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Paul A. Herbig

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Paul A. Herbig*

College of Commerce and Business Administration, Jacksonville State University

Game Theory in Marketing: Applications, Uses and Limits

The use of game theory as a useful and appropriate tool to define and explain marketing problems has many proponents and critics. This paper reviews the tenets of game theory, outlines both sides of the debate concerning the value of game theory within the marketing discipline, reviews those marketing oriented applications where game theory has been studied, and provides a summary of those particular applications where the use of game theory seems both warranted and functional in yielding interesting and useful marketing results.

Introduction

Ever since game theory was formalized by Von Neumann and Morganstern in 1944, its applications to marketing situations have seemed a natural fit, especially in the area of competitive behaviour and negotiations. The extensive usage of game theory by many economists in describing competitive situations such as oligopolistic behaviour, collusion, cartel formation and structure and evolutionary economics was the foundation for its usage within the marketing discipline. Since then, the use of game theory in marketing has ventured far from its initial emphasis on competitive behaviour, into many other applications of marketing.

Yet its role in marketing is still unclear, its detractors many, its support fragile, and its champions all too few. For although there are many advocates for using game theory within the marketing discipline, there are equally as many that declare game theory is too limited and theoretical in nature to have widespread applications in the marketing discipline. The objective of this paper is to compare and contrast the two opposing viewpoints, to examine marketing applications where game theory has been successfully utilized, and to attempt to define those niches where game theory is well suited to modelling and explaining/predicting real world applications.

Tenets of Game Theory

The assumptions of game theory are:

1. Complete information: all players know all the rules of the game and the preferences of the other players for each of the outcomes.
2. Perfect information: each player is fully informed about all prior choices when it is time to decide.

* Department of Management/Marketing, College of Commerce and Business Administration, Jacksonville State University, Jacksonville, Alabama 36265, USA.

3. Rational decision making: each player will make his decisions based upon maximizing his utility, that is, the expected profits or payoffs from the decisions. When faced with uncertainty, players will make subjective estimates of probabilities and then calculate their utility function from these estimates.

4. Intelligent: all players in the game are rational; all are assumed to be maximizing their own utility. Intelligent firms can put themselves in the other firms' positions and reason from their competitors' point of view.

5. Competitive behaviour not co-operative. As a consequence of the above four points, there is a tendency to act non-co-operatively since it is the individual maximization, and not the joint maximization, of utility that determines an individual's choice. This often can result in a non-optimum societal decision as is clearly demonstrated in the classical prisoners' dilemma game.

6. Dynamic: states will change as environmental factors change. Most games are not static nor a single move in duration. Most are multi-move and dynamic. Changes in state—the player's position—are expected over time.

7. Interdependence: one· player's performance is directly related to decisions made by another player; no unilateral decisions are made. This is the key characteristic of games which makes them useful as a decision making tool.

8. Time: the game's outcome is influenced by the duration of the game. End game strategies are often divergent from the normal moves. This is analogous to a person changing his lifestyle if he knew exactly when he was going to die.

9. Interactive: game theory seeks to establish an equilibrium among several active players.

Objections to the Usefulness of Game Theory

Many marketing practitioners are doubtful about the usefulness of game theory. Wagner (1975) remarked that game theory "does not contribute any managerial insights into competitive and co-operative decision maker behavior that are not already familiar to church-going poker players who regularly read the Wall Street Journal." Lazer and Thomas (1974) further criticized game theory when they said "... it is highly unlikely that game theory will be used to solve any practical marketing problems."

These critics and others have generally concentrated their criticisms on several of the basic assumptions of game theory and hence its usefulness with these assumptions in place. The weaknesses of game theory according to critics are:

1. Rationality. In industrial marketing it is not always the best price that is chosen; often it is irrational motives such as the relationship with the sales rep or the emotional preferences of the CEO. Firms often set other goals than sales or profits, market share or even public goodwill—they are maximizing a different utility function to the rest of the· industry. Irrational actions also occur frequently and occasionally purposely to mislead or bluff an opponent. The objective of a firm might be to do as much damage as possible to an opponent. This would not necessarily mean an optimized revenue or profit

profile. Objectives also could very well differ between competing firms: such as long term outlook versus short term perspectives.

2. Complete information presumes the environment is known with certainty. In business, as we all know, the future is uncertain and unpredictable. The most comprehensive research is at best probabilistic, but never 100% certain. Critics would say that game theory predictions are best with perfect information but less accurate when one player has limited knowledge of the other players' profiles. Incomplete information (some players start out with more information than others and therein exists a discrepancy between players) exists when the rules of the game are not common knowledge within the industry. Incomplete information is the norm for most business strategies. Most firms know more about their own capabilities than they do about their competitors' capabilities. Therefore the assumption of complete information is unrealistic and detracts from the usability of the model applied.

3. Mixed strategies: in many outcomes of game theory the optimum decision is not a fixed scenario but a probabilistic choice (mixed strategy: 6/11 do this, 5/11 do that). In a business setting, few bosses would like their subordinates to make such a recommendation to them, that a decision should be made on the roll of a die! This is contrary to the "go-no go" decision usually desired by managers.

4. A tendency towards competitiveness not co-operation is highlighted by game theory. The prisoners' dilemma in a single shot encounter will always lead to a non-optimum outcome (both sides defect) but if there exists a knowledge of many interactions, a long and lasting relationship to exist, a spirit of co-operativeness could ensue that is not fully described by the minimax outcome of the game.

5. Formal game-theoretic models do not fully take into account the phenomenon of reputation of a firm as being "tough" or "benevolent" (Kreps and Wilson 1982). However reputation and credibility exists and is often a vital part of a firm's marketing strategy.

Counter Arguments

Game theory has its many supporters as well. The following counter arguments have been proposed to attest further the usefulness of game theory within the marketing discipline:

1. Complete information is available (in a fashion) from a game of incomplete information by the use of market signalling, that is indicating to the competition one's preference for a move and one's likely action or reactions. Market signalling helps establish an equilibrium in case of incomplete information (Cho and Kreps 1987). One form of market signalling is the pre-announcement, a formal, deliberate communication made before a firm actually performs the behaviour (Eliashberg and Robertson 1988).

2. Competition is often handled unsatisfactorily by most models (usually accomplished by unilateral decision making). Earlier marketing models were primarily optimizing and asymmetric by taking the view of a single active decision maker (Chatterjee and Lilien 1986). Competitors are often assumed

away as a non-reactive force. Game theory on the other hand, provides a most satisfactory model for the interdependence and interaction effects that exist among competitive firms and does not assume away competitive reaction but makes it an essential part of the decision by directly addressing competition.

In the real world, as in game theory, the firm's results are not unilateral but dependent upon its competitors reactions. Benjamini, Gofal and Maital (1986) reviewed why many hospitals have the same inevitable and sometimes suicidal tendency to buy the newest most expensive technology: it is needed to compete successfully; to provide and highlight the prestige and power of those who manage the hospitals; and to provide a competitive advantage for any particular hospital (especially as a marketing tool to attract patients).

3. Much recent work has been conducted on non-co-operative, incomplete information for game theory; this would appear to be much more useful in predicting real world events as well as resolving one of the major arguments against the usefulness of the science. In games of incomplete information (Harsanyi 1967–1968) uncertainties exist for the important parameters: payoffs, strategies, information, but subjective probabilities exist. The game becomes a Bayesian equivalent through a natural lottery, with the subjective probabilities first, then the particular relevant sub-game next. Incomplete information also tends to make formal analysis more tractable and realistic by reducing the number of equilibria that exist.

   Game theoretic models based upon incomplete information often provide more than satisfactory explanatory cases for events with available information. Unlike other models where complete information must exist or is otherwise assumed away, the lack of information can be used within the game theory framework to describe market equilibria or competitive objectives.

4. Mixed strategies: The concern over management dislike for this concept is understandable. However, the idea has appeal for two major reasons: secrecy (randomness) and perpetuating incomplete information. One's competitors can be assumed to reason through one's strategy, but cannot be expected to foretell a random event. Therefore, a mixed strategy provides a chance occurrence and is a way to prevent one's strategic decision from being fully anticipated and countered. The more competitive the market situation, the more the tendency to have mixed strategies and hence less information available to one's competition.

5. Dynamic: Most models have a tendency to be static in nature. Game theory provides a useful method of modelling a dynamic system; its responsiveness could be seconds, days or years. This provides for learning of consumers, of competitors, and of market trends. Game theory can also be infinite in duration or have a planned end game according to the player's needs. This accounts for the short term versus long term nature of games: good competitors with long relationships versus used car salesman on a single shot basis. Whether it is a one shot prisoner's dilemma, encouraging defection, or a long term co-operative encounter can be ascertained in the duration of the game, thus providing realistic data and results.

6. Competition versus co-operation: Tullock (1987) argued that in the marketplace, co-operative effort is most logical owing to economies between buyers

and sellers. However, between competitors, co-operation is not a feasible strategy.

7. Rationality. As Harsanyi (1982) states, "game theory is basically a question of how to act in game situations against highly rational opponents ... a psychologist trying to explain a move by a given player in a game must explain it either as a move justified by normative game theoretical rationality or as a psychologically understandable deviation from it."

   Irrationality can also be approached from the usage of bluffs and threats. An irrational action would be unreasonable if the player were not able to back up the action (bluff or threat). The unbelievability involving a bluff or a threat by one player deters the credibility of that player. An equilibrium is unsustainable if any bluff or threat or irrational action by one player lacks credibility.

   Rationality or the lack of it (through unwilling threats and bluffs) are responsible for most of the paradoxes in game theory (Howard 1987). Credibility and irrationality must go hand in hand. Behaviour that would be viewed as irrational in games of complete information, may be entirely plausible in situations of incomplete or imperfect information (diBenedetto 1987).

8. Kreps and Wilson (1982) explored an expansion of the game theory models to incorporate the factor of reputation in the analysis. They indicated that if a firm demonstrates strength through sharp price cutting or some other actions in market A or Product B, competitors' actions or reactions in Market C or Product D will most certainly be influenced. The firm's benefits from predation in Market A will be supplemented by an inhibition of competition in Market C.

Applications within Marketing

The usage of game theory as a technique to study behaviour in marketing has been used in a host of marketing related applications.

1. Negotiation/Bargaining

Roth and Schaumaker (1983) concluded that results in bargaining were influenced by the expectations and reputations of the active players. Chatterjee and Ulvila (1982) studied bargaining with shared information and found that bargaining over a single issue was simplistic enough to enable the players to calculate all their options easily, however, if the bargaining has a multitude of factors involved, it then becomes extremely difficult to examine and understand all the options available to the players, thereby increasing the risk of making the wrong assumptions. Chatterjee and Samuelson (1985) later concluded that each player's bargaining strategies were directly proportional to the information he possesses on the other's strategies, and hence, bargaining under uncertainty tends to fail to be pareto optimum.

Neslin (1983) created a model which predicted the outcomes of buyer-seller negotiations. Interaction was determined to be the key to a sales relationship; one should co-operate for mutual benefit. A long term interdependent relationship

would yield a fair and equitable settlement. The outcome reached was good with perfect information, but less accurate with limited knowledge of each other's strategies. Bard (1987) indicated that too often mutual distrust (an exploitative relationship) exists between buyer and seller. He suggested one must look at a co-operative prescriptive for buyer-supplier relationships.

Other studies involving game theory in negotiations/bargaining include: Chatterjee (1984) (who confirmed the theory of the more information the better); Shency (1980); Roth and Murnigham (1982) (bargaining strategy is dependent upon the type and amount of information available); Pohjula (1984) (the impact of threats and bluffs upon a player's bargaining power); Rachet (1987); and Milgram and Roberts (1986) (relying on information of interested parties).

2. *Competitive Behaviour*

Karnani (1984a) indicated that game theory is a useful study of mature oligopolistic markets where market share is gained only at the expense of another participant, the common features being conflict, interdependence and a small number of identifiable players. Geroshi, Phillips and Ulph (1985) studied incomplete information and collusion. They reported that less information resulted in a more competitive industry with tendencies towards launching price wars, while more information usually results in less competition. A cartel requires complete information in order to deter cheating and to maximize the joint profits of the cartel.

Other studies involving game theory and competitive behaviour include: Hanssens (1980), Dutte and King (1980), who performed a metagame analysis on competitive behaviour; Wilson (1978) (competitive exchange); Rees (1985) (a cartel will eventually self destruct in an evolutionary manner); D'Aspremont and Jacquemin (1985) (incomplete information affects market, and side actions yield information); Bae (1987) (tacit collusion); Hellwig (1987); and Bernheim and Whinston (1985) who reviewed the common market agency as a device for facilitating collusion between firms within an industry.

3. *Innovation*

Game theory has also been used in the analysis of innovation, technical uncertainty, and the diffusion process. Erik Von Hippel (1988) in his book, *Sources of Innovation*, used game theory to determine when a company should and should not provide trade information to competitors. Park (1987) reviewed patents and discovered that innovative leaders invent more than followers; that firms compete more vigorously in later stages of their life than earlier; and the follower is more likely to choose a riskier innovation path as the only means possible to become the next generation leader and leapfrog the current technological leader.

Mamer and McCardle (1987) studied technical and strategic uncertainty and found an unknown probability inherent in a firm's adoption decision: adoption decreases if the competition is derived from substitute technologies (more conservative) but increases if the competition comes from complementary technologies. The high cost of new or additional information distorts the decision making process and potentially prolongs the adoption process. Other studies of innovative

behaviour using game theory include: Muto (1987) (reviewing relicensing and patent protection), Gallini and Winter (1985) (trade information via licensing to stimulate innovation), and Fudenberg and Tirola (1987) on the use of patents in the adoption of a new technology.

4. *Pricing/Bidding*

Another very common area for game theorists is to review pricing and competitive bidding. Oren and Williams (1975) used game theory to study competitive bidding for oil and gas leases. Wernerfelt (1985) determined that prices are set as a function of time; they decline then increase. Growth is maximized early but never later. A bigger gain can be obtained early but it can only lose later to smaller firms.

Goretsky (1987) discussed the bid proposal process for government contracts, when it pays off, and when it does not, and noted that it is very difficult to estimate the required input variables (competition) to make good decisions. Matthews and Mirman (1983) observed that the limit pricing function was related to the prior beliefs and reputations of sender/observer and how the player uses it in a market signalling context. Milgram and Roberts (1982) reviewed the usage of market signalling as an entry deterrence tactic.

Other studies include Domowitz, Hubbard and Petersen (1987) (trigger strategies and cyclical pricing); Shupp (1985) (limit pricing in a mature market so as to maximize joint profits); Clarke, *et al.* (1984) (pricing strategies for dynamic environment); and DeGraba (1987) who found that most favoured customer clauses result in more non-price competition.

5. *Market Strategy/Market Share*

Game theoretic models have often been used in a market strategy or market share context. Karnani (1985) studied market share attraction models. He determined that profits and market share are related, that greater economies of scale and bigger firms have an inverse relationship between marketing/sale ratio and market share. Karnani (1983) made a determination of minimum firm size and studied the effectiveness of a low market share strategy. There exists a threshold share value that is an entry barrier. The likelihood of a concentration in an industry is dependent upon the threshold value; price elasticity increases the threshold value; greater economies of scale also increase the threshold value. For an industry at equilibrium, all firms must have market share above a certain threshold level; the lower the threshold the easier it is for small firms to be profitable in that market. Karnani (1984a, b) suggested a firm build share as early as possible since the value of market share decreases most rapidly during the growth stage.

Other studies include: Monahan (1987); McDonald (1975) who reviewed real world market strategies in a game theoretic mode (e.g. GM versus Ford in the 20s); and Eaton and Ware (1987) who indicated that at equilibrium there never exists excess capacity, the profits are positive, and the equilibrium is the smallest that still deters entry.

6. *Advertising/Promotion*

To a lesser extent game theoretic models have been used to review advertising and promotion. Studies include: Dirven and Vrieze (1986) (advertising models); Deal (1979) who reviewed the timing of advertising expenditures over the life cycle of the product; Wernerfelt (1985) who discussed awareness advertising (informative) as being used by low priced firms only, while persuasive (positional) advertising is used by both high and low priced firms; and Teng and Thompson (1983) who studied optimal advertising policies for between 3 and 10 firms in an industry. Kihlstrom and Riordan (1984) reviewed advertising as a signal of product quality and conjectured that a positive relationship should exist between quality and advertising expenditures but only if high quality firms' advertising expenditures were more than lower quality firms' expenditures.

7. *Market Channel/Channel of Distribution*

Studies investigating marketing channels/distribution using game theory include: Coughlan (1985) who studied the international semiconductor industry and determined that vertical integration of the firms is inversely related to substitutability of products; Jeuland and Shugan (1983) who reviewed problems in channel co-ordination and found that the incentives were towards not to unless all forced to; lower margins, higher levels of marketing effort, lower retail prices and larger total channel profits; and Eliashberg and Steinberg (1987) who studied pricing and inventory levels between manufacturer and distributor.

8. *Product Marketing*

A most interesting article in the field of new products used game theory (in particular metagame analysis) to study new products screening options. Mitchell and Hustad (1981) used an analysis of options technique for the complex decision making process of reviewing new products.

9. *Market Signalling*

Market signalling is a strategic tool used predominantly in competitive situations. Although not a pure discipline like many of the applications above, it is a hybrid and another interesting special application. Kreps and Wilson (1982) studied the power of reputation and found it worthwhile for a firm to maintain or acquire a reputation, that uncertainty will substantially affect the playing of the game, and that the power of reputation is positively related to its fragility. They also found that imperfect information was advantageous to incumbents as the immediate cost of predation makes it worthwhile to protect, enhance and sustain his reputation, since it deters entrants. The monopolists' ability to create uncertainty deterred new entrants. Milgram and Roberts (1982) indicated that predation may be rational against other firms, even if costly, because it yields a reputation which deters other possible entrants.

Camerer and Weigelt (1988) examined models of reputation formation in an incomplete information game. Rogerson (1983) indicated that in imperfect markets, reputation assures product quality. As a result of the effect of reputation, high quality firms have more customers since fewer are dissatisfied and leave while more arrivals are drawn by word-of-mouth. Miller and Plott (1985) found that sellers developed reputations for selling high quality products and commanded premium prices. Roth and Schaumaker (1983) indicated that bargaining was influenced by expectations and reputation.

Banks and Sobel (1987), and Cho and Kreps (1987) reviewed sequential equilibria of signalling games of incomplete information. Engers (1987), and Engers and Fernandez (1987) studied competitive equilibrium with hidden knowledge where the sellers give some signals to buyers. Kihlstrom and Riordan (1984) reviewed advertising as a signal of quality.

Recommendations on Applications and Limitations of Game Theory Uses within Marketing

1. Game theory has been shown to be extremely useful in the explanation of the behaviour of mature oligopolistic markets where any market share gained is at the expense of another participant (Karnani 1984a, b). The key parameters are a small number of identifiable players, conflict, interdependence, relatively high market share, and a highly interactive competitive environment. This should not be surprising given that the first studies of game theory in economics were oligopolies.

2. Game theory is useful in providing a framework for buyer-seller interactions and negotiations/bargaining. The limitations of two-party (duopoly) games are actually advantageous since in most bargaining situations only two players are involved. The concern of complete information does exist, but many studies have indicated that, the more open (analogous to approaching the complete information state) one is to a potential long term partner, as should be the case in industrial buyer-seller relationships, the more successful the final outcome will be. This area has typically been neglected in most other marketing models.

   Game theory, therefore, should provide a useful and realistic means of modelling the buyer-seller interaction by focusing attention on the information that must be collected as well as suggesting equitable solutions.

3. It is when the number of identifiable players is small, game theory is most useful. Game theory is more useful in an industrial marketing context than it is in a consumer marketing situation. Game theory can provide a diagnostic or auditing function for industrial marketing efficiency, identifying inefficient situations and suggestions to increase efficiency (most often in pricing and competitive bidding situations).

   Game theory is most useful in modelling a small number of players. Therefore its usefulness in analysing or explaining behaviour in many new markets (which usually have many competing firms) is questionable. However, once the market has matured and the "weeding out" has occurred in the marketplace, those influential survivors typically are few in number and this is a prime area of possible game theory applications.

4. Game theory is particularly useful when analysing the behaviour of two competitive parties. Many studies of warfare have explained successfully the actions of

commanders in a game theoretic context (Zagare 1987). Where only two oppos-
ing camps exist, their actions and behaviour can be quite admirably explained
and modelled in game theory terms. Many aspects of two player behaviour can
be modelled by game theory, particularly negotiations and buyer-seller actions.
Another similar situation exists when an industry has only two predominant
firms, but this is rarely seen in the marketplace. Another interesting possibility
is in international marketing, in the context of two great national powers and
their rivalry for domination (either militarily or economically).

Future Research

A logical extension to all the previous and current work in game theoretic views of
marketing, is to expand earlier work from two player complete information zero-
sum games of dubious value, to multi-player incomplete information non-zero sum
variants. This would certainly provide a more realistic view of the world, with
results of definite interest to managers. Extending game theory to other appli-
cations within marketing, such as promotion, channel conflict, etc., where little or
no previous game theoretic work has been accomplished, would allow us to view
and either confirm, or not, its usefulness in these areas.

Summary

Although, game theory has been in existence as a formalized mathematical study
for over 40 years, marketing has been a late entrant in its usage of game theory.
Applications within marketing have been many and varied, although many have
such severe constraints as to make their results of little general use. The use of
game theory does, however, allow researchers to take a different approach to many
marketing problems and bring refreshing new analysis to them.

Game theory in marketing is best utilized in industrial applications where there
exist a limited number of participants. Game theory is most widely used, and with
worthwhile results, in competitive situations and competitive analysis, buyer-seller
relations (including negotiations), and strategy issues.

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