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Rhonda K. Reger
Department of Management
Arizona State University

Joseph T. Mahoney
Department of Business Administration
University of Illinois

Bureau of Economic and Business Research
College of Commerce and Business Administration
University of Illinois at Urbana-Champaign

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RHONDA K. REGER
Department of Management
Arizona State University
Tempe, AZ 85287-4006
(602) 965-1347
FAX (602) 965-8314

and

JOSEPH T. MAHONEY
Department of Business Administration
University of Illinois -- Urbana
1206 South Sixth Street
Champaign, IL 61820
(217) 244-8257

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MANAGERIAL MODELS OF COMPETITIVE DYNAMICS: ADDRESSING THE RELEVANCE ISSUE IN GAME THEORETIC MODELING

ABSTRACT

Game theory provides a useful tool for formally modeling strategic interaction. For the most part, however, the application of game theory to describe strategic interaction has not reached its full potential. To provide greater relevance for strategy research, this paper suggests that future game theoretic investigations be redirected to devote more attention to executive models of competitive dynamics. Game theoretic research should be grounded in a better understanding of managerial cognition about competitors.

Game theory can be a useful tool for understanding and describing competitor behavior. Fruhan (1972) and Sultan (1974) recognized the fruitfulness of game theoretic modeling for comprehending competitive dynamics. Renewed interest within strategic management was sparked by Porter's (1980) game theoretic analysis of competitive moves over time. Numerous theorists also have suggested that mathematical modeling is needed to advance the rigor of strategic management research (Camerer, 1985, 1991; Montgomery, 1988). Utilizing game theoretic models, industrial organization economics is increasingly making strides in exploring hypothesized results in stylistic oligopolistic settings (Friedman, 1977; Fudenberg and Tirole, 1989; Kreps, 1990a; Shapiro, 1989; Tirole, 1988).

Many observers note that game theory's promise has not been realized in descriptive, empirical research on competitive dynamics (Camerer, 1991; Fisher, 1989; Saloner, 1991; Weigelt and MacMillan, 1988; Zajac and Bazerman, 1991). This paper argues that game theory's possibilities for apprehending dynamics in real competitive interactions remain significant, but that strategic management has only begun to tap potential applications. For example, Conner's (1988) work on product cannibalism based on a patent race game, and Weigelt and MacMillan's (1988) formal model of managerial perceptions under conditions of incomplete information are exemplars that might lead to improved managerial decision making by more explicitly specifying managerially relevant options and payoffs in dynamic competitive situations.

Game theoretic research in strategic management needs to be explicitly redirected to focus on constructing managerial models of competitive situations by utilizing cognitive methods to elicit key game parameters. Rubinstein (1991: 919) argues that:

> If we adopt the view that a game is not a rigid description of the physical rules of the world then a game-theoretic model should include only those factors which are perceived by the **players** to be **relevant**. Modelling requires intuition, common sense, and empirical data in order to determine the relevant factors entering into the players' strategic considerations and thus should be included in the model. This requirement makes the application of game theory more an art than a mechanical algorithm.

A cognitive approach to game theoretic modeling may provide relevant descriptions of real competitive dynamics that are needed to invigorate game theoretic investigations. Before attempts are made to prescribe normative advice, descriptions of management practice should precede both mathematically rigorous game theoretic analysis and behavioral investigations (Bowman and Johnson, 1992). If the cognitive foundations of game theory are not provided, normative game theory research may be providing advice on how to execute strategies that are not applicable to management practice.

The development of game theoretic models in strategic management has concentrated on a circumscribed set of game formulations, most notably the Prisoner's Dilemma (Oster, 1990; Porter, 1980), the Cournot game of output determination, and the Bertrand game of pricing strategy (Camerer, 1991; Saloner, 1991). There is scant evidence that these games characterize managers' understanding of their competitive circumstances[1]. The field has made few attempts to elicit managerial cognitive models of competitive dynamics (Weigelt and MacMillan, 1988).

The purpose of this paper, then, is to focus attention on game theory's ability to formalize the implicit competitive models held by managers. Several examples are provided to illustrate game theory's ability to capture some of the richness and variety of managerial understanding of competitive circumstances. These prototypes are meant only to exemplify the potential that a managerial cognitive approach can add to game theoretical analysis. They are not meant to be an exhaustive taxonomy of game theoretical formulations that might be applicable to industrial competition. We submit that the game formulations that are most important for describing industrial competition are those in the minds of the strategic decision makers. The fundamental challenge of this approach for game theorists is to utilize appropriate methods to uncover and accurately represent managers' mental models of competitive dynamics. These descriptive models can then be subjected to mathematical and behavioral scrutiny to explain and predict competitive outcomes and offer normative advice to managers.

Executives almost always make decisions without knowledge of all values in the payoff matrix and must, therefore, rely on their beliefs and assumptions about competitors; beliefs and assumptions that may very well differ from those held by researchers (Porac and Thomas, 1990; Saloner, 1991; Weigelt and MacMillan, 1988). Therefore, game theoretic research in strategic management should begin with an understanding of executive cognition to better understand firm behavior.

A COGNITIVE GAME THEORETIC APPROACH

A cognitive approach to game theoretic modeling recognizes the primacy of managers' mental models for understanding strategic action (Dutton, 1993; Porac and Thomas, 1990; Reger and Huff, 1993; Weick, 1979). In particular, we depart from the deductive economics approach of game theory that assumes unlimited cognitive capabilities of players. We suggest that models of bounded rationality (Simon, 1982) are more relevant to strategic management, as a pragmatic field. To illustrate this point, we note that since the game of chess is a game of complete and perfect information, in principle we can use backward induction to solve the game (Von Neumann and Morgenstern, 1944), however, game theory does not specify how one should play the game. On the other hand, models of bounded rationality concentrate on heuristics to aid those who are puzzled on "what to do?" A quote from Von Neumann and Morgenstern (1947: 125) is worth repeating:

> if the theory of Chess were fully known there would be nothing left to play. The theory would show which of the three possibilities (white wins, white ties, or white loses) actually holds, and accordingly the play would be decided before it starts ... But our proof, which guarantees the validity of one (and only one) of these alternatives, gives no practically usable method to determine the true one. This relative human difficulty [of bounded rationality] necessitates the use of those incomplete, heuristic models of playing, which constitute "good" chess; and without it there would be no element of "struggle" and "surprise" in that game.

In this paper, the cognitive "struggle" of business executives' "managerial mental models" are brought to the foreground of the game-theoretic approach. The cognitive model in Figure 1

summarizes the impact of executive assessments of key elements of strategic domains on competitive dynamics. Competitive interaction, in turn, shapes industry structure (Porter, 1980; Reger and Huff, 1993). Feedback loops from industry structure and competitive dynamics consider the effects of these factors on managers' conceptions (Huff, 1982; Porter, 1980; Prahalad and Bettis, 1986).

Insert Figure 1 about here

To abstract the essential cognitive elements of any competitive situation requires that managerial beliefs about three generic parameters be elicited. First, the researcher must uncover managerial opinions about relevant players, that is, the actors decision makers judge to be competitors. Next, managerial assessments of alternative strategies available to those players must be extracted. Finally, managerial estimations of the payoffs associated with each set of strategies provides the third ingredient in modeling decision makers' conceptions of the competitive environment. Inescapably, as indicated in Figure 1, the amount of communication, market signaling, and subjective evaluations of others influence managerial assessments of these three basic parameters.

The paper is organized in four parts. First, the vital roles of market signaling and competitive reputation in shaping executive perceptions of the generic parameters are examined. Second, the significance of managerial judgments about these three parameters--players, strategies, payoffs--for describing competitive dynamics is illustrated. Illustrations include prototypical examples of the volatile implications of divergent belief structures within an industry. Third, a cognitive approach to game theory is contrasted with mathematical and behavioral approaches. Finally, some of the future research directions that a cognitive approach to game theoretic modeling opens are outlined. Issues for empiricists interested in eliciting and building cognitive game theoretic models are discussed in the appendix.

Competitors often must resort to market signaling to communicate intentions and desires (Heil and Robertson, 1991; Porter, 1980). Antitrust law prohibits many types of direct communications and formal agreements between rivals (Scherer and Ross, 1990). Thus, in the absence of overt agreements, market signals can encourage interfirm coordination. Heil and Robertson define competitive market signals as "announcements or previews of potential actions intended to convey information or to gain information from competitors" (1991: 403). This paper adopts a broader definition of market signals to include any announcement or action that conveys information or gains information from competitors whether intended or not[2].

Market signaling, because it influences rivals' perceptions of ambiguous environments, is a critical component for understanding competitive dynamics (Fombrun and Shanley, 1990; Heil and Robertson, 1991). As depicted in Figure 1, an opportunity is created for rivals to influence each other's perceptions of players, viable strategic options and payoffs. Through market signaling, rivals attempt to learn or change others' perceptions of the nature of the game. Intentional signals are sent to competitors to communicate which game the firm wishes its opponents to believe they are playing, or to communicate which set of joint actions is preferred. Of course, firms may, intentionally or not, send mixed messages that increase rather than decrease ambiguity.

The first role of market signaling is to convince rivals of the kind of game being played. In industrial competition, it is often impossible for a firm to be sure about the nature of the game it is playing since strategic alternatives and payoffs are rarely known with certainty. Typically, the company knows payoffs associated with actual historical choices, and these outcomes are only loosely coupled to choices (Weick, 1979). **Perceptions are critical**. Rubinstein argues that: "a good model in game theory has to be realistic in the sense that it provides a model for the **perception** of real life social phenomena" (1991: 910). Strategists have the opportunity to influence others' judgments

because firms' managers are forced to act on their beliefs, not on objective reality. Market signaling that influences rivals' perceptions of the nature of competition in the industry and, therefore, affects their strategic choice behavior, is decisive to competitive success.

In addition to attempts to influence perceptions about the nature of the game, rivals also communicate which strategy they plan to adopt and which actions they hope other firms in the industry will pursue (Heil and Robertson, 1991). Thus, the second role of market signals is to communicate which set of joint actions is preferred. For instance, to "minimize the provocation" (Porter, 1980), a rival communicates that it is choosing a cooperative strategy, given the game being played and the strategies available to it. Without this market signal, rivals might perceive the action to be more aggressive than the firm intended. This misinterpretation could lead to a costly competitive battle that harms all players. One example of this scenario is a dominant firm may attempt to persuade its smaller rivals that it is being statesmanlike, even though its action may appear hostile to an observer unaware of the firm's available strategic options. If the smaller firms' managers ignore the signal, an undesirable war could result that leaves them in lesser preferred positions than if they had heeded the market signal. Similarly, once rivals understand the need to develop industry standards, signaling is often aimed at establishing the specifics of industry norms on such practices as pricing, advertising/sales ratios and discount levels (Heil and Robertson, 1991). These signs provide guides to rivals that influence their interpretation of otherwise ambiguous strategic actions[3] (Weigelt, Camerer and Hanna, 1992).

Because industrial competition usually unfolds over many years, strategists have a rich memory store of competitors' past actions and outcomes (Finkelstein and Hambrick, 1990; Huff, 1982). These assessments of competitors become synthesized into a firm's competitive reputation[4] (Fombrun and Shanley, 1990). Competitive reputation is defined as the beliefs held by rivals about the firm concerning the firm's posture in the industry. Our view of reputation suggests that

reputation is disaggregated by constituent group, a view somewhat at odds with Fombrun and Shanley (1990). Fombrun and Shanley suggest that "individual interpretations aggregate into collective judgments that crystallize into reputational orderings of firms in organizational fields" (1990: 234). The perspective we develop here is that different stakeholders filter information differently, because they seek divergent results from the firm and thus evaluate the firm by different criteria. Therefore, it is not unreasonable to suggest that various stakeholders may hold radically different ideas about the firm's reputation. For example, customers could hold a firm in high esteem (positive market reputation) while investors are less enamored (poor financial reputation) and rivals overtly distrust it (poor cooperative reputation).

Importantly, a competitive reputation develops over time as rivals interpret the firm's announcements and actions. Market signals may include bluffs, lies or what economists call "cheaptalk"[5] (nonbinding preannouncements) that may not necessarily be followed (Camerer, 1991; Farrell, 1987). However, in long-term repeated games that characterize much of industrial competition, any short-term gains from misleading announcements are likely to result in long-term reputational losses. Since strategic firms are aware of the value of their reputations, it is expected that they would trade off short-term gains for longer-term reputational gains (Fombrun and Shanley, 1990). If a firm repeatedly engages in misleading cheaptalk, unintended signals may convey more accurate informational content than intended messages. In such cases, rivals are expected to learn to ignore deceptive, intended messages. Again, to describe industrial competition, it is not appropriate for an outside observer to impose interpretations on market signals. Rather, managerial interpretations must be elicited to uncover subtleties that may not be readily apparent to outsiders (Gioia and Chittipeddi, 1991; Reger and Huff, 1993).

Delineating the influence of market signaling on managerial assessments of key game parameters is critical for developing accurate managerial models of industrial competition. Notably,

competitive reputation, which results from the interpretation of past market signals, actions, and outcomes over time, provides salient cues as to the veracity and significance of current and future market signals. Thus, both current market signals and competitive reputation impact executive assessments of key aspects of competitive dynamics. Market signals and reputation should be given a more central focus in game theoretic attempts to describe industrial competition.

PREEMPTION AND INDUSTRY NORMS

Next, this paper considers examples to illustrate the rich potential of a cognitive game theoretic approach for describing competitive dynamics in interdependent industries. In competitor analysis, it has been suggested that **preemption** and **developing competitive norms** may provide the greatest opportunities for potential benefits while also carrying the greatest risks (Heil and Robertson, 1991). Since game theoretic analysis is appropriate in any situation in which firms are inter-dependent (Jacquemin, 1987; Tirole, 1988), these two types of dynamics can be generalized to a wider variety of competitive circumstances.

The preemption pattern is constructed from research reports of industrial competition in the electrical turbine industry, while the development of competitive norms is abstracted from popular press accounts of the early time period in the VCR industry. These examples ground the theoretical discussion of a cognitive approach to game theoretic modeling in specific contexts to better illustrate the potential of the approach. These cases are open to multiple interpretations, and in fact, a central argument here is that the managers involved may very well have had different interpretations of their competitive situations than outsiders attempting to construct game theoretic models based on secondary sources.

First, to illustrate when preemption is possible, managerial perceptions of capacity expansion decisions are modeled with two alternative game formulations. The Chicken game, which is

especially promising for understanding preemption, is contrasted with the Prisoner's Dilemma (PD) game. Although focused on capacity expansion decisions, the dynamics modeled here apply to a wide range of competitive circumstances including pricing, introducing new technology and advertising (Heil and Robertson, 1991). Second, the Battle of the Sexes game, which rewards concerted action (Luce and Raiffa, 1957), and thus provides a template for understanding imitation and competitive norms of conduct, is offered to illuminate cooperative behavior between rivals.

Modeling Preemption: A Capacity Expansion Illustration

Theorists have suggested that capacity expansion decisions are usually strategic because "they involve substantial capital, are considerably complex, and have the potential to influence competition and profitability" (Zajac and Bazerman, 1991: 44; Porter, 1980). Game theoretic analysis is central in a landmark study of capacity expansion in the electrical turbine oligopoly (Sultan, 1974). In this study, the Prisoner's Dilemma formulation was applied to the relationship between Westinghouse and General Electric with respect to capacity expansion. A simple mathematical representation of a Prisoner's Dilemma game is illustrated in the top panel of Figure 2.[6]

Insert Figure 2 about here

PD games lead rational competitors to follow decision rules similar to the one Sultan proposed to describe the decision process he observed:

> Each of the two major competitors may increase his own manufacturing capacity in proportion to the perceived amount of expansion of his major rival. General Electric managers may be stimulated to add capacity merely because Westinghouse is adding capacity, and vice versa. Such an interdependent mode of expansion would be consistent with theorizing concerning strategic behavior in oligopoly (1975:183).

In the electrical turbine oligopoly, which did not experience chronic overcapacity or suffer low profits, the major players appeared to agree that theirs was a repeated PD game. If

Westinghouse had aggressively added capacity, the best strategy for GE would have been to also add substantial capacity. Armed with at least a tacit understanding of the repeated PD game matrix, both rivals perceived that the result of large capacity expansions would be industry-wide overcapacity, that is, the D1D2 payoff of (1,1) found in cell 4 in the top frame of Figure 2. Since both players appeared to be aware of the "rules of the game," Sultan (1975) argued, neither tried to preempt the other with very large capacity additions. In game theoretic terms, in a repeated PD game with an unknown ending to the game, cooperation between General Electric and Westinghouse may be an equilibrium outcome[7].

Porter, unlike Sultan, considers a more static version of the PD game (e.g., a one-period game or a game with a known finite ending) and thus recommends preemption as the individually rational choice in PD games (Porter, 1980; Porter and Spence, 1982). If rational rivals perceive a true PD formulation as portrayed in Figure 2, preemption will not be collectively rational (successful) but unfortunately, preemption will be individually rational because the payoff for unilateral cooperation is less than the payoff for reciprocal defection. Preemption is <u>always</u> the best action given the other player's choice. In game theoretic terms, preemption is a <u>dominant strategy</u> for each player and consequently D1D2 is a <u>dominant strategy equilibrium</u>[8].

If rivals can be induced to perceive payoffs consistent with another mixed motive game, the Chicken game, Porter's advice is also sound and preemption becomes a rational alternative. A standard mathematical interpretation of the Chicken game matrix is shown in the center panel of Figure 2.[9] Subtle differences in the PD and Chicken game payoff structures dramatically affect the amount of cooperation and competition likely to occur. In the Chicken game, the payoff from joint competition is <u>less</u> than for unilateral cooperation; whereas in the PD game, this situation is reversed. There are two pure strategy (Nash) equilibrium outcomes, C1D2 and D1C2. If a distinction is made

between a true PD game and a Chicken game, the fundamental difference between the two games has profound, and predictable, strategic implications:

> The chicken game differs from the PD game...in that the DD outcome had the lowest payoff in the game (simulating the disaster of a head-on collision). This means that the competitive move does not completely dominate the cooperative move [as in PD], and therefore the rational response to a highly competitive other is to cooperate, whereas in the PD game it is to compete (Oskamp, 1972: 148).

In his review of various strategies in mixed motive games, Oskamp (1972) notes that not only are these differences rational from the structure of the payoff matrices, but perhaps more interesting, these differences are observed in empirical behavioral studies. In PD, subjects respond to highly competitive opponents by competing; in the Chicken game, they back down. For a preemptive strategy to be successful, rivals must <u>believe</u> that they will be better off (in game theory terms, will receive a larger payoff) by not adding capacity than they will be by matching the aggressor's would-be preemptive move. The importance of knowing which game the participants think they are playing should be self-evident. For preemption to be successful, rivals must first be convinced that they are playing a Chicken game, not a Prisoner's Dilemma.

Consideration of multiple models allows us to begin to understand why industries develop differently. Sultan's (1975) report can be reconciled with Porter's (1980) prescriptions. These authors outline similar games, but ones where decision makers perceived disparate payoff structures (due to e.g., static versus dynamic conceptions or different conceptions of the type of game being played). As the disparate recommendations of each author illustrates, seemingly minor differences in perceptions of payoff structures and time horizons can lead to quite different competitive dynamics.

Modeling Norms of Competitive Conduct

Another significant game theoretic formulation, the "Battle of the Sexes" game[10] is promising for understanding competition that results in industry standards or norms of competitive

conduct (Heil and Robertson, 1991). More generally, the Battle of the Sexes game may model any situation when rivals perceive coordination to be necessary (Weigelt, Camerer and Hanna, 1992). In the Battle of the Sexes game, players have the highest payoffs for concerted action. The early VCR industry may provide one illustration of the dynamics of this game. One interpretation of the early preferences of Sony and its competitors is shown in the bottom panel of Figure 2.[11] In this scenario, Sony preferred its Beta format while competitors favored VHS. Videotape producers and rental stores pressed for industry standardization on one format to reduce production and inventory costs. Eventually, the VHS design dominated, and Sony withdrew Beta from the consumer market even though many industry observers believed it was technologically superior. Perhaps Sony assumed technological dominance was the primary strategic issue for this market. If so, a Chicken game would explain Sony's actions: they aggressively promoted the Beta format and refused to license it hoping rivals would "turn away" from the market. However, if the Battle of the Sexes model is an accurate interpretation of payoffs in the industry, industry standardization was crucial to competitive success. Sony's rivals appear to have believed a Battle of the Sexes game realistically modeled their competitive circumstances. Unable to match Sony because it refused to license Beta, rivals formed a successful alliance based on VHS technology, instead of each attempting to market unique formats.

Implications of Divergent Belief Structures Within an Industry

The models discussed above are admittedly simple and the examples, although based on managerial conceptualizations, are abstracted and stylized for illustrative purposes. Empirical research is likely to uncover more complicated and more interesting cases, such as when one player thinks the game is PD and another is playing the Chicken game. When competitors fail to recognize divergent perceptions of payoff matrices, strategic mistakes may be especially likely (Harrigan, 1985; Zajac and Bazerman, 1991).

For example, Fruhan (1972) employed the Prisoner's Dilemma logic to model the interdependency of capacity expansion decisions for airline industry rivals. His observations supported Sultan's findings--one firm's "defection" or aggressive capacity building was most often countered with similarly hostile capacity building by rival airlines. Unlike the electrical turbine industry, however, the airline industry suffered from chronic overcapacity and low profitability even before deregulation (Fruhan, 1972).

Fruhan (1972) concluded that, given the industry's cost structure and idiosyncratic assets (i.e., given the payoff structure inherent in PD games), the reacting airlines' actions were rational--their best strategy was to follow the lead of any capacity additions, even if it led to industry-wide overcapacity. But what about the would-be preemptors? Why would firms attempt to preempt rivals in a PD game, knowing that gentlemanly cooperation would lead to higher payoffs? In other words, why were the airlines unable to learn the lesson Westinghouse and GE seemed to have understood so well? One possibility, based on Zajac and Bazerman (1991) and Porter's (1980) analysis of preemption in capacity expansion decisions, is that the airline industry's chronic overcapacity was the result of judgment errors stemming from competitive blind spots.

At least three types of judgment errors could have been operating in the airline industry. First, the rivals may not have been aware of their interdependencies. This seems unlikely given the long history of interdependent competition in this industry. Second, the aggressors may not have believed they were playing a PD game. If they believed the game was the Chicken game, for instance, then preemptory actions were reasonable. Third, perhaps the aggressors' actions were intended as market signals aimed at changing their competitors' perceptions about the nature of the game. If an airline could convince a rival that the game was a Chicken game, then a rational response to aggressive capacity expansion would be to exit that route. To understand outcomes of strategic interaction, research must focus on eliciting managerial mental models.

In another example, during the early days of the personal computer industry, several operating systems competed. But most rivals perceived the compelling need to standardize on one operating system so that business customers would adopt personal computers in large numbers. IBM, as a dominant player, was able to force that standardization on IBM's preferred option, the DOS operating system. Of the major players, only Apple failed to adopt the DOS environment. Again, we could call this a competitive blind spot and suggest that Apple's management was irrational. But to do so would mean that we know with certainty that this was a Battle of the Sexes game, and Apple's payoffs (e.g., future profits) would have been higher if they would have acquiesced to IBM's preferred standard. Since the payoffs of actions not taken are impossible to determine in industrial competition, a cognitive approach to game theoretic modeling suggests that belief structures must be elicited from the key decision makers in order to understand the rationale behind their actions.

A critical contribution of a cognitive approach to game theoretic modeling is the explicit recognition that managers at competing firms might view competition quite differently (Daniels and Johnson, 1992; Harrigan, 1985; Porac and Thomas, 1990). Decision makers can only be boundedly rational (Cyert and March, 1963; Simon, 1982) when making decisions about competitive dynamics. Decisions which appear to be irrational, or to represent "competitive blind spots" (Zajac and Bazerman, 1991) to competitors or to industry outsiders may actually be quite rational given the information and beliefs about players, strategies and payoffs of the those involved in the decision. Developing cognitive game theoretic models for competing firms allows the ramifications of such cases to be explored. Research conducted with valid and reliable cognitive methodologies as discussed in the appendix to this paper may be able to represent competitive dynamics more realistically, especially when rivals disagree about the true nature of the game.

Recent strategic research in this area has gone astray by pursuing equilibrium solutions to games of interest to theorists without adequately grounding formulations in managerial practice (Postrel, 1991). There is nothing intrinsically wrong with an equilibrium approach as it appears to serve economics well and provides insights into potential competitive outcomes (Camerer, 1991; Wernerfelt and Karnani, 1987; Weigelt, Camerer and Hanna, 1992). However, simplifying assumptions necessary to accommodate mathematical solutions in game theoretic models may not accurately reflect industrial competition (Zajac and Bazerman, 1991).

Behavioral game theorists have found that even slight changes in game parameters can have profound effects on the strategies individuals adopt and on game outcomes (Murnighan, 1991; Oskamp, 1972; Rapoport and Guyer, 1966). Observation suggests that firms, like individuals, behave quite differently in competitive situations that are not too disparate. Research that uncovers subtleties in managers' mental models of their competitive arena may add to economic explanations of industry heterogeneity (Camerer, 1991; Porac and Thomas, 1990; Reger and Huff, 1993).

A cognitive approach to game theoretic modelling adds significantly to mathematical analysis and behavioral experiments, the two approaches to game theory currently being applied to competitive dynamics. Table 1 explicitly contrasts how each of these three address key issues in modeling competition.

A cognitive approach argues that to understand rivals' actions, the important questions are not what game and which cell are being played. Rather, the focus must be on the game(s) the participants <u>think</u> they are playing and the strategies they <u>believe</u> have been chosen. As Kreps notes, a shared understanding of the "rules of the game" may be "the product of long-term experience by a society of boundedly rational and retrospective individuals" (1990b: 183)[12]. In ambiguous environments, executive assessments of all game parameters--players, strategies, payoffs and the

meaning of market signals--take on increased importance. Once managerial mental models are elicited and formalized, mathematical and behavioral game theory provide the mechanisms for exploring the ramifications of these models for competitive dynamics and industry evolution.

Insert Table 1 about here

FUTURE RESEARCH DIRECTIONS

When attention is directed toward modeling managerial conceptions of competitive dynamics, many important research questions are answerable using game theoretic models. For example, how executives decide what game they are playing, who they watch as interdependent players and the attributions they make concerning rivals' market signals and actions can all be addressed by empirically deriving payoff matrices. First, executives should become data sources to develop perceptually based understanding of competitive dynamics (Huff, 1990; Porac, Thomas and Baden-Fuller, 1989; Reger and Huff, 1993). Once the key elements are elicited from decision makers and formalized into payoff matrices, empirical research can test theories about strategies and outcomes under controlled conditions. These tests include behavioral experiments (Camerer, 1991; Green and Kagel, 1990; Murnighan, 1991; Oskamp, 1972; Saloner, 1991; Zajac and Bazerman, 1991), mathematical solutions (Camerer, 1991; Saloner, 1991; Weigelt and MacMillan, 1988), computer simulations (Bruderer and Mitchell, 1992), and behavioral simulations with executive samples. Laboratory experiments may be especially promising as the four parameters can be systematically varied to shed light on how industries develop under various conditions (Weigelt, Camerer and Hanna, 1992). In this area, researchers can build on the extensive behavioral game theoretic literature, but should also realize that much of the extant research may have only limited application

to executive decision making since it often utilizes student reactions to researcher contrived games (Murnighan, 1991; Oskamp, 1972; Weigelt, Camerer and Hanna, 1992).

Clearly, executives make mistakes and suffer from competitive blind spots (Zajac and Bazerman, 1991). Strategic decision makers can unwittingly destroy a favorable industry structure by basing their actions on erroneous beliefs (Porter, 1980). A cognitive approach to game theory opens a significant avenue for future research. Managerial models can be compared to expert models based on objective assessments of industry conditions. The comparison of economic and managerial positions should enrich both perspectives and help to break down artificial research barriers (Reger and Huff, 1993; Zajac and Bazerman, 1991).

To date, game theoretic research has tended to be either theoretical (e.g., a search for mathematical, equilibrium solutions) or behavioral (e.g., an examination of equilibrium solutions that emerge in experimental play). While psychology has focused on behavioral dynamics of experimental play, economics has primarily scrutinized mathematical, equilibrium solutions and has only adopted behavioral protocols relatively recently (Green and Kagel, 1990; Weigelt, Camerer and Hanna, 1992). By utilizing cognitive methodologies to uncover managerial conceptions of key game parameters in genuine competitive dynamics, strategy researchers can add to both mathematical and behavioral game theoretic research by providing interesting and potentially more realistic models as input for their respective analyses.

The perspective developed here is necessarily limited. Many other mixed motive games have been specified that might also provide additional insight into industrial competition (Murnighan, 1991; Oskamp, 1972; Rapoport and Guyer, 1966; Rasmusen, 1989). The Chicken game is particularly relevant because it carries almost opposing strategy implications compared to PD, and because it accounts for a commonly observed industry pattern of dominant industry leader with smaller niche competitors. The Battle of the Sexes game is promising as it models environments where cooperation

is more important than competition. The crucial point of a managerial cognitive approach to game theory, however, is that the most influential formulations for understanding strategic action are the ones in the minds of managerial players.

Competitive dynamics are as likely to entail sequential as simultaneous competitive moves. Theorists have noted that extensive form payoff matrices are more appropriate in such cases (Myerson, 1991; Oster, 1990; Weigelt and MacMillan, 1988). The primary contrast between simple matrices such as those presented in this paper and extensive form games relate to differences in finding equilibrium solutions, that is, solving for the optimal strategy. For competitive sensemaking, deriving simple matrices might actually be preferred due to the cognitive limitations of users (Schwenk, 1984). Nonetheless, empiricists are urged to also consider extensive forms to determine if they better capture executive models.

CONCLUSIONS

Game theoretic concepts, especially the Prisoner's Dilemma formulation, have been used in strategic management for some time and have been given new exposure recently. This paper argues for the importance of adding managerial conceptions to game theoretic modeling. A cognitive approach provides needed insights into the diversity of competition and cooperation exhibited across industries and within an industry as it evolves. The Prisoner's Dilemma, the Chicken game, and the Battle of the Sexes game, which were used to illustrate possible managerial conceptions of competitive dynamics, are especially promising for strategic management because the incentives for competition and cooperation, for preemption and imitation, vary systematically in these three game formulations.

Game theory's ability to model manager's beliefs about the key components of competitive conditions also may have practical applications. As a decision support aid, alternative game formulations can become a focal point in policy dialogues through providing competing models of

competitive situations (Bruderer and Mitchell, 1992; Mason and Mitroff, 1981; Schwenk and Thomas, 1983; Thomas, 1982). That is, they can provide stylized archetypes that bootstrap the decision team's expertise in ambiguous situations (Weigelt and MacMillan, 1988).

The incorporation of a managerial cognitive perspective can enrich game theory applications for strategic management issues. Industrial organization economics progresses in developing sophisticated theory and solutions for a variety of game formulations. The strategy field should continue to monitor and incorporate this work in our own endeavors. While not every article must have immediate practical application, the strength of strategy research rests on its direct applicability to practice (Montgomery, Wernerfelt and Balakrishnan, 1989). Research that seeks to model real competitive situations based on empirical observation adds pragmatism without sacrificing game theory's attractive rigor. To revitalize game theoretic research in strategic management, there is a need to shift the focus from mathematical solutions of abstract games to managerial assessments of competitive dynamics in real industries. We believe that Rubinstein provides the best summary of this position:

> We are attracted to game theory because it deals with the mind. Incorporating psychological elements which distinguish our minds from machines will make game theory even more exciting and certainly more meaningful (1991: 923).

APPENDIX

This appendix outlines a cognitive approach to each of the key game theoretic parameters discussed in the paper and addresses several empirical issues in constructing game theory formulations based on managerial assessments. A cognitive approach gives primacy to managerial beliefs about each of the key parameters--players, strategies and payoffs.

Players

Relevant players are limited to those firms that decision makers recognize as interdependent. Thus, players may include all firms in an industry (Oster, 1990; Porter, 1980) or may be restricted to those within a particular strategic group (Huff and Reger, 1993). In some cases, they may span traditional industry boundaries (Fombrun and Zajac, 1987). Players may even be confined to pairs of firms that jockey for position between themselves while largely ignoring others in their industry. Although it is true that companies may be interdependent without realizing it, germane to the approach developed here, a rival must recognize the interdependency. If interdependencies are not recognized, strategic mistakes may be uncovered in postmortems (Zajac and Bazerman, 1991). But, unless the players realize they must consider competitor's actions, those actions will have no effect on their strategies.

Generic game formulations, such as the Prisoner's Dilemma, are often presented as two player games although recent research has begun to examine multi-player games (Bernheim and Whinston, 1986; Camerer, 1991). This simplifying convention greatly aids mathematical analysis to reach equilibrium solutions, but has been criticized for being unrealistic (Weigelt and MacMillan, 1988). This simplification may not be as serious as previously thought because, as was true in Weigelt and MacMillan's (1988) study, cognitive research suggests that managers consider a surprisingly small set of firms when making competitive decisions (Daniels and Johnson, 1992; Gripsrud and Gronhaug, 1985; MacMillan, McCaffery and Van Wijk, 1985; Porac, Thomas, and

Baden-Fuller, 1989; Reger and Noble, 1992). Even if executives recognize multiple rivals, additional players present substantial problems for finding equilibrium solutions, but create only relatively minor issues for understanding managerial conceptions of the nature of competition.

Multiple rivals add to the complexity of structuring competitive dynamics primarily by providing the ability for coalitions to form (Komorita and Tumonis, 1980; Murnighan, Komorita and Szwajkowski, 1977). Coalitions may be overt and formal, such as joint ventures and other cooperative agreements, or they may be covert and tacit. Since firms in coalitions act collaboratively, the coalition often can be treated as a single player in modeling the competitive arena. Of course, coalitions can break apart. Within coalitions, mixed motivations to compete for one's own gain and to cooperate with other coalition members to defeat the common enemy (Pfeffer, 1981) suggest that managerial understanding of coalitional dynamics also can be modeled with game theoretic formulations.

Strategies

Strategies are the alternative actions that a player believes are options in a given situation. Game theory research has been criticized because it oversimplifies the range of available strategies (Saloner, 1991). In many game formulations, strategies are stylized into two generic alternatives. For example, as portrayed in the illustrations in this paper, the two are often the competitive and cooperative alternatives. This simplification is not a structural limitation of game theory (Camerer, 1991). If desired, game theoretic analysis can be constructed to accommodate a wide range of choices. However, for understanding managerial cognitions about competitive dynamics, stylized matrices may not only be justified, they may actually be preferred to more complex, albeit objectively realistic, models. In theory, the strategic alternatives are many; but, abundant evidence from cognitive psychology and strategic management suggests that decision makers quickly simplify their options to a very restricted set (Cyert and March, 1963; Eisenhardt, 1989; Fiske and Taylor, 1984;

Huff, 1990; Prahalad and Bettis, 1986; Schwenk, 1984). To do otherwise results in cognitive overload and the inability to fully comprehend the options (Cyert and March, 1963; Duhaime and Schwenk, 1985; Reger and Huff, 1993). The important issue in constructing cognitive models is to elicit the options the firm perceives for itself and for its rivals.

Payoffs

Payoffs are associated with each strategy set. A payoff is the compensation a player believes will result from a strategy, given the choices made by all other players. Payoffs can be profits, market share gains, or sales; but, more generally, are the perceived utility or desirability of the outcome to the player. Again, perceptions are critical. Managers are uncertain what consequences will result from their strategic choices. They learn the payoff of a chosen strategy only after the decision is made, and since extraneous events may have affected outcomes, even historical payoffs are ambiguous at best (Weick, 1979). Executives never know the true value of choices not taken. Managers, therefore, are forced to take action based on their beliefs that may be only loosely coupled to objective reality. A cognitive approach to game theoretic modeling, therefore, focuses on eliciting managerial perceptions and beliefs about payoffs rather than attempting to determine unbiased, objective outcomes.

In sum, these parameters capture the essential elements of any competitive situation: players, strategies and payoffs. With these ingredients, game theory can model key aspects of otherwise ill-structured and ambiguous competitive situations. Since decision makers' perceptions about the parameters are crucial to firm behavior, a cognitive approach focuses on executive beliefs about the nature of competitive interdependencies (Porac and Thomas, 1990; Reger and Huff, 1993; Weigelt and MacMillan, 1988), even if these beliefs are erroneous due to competitive blind spots (Zajac and Bazerman, 1991).

The Organization's Model

A final issue in constructing managerial cognitive models of competition is determining which mental model within the organization matters for strategic action (Huff, 1990: Gioia and Chittipeddi, 1991). Decision makers in the same firm may hold divergent models and simply averaging them may not capture the political dynamics that intercede between individual cognition and organizational action (Fiol and Huff, 1992). There are a variety of ways to consolidate individual cognitive maps into single group maps that represents the dominant belief structures of the top management team (Eden, Jones and Sims, 1979; 1983; Huff, 1990; Weick and Bougon, 1986). Certainly, when developing game theoretic models to describe industrial competition, it is critical that a firm's map reflect the dominant beliefs that actually influence strategic decision making, and not just the beliefs of a single individual (Hambrick and Mason, 1984; Prahalad and Bettis, 1986). Thus, a key empirical issue in a managerial cognitive approach to game theoretic modeling is the need to construct a group map representing the firm's belief structure.

FIGURE 1

A Cognitive Model of Competitive Dynamics

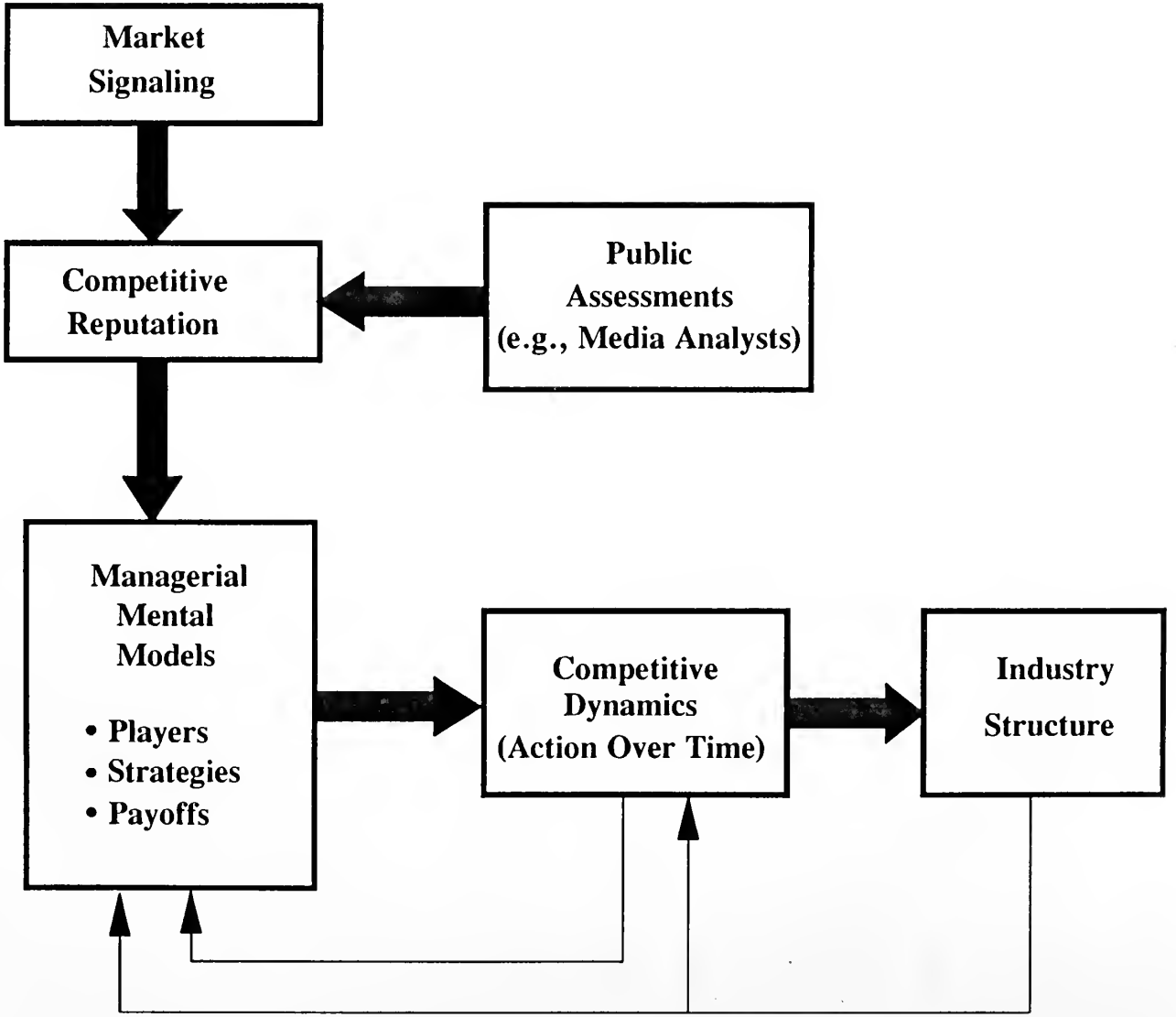

FIGURE 2
Alternative Game Theoretic Formulations

Prisoner's Dilemma Payoff Matrix

Player 1 \ Player 2	C2	D2
C1	3,3 (cell 1)	0,5 (cell 2)
D1	5,0 (cell 3)	1,1 (cell 4)

Chicken Payoff Matrix

Player 1 \ Player 2	C2	D2
C1	3,3 (cell 1)	1,5 (cell 2)
D1	5,1 (cell 3)	0,0 (cell 4)

Battle of the Sexes Payoff Matrix

VHS Coalition \ Sony	BETA	VHS
BETA	2,4* (cell 1)	0,0 (cell 2)
VHS	1,1 (cell 3)	4,2 (cell 4)

* 2,4 are the classic cell 1 payoffs for a generic Battle of the Sexes game. Since Sony refused to allow rivals to choose this cell, the payoffs are irrelevant.

Table 1
Comparison of Three Approaches to Game Theory

	Mathematical	Behavioral	Cognitive
Rationality	assumed	inferred from observation	elicited directly
Players	specified by researcher	specified by experimenter	elicited directly
Alternatives	specified by researcher	specified by experimenter	elicited directly
Payoffs	specified by researcher	specified by experimenter	elicited directly
Strategies	specified by researcher	inferred from observation or elicited directly	elicited directly
Market Signals	level and type specified	manipulated by experimenter or observed in experimental play	elicited directly
Competitive Reputation	specified by researcher	manipulated by experimenter or observed in experimental play	elicited directly

ENDNOTES

1. There are two real-world business examples where manager's implicitly (if not explicitly) understand that their firm may be gored on the horns of a prisoner's dilemma. First, a **fair-price amendment** has been proposed by a target firm's managers as a corporate charter antitakeover defense that may be for the purpose of solving a prisoner's dilemma that has been induced by an acquirer's two-tiered tender offer (for a clear game-theoretic analysis of why the two-tiered tender offer puts the target firm's stockholders in a prisoner's dilemma, see Dixit and Nalebuff, 1991, pp. 81-84; the fair price amendment prohibits the firm from entertaining any two-tiered offer). The fair-price amendment limits the options of a firm's stockholders and this **loss** of flexibility may be a strategic advantage. This example is a special case of an idea expressed by Schelling (1960) who calls:

> attention to an important class of tactics, of a kind that is peculiarly appropriate to the logic of indeterminate situations [e.g., the bilateral monopoly between one acquirer and one unique target firm]. The essence of these tactics is some voluntary but irreversible sacrifice of freedom of choice. They rest on the paradox that the power to constrain an adversary may depend on the power to bind oneself: that in bargaining weakness is often strength, freedom may be freedom to capitulate, and to burn bridges behind one may suffice to undo an opponent (1960: 22).

The sacrifice of the stockholders' freedom to accept a two-tier offer enables the target firm's stockholders to avoid the prisoner's dilemma.

Second, Oster refers to a **most favored nation** (MFN) clause found in some sales contracts as a "facilitating device to ease coordination difficulties" (1990: 217). Under this clause, the seller agrees that if their firm offers any buyer a lower price during a specified period of time for a particular item, that same price will be given to the firm with which the MFN has been signed. The MFN clause is another example of Schelling's powerful insight above. Through a MFN clause the firm's true incentives have been voluntarily, conspicuously, and irreversibly changed. By reducing the firm's flexibility and reducing options for lowering price (i.e., lowering price is now prohibitively costly), the firm may increase profits. (See Scherer and Ross, 1990: 208-213 for a game theoretic analysis of how General Electric and Westinghouse were initially in a prisoner's dilemma each charging low price and how their mutual adoption of the MFN clause transformed the payoff matrix to encourage cooperation in the pricing of turbogenerators in the 1964-1976 period.)

2. Thus, for the purposes of our paper, we will not distinguish between signaling models where information is sent intendedly and screening models where information may not be provided intendedly (see Rasmusen, 1989).

3. Signaling models in economics have also been used by researchers to tell stories which we find unconvincing. For example, while signaling models can make the case that antitakeover amendments are adopted to maximize stockholder wealth, the main case is almost certainly management favoring (Jarrell and Poulsen, 1987; Mahoney and Mahoney, 1993). To be blunt, signaling models can be used to explain just about anything. For an example that makes this point while bringing some fun into these games, see Postrel's (1991) Flaming Trouser Equilibrium. We suggest that, upon closer scrutiny, Postrel's seat of the pants argument also goes up in smoke. To be fair to signaling models and game theory in general, we do acknowledge Saloner's arguments that game theory: (1) provides an "audit trail" of the detailed logic that underlies assertions; (2) creates novel insights; and (3) provides a common language for cumulative learning. Nevertheless, Saloner does admit that: "the degree of modeling discretion is so significant that a model can be devised to explain almost any fact" (1991: 129). To paraphrase the economist Joan Robinson, strategic management students should study game theory so that they are not fooled by game theorists. The message

of our paper is that game theorists should be grounded in a better understanding of managerial cognition about competitors or they may wind up fooling themselves. Game theory, after all, is not self-contained but is only a tool. Kreps (1992) paper on "(How) can game theory contribute to a unified theory of organization?" begins with the following statement: "almost any theory of organization which is addressed by game theory will do more for game theory than game theory will do for it" (1992: 1). Similarly, Williamson argues that: "Not only is the relation between organization theory and game theory a two-way street, but game theory is the principal beneficiary!" (1993: 107).

4. Game-theoretic models of a firm's competitive reputation for pricing strategy were pioneered by Kreps and Wilson (1982b) and Milgrom and Roberts (1982). These models are based on the presumptions that each player maximizes perfectly and completely against the strategies of her opponents, and the character of those opponents and of their strategies are perfectly known, and that players are able to evaluate all their options. Of course, none of these conditions may be met in all respects in real-time competition.

5. Cooper, DeJong, Forsythe and Ross (1989) provide some experimental evidence that "cheaptalk" can in fact make a difference in the Battle of the Sexes game. They found a preplay announcement by one player improved coordination dramatically. Simultaneous cheaptalk by both players led to more conflict. Cheaptalk, however, appears useless in the Game of Chicken. Rubinstein notes that: "although language plays a crucial role in resolving conflicts, game theory has so far been unable to capture this role" (1991: 921).

6. The classic interpretation of the PD game is provided by Luce and Raiffa:

> Two suspects are taken into custody and separated. The district attorney is certain that they are guilty of a specific crime, but he does not have adequate evidence to convict them at a trial. He points out to each prisoner that each has two alternatives: To confess to the crime the police are sure they have done, or not to confess. If they both do not confess, then the district attorney states he will book them on some very minor trumped-up charge such as petty larceny and illegal possession of a weapon, and they will both receive minor punishment; if they both confess they will be prosecuted, but he will recommend less than the most severe sentence; but if one confesses and the other does not, then the confessor will receive lenient treatment for turning state's evidence whereas the latter will get "the book" slapped at him (1957:95).

Converting the classic interpretation to standard game theory notation, the PD payoff matrix is represented in the top panel of Figure 2, where C1 and C2 are cooperative moves for players 1 and 2 respectively (cooperative with each other, or refusing to confess), and D1 and D2 are "defecting", or competitive moves for players 1 and 2, respectively. Player 1 payoffs are listed first in the payoff matrix. The numbers in the matrix correspond to the utility or desirability of the payoff such that $5 > 3 > 1 > 0$ following one convention that has been used extensively in behavioral research (Oskamp, 1972).

7. Researchers (several folk) have already proved a "folk theorem" stating that any outcome in the range from total cooperation to total defection is possible in the repeated Prisoner's Dilemma (Fudenberg and Tirole, 1986). Myerson (1992: 332) prefers the phrase **general feasibility theorem** in place of the "folk theorem", because naming a theorem for the fact that it is part of an oral folk tradition in game theory conveys no useful information for the pragmatically oriented.

8. A dominant strategy equilibrium is a strategy combination consisting of each player's dominant strategy. A weaker equilibrium concept for static games of complete information is a Nash equilibrium (Nash, 1950). A strategy combination is a Nash equilibrium if no player has incentive to deviate from her strategy given

that the other players do not deviate. Every dominant strategy equilibrium is a Nash equilibrium, but not every Nash equilibrium is a dominant strategy equilibrium. Other important equilibrium concepts include: subgame perfect (Nash) equilibrium (Selten, 1965) that rules out Nash equilibrium which rely on players that make "empty threats" in dynamic games of complete information. For games with incomplete information, a Bayesian Nash equilibrium (Harsanyi, 1967) is an established solution concept, while for dynamic games of incomplete information perfect Bayesian (Nash) equilibrium (Selten, 1975) and sequential equilibrium (Fudenberg and Tirole, 1991b; Kreps and Wilson, 1982a) have been developed. While our paper provides an overview of the "forest" of game theory, the student of strategy must still study these (extensive form game) "trees" (see e.g., Fudenberg and Tirole, 1991a; Gibbons, 1992; Myerson, 1991). Weigelt and Camerer argue that: "the study of sequential equilibria in incomplete-information games may begin to finally fulfill the potential for applications of game theory to strategy research" (1988: 446).

9. The classic interpretation of the chicken game comes from the teenage automobile game of the same name. Two drivers aim their cars at each other and speed toward a head-on collision. The first driver to turn away from the collision is the "chicken" and the loser. However, if neither driver turns away, both risk death in a head-on collision.

10. Murnighan (1991:46) notes that: "The Battle of the Sexes is intriguingly but unfortunately named. The sexes certainly have had and will have battles like this. But disputes of this kind are not restricted to the sexes. Anyone can have a conflict like this!" In the original version the man wants to go to the prize fight and the woman wants to go to the ballet. While selfish, they are deeply in love, and would, if necessary, sacrifice their preferences to be with each other. When the Battle of the Sexes game is played sequentially, it provides a stylized example of "first-mover advantages" (Lieberman and Montgomery, 1988; Spence, 1981). The text provides a business example involving Sony.

11. This example and the personal computer example to follow are stylized based on popular press reports. The cases are presented to illustrate the Battle of the Sexes game and the authors acknowledge that in both cases, the true evolution of the industries is more complex, and thus open to multiple interpretations.

12. Similarly, Fudenberg and Tirole note that: "the likely outcome of a game depends on more information than is provided by the strategic form [game]. For example, one would like to know how much experience the players have with games of this sort, whether they come from a common culture and thus might share certain expectations about how the game will be played, and so on" (1991a, p.13). For example, Schelling's (1960) "focal points" depend on the players' culture and past experience.

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