decision-tools) most likely to add to the market's efficiency. An example where this approach has proven effective is in bidding for oil leases, where many companies (e.g., Oren and Williams (1975)) publish their approaches in the hope of reducing the effect of the so-called 'winner's curse'. This occurs when a bidder underestimates costs or overestimates lease-tract-value and increases his probability of winning the bid due to poor data or poor processing of information. The widescale publication of such approaches is aimed at reducing the effect of this phenomenon and at leaving less oil-lease money on the table.

Market mechanism design. In many business/industrial markets with one or several buyers (defense contract markets in particular) the buyer may have the power to design the market; i.e., to structure the conditions under which sales will be made. This problem is critical in certain defense markets where the government states that it wishes to create conditions in which slack capacity exists in peacetime to be used in the event of a 'surge' - a rapid military buildup. Game theory provides the solution concepts necessary to determine the market conditions (How many firms share a winning bid? What return is provided for the winner(s)? What cost-sharing does the government provide for cost over-runs? What assurance of long-term government commitment to a procurement program should be provided?) necessary to meet government's need for slack capacity and to encourage firms to invest in cost-reducing production-improvements (Kratz, Drinnon and Hiller (1984), Seshadri (1985)).

Similarly, in the private sector, what choreography of offers and counter-offers are most likely to lead to a contract when it is cost-beneficial to do so? Work such as that of Chatterjee and Lilien (1984), focusing on the sequence of offers and counter-offers most likely to lead to agreement, suggest that buyer-first offer and seller-first offer procedures appear to dominate simultaneous offer procedures and multi-stage bargains do at least as well as single stage bargains. These types of results can improve the efficiency in markets made by a buyer-seller combination.

5.2. Applications of marketing in game theory

Much of game theory appears sterile to the marketing scientist. The axiomatic approach to characterizing players is at odds with the observation-based analysis of customer response which is often the focus of market models. Much of marketing science focuses on understanding, measuring and affecting customer response.

Many scientists characterize the research process as a cycle of theory (or model) building, observation, evaluation, new theory/model, etc. (e.g., Bunge (1967)). It is curious how infrequently game theorists seem compelled to subject theoretic results to empirical tests. This tendency is despite the fact that the impetus for several, interesting investigations was provided by classrooms simulations (Raiffa (1982)); as Roth and Murnighan (1982: 2) point out:

'Although it has not yet become standard practice to test economic theories with experimental data, bargaining seems to be a subject well suited to the endeavor, both because there is a well-developed body of deductive theory on the subject and because, being an activity which can take place between as few as two agents, it readily lends itself to reliable investigation.'

These experimental investigations and empirical tests of game theoretic results provide the links between hypothesis, theory and law that are, the glue of scientific inference. The marketing scientist is well suited to help arrange for empirical tests that can raise questions with existing game theory results.
and to suggest future directions for both theoretical and empirical research.

6. Conclusion: Value, operational problems and future of game theory in marketing

We will deal with the points in the title of this section in turn; first, consider the value of game theory in marketing. Managers feel that competition is situation specific, is messy and is not related to elegant, abstract models. Yet, the value of game theory in marketing is to allow the marketing model-builder to think better about a particular problem. Corporate strategists in a firm who are familiar with pseudo game-theoretic reasoning (Henderson (1967)) or the use of game-theoretic concepts (e.g., Porter's (1980) 'Competitive Strategy') may obtain some general insight by more explicit game-theoretic analysis. More specific results on potential market equilibria and the efficiency associated with bargaining agreements are potentially potent ingredients in the marketing scientist's arsenal.

The future of this area for marketing modelers and marketing practitioners calls for a marriage of the abstract work of game theorists with the more empirical focus of marketing scientists. Laboratory experiments and careful empirical observations in the marketplace may help specify the type of model most useful for the specific competitive situation. We need a taxonomy of models and competitive situations: An extension of the observations of Dolan (1981) about the form of competition that characterizes various markets should allow us to choose one or several appropriate game-theoretic models for a specific market area.

Bargaining theory, especially under incomplete information assumptions should provide an alternative to market response analysis when the numbers of buyers and sellers are small. This theory has direct application to industrial marketing strategy and should apply to channel relationships in consumer markets as well.

On net, game theory provides a powerful set of concepts and a few operational tools for marketing scientists. The marketing scientist has understanding of and empirical data on the operational problems arising in real markets. The challenge to both disciplines is to devise realistic models of active competition that are solidly based on empirical foundations, provide operational insights and that have an impact on practice.

References


Cramton, Peter C., 1983b. The role of time and information in bargaining. Stanford, CA: Stanford University. (Mimeo.)


Lilien, Gary L. and Bunsan Yoon, 1985. An oligopoly market model when capacity and price are decision variables: A case study of the Titanium Dioxide Industry. (JSBM Technical Report #10)


