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CYCLES OF CONFLICT

BY

Steven J. Brams

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C. V. STARR CENTER FOR APPLIED ECONOMICS

NEW YORK UNIVERSITY
FACULTY OF ARTS AND SCIENCE
DEPARTMENT OF ECONOMICS
WASHINGTON SQUARE
NEW YORK, N.Y. 10003

ABSTRACT

Cycles of Conflict

"Cycles of conflict" occur when conflict first escalates, then de-escalates, with this pattern possibly repeated again and again. A dynamic model, based on the theory of moves, is used to analyze cyclicity patterns in the 78 2 x 2 strict ordinal games.

The model distinguishes 42 noncyclic games from 36 cyclic games, which are broken down into three categories: strongly cyclic, moderately cyclic, and weakly cyclic. For each of these categories, the effects of "moving power," which is the ability to continue moving when the other player must eventually stop, are indicated.

Moving power is shown to be irrelevant in a game postulated to model bombing campaigns waged by the United States against North Vietnam in the latter part of the Vietnam war. However, North Vietnam's misperception of U.S. preferences made it think that it was playing a different game in which its moving power was effective, which probably prolonged the war. More generally, moving power is not effective in a majority of cyclic games; even those in which it is effective need not result in physical cycling unless there is incomplete information about which player possesses this power.

Cycles of Conflict

l. Introduction

There has been a dearth of research, grounded in rational-choice models, on wars and other recurrent conflicts that *cycle*: the level of conflict first escalates, then deescalates, with this pattern possibly repeated again and again. Instead, rational-choice modelers have concentrated on problematic games, like Prisoners' Dilemma or Chicken, to explain why rational players find it so difficult to extricate themselves from conflict. Or they have analyzed repeated play of these games to explain how cooperation may evolve (Axelrod, 1964). None of these models, however, explains why players would cycle in and out of conflict.

In politics, one observes cyclic conflicts at both the both domestic and international level. Thus, the racial, religious, and ethnic strife in places like South Africa, Northern Ireland, and Yugoslavia are primarily cases of domestic conflict, although there has been considerable outside intervention in all these situations. International conflict that has recurred in cycles or waves includes that between Israel and the Arab countries, India and Pakistan, and—over the last several centuries—England, France, and Germany. The human toll of these recurrent conflicts has been enormous.

In international relations, there has been a spate of literature purporting to explain such conflicts. This has been particularly true of "long cycles" of peace and war (Modelski, 1987; Rosecrance, 1987; Goldstein, 1988; Thompson, 1988), which has led to a vigorous debate about their statistical foundations and empirical validity (Beck, 1991; Goldstein, 1991).[1] Whereas

[1] A wide-ranging review of the literature on longitudinal patterns (e.g., Kuznets cycles and Kondratiev waves) in economics and politics is given in Berry (1991), who concludes that there is strong evidence of cyclical behavior.

this work is primarily inductive—focusing on demographic, economic, political, technological, and territorial factors—I propose here a deductive rational-choice model, rooted in game theory, to explain cycles of conflict.

To model cyclic conflict, I begin with the 78 distinct 2 x 2 strict ordinal games in which two players, each with two strategies, can strictly rank the four outcomes from best to worst. I distinguish "cyclic" games, of which there are 36, from "noncyclic" games, of which there are 42, showing that all cyclic games cycle in either a clockwise or counterclockwise direction but not in both directions.

I then divide the 36 cyclic games into three mutually exclusive categories—strongly cyclic (9 games), moderately cyclic (18 games), and weakly cyclic (9 games)—depending on whether neither, one, or both players does immediately worse as the game cycles. These different categories of cyclicity may be thought of as measuring the "friction" of cycling. Thus, a strongly cyclic game is essentially frictionless, because each player, in switching strategies when it has the next move, always does *immediately* better as play moves around the 2 x 2 matrix.

The game-theoretic analysis I employ to explicate the logic of cycling is based on the "theory of moves" (Brams, 1992). In an earlier incarnation, this theory was used to define various equilibrium and power concepts (Brams, 1983), based on the notion that players look ahead in a game of complete information to ascertain whether it is rational to move from an initial outcome. Here I use the theory instead to model the *dynamics* of cycling, without reference to where play starts but with reference to where it may terminate and whether, on this basis, it is it better for a player to continue to move or to stop.

Among other findings, I show how an asymmetry in capabilities between two players, based on "moving power," may enable one player to implement a preferred outcome by wearing down its opponent through repeated cycling. Such power, if effective in a game, may be a more important source of instability than the kind of cyclicity (strong, moderate, or weak) that a game possesses. For even in a weakly cyclic game, wherein each player's move does not always leads to an immediately better outcome, moving may be better for a player than staying in order to force an opponent to terminate play at a preferred outcome.

Outcomes at which play terminates in cyclic games do not necessarily coincide with Nash equilibria—the standard concept of stability in noncooperative game theory—because the theory of moves assumes different rules of play from those postulated in classical game theory. Whether the new rules better capture the move possibilities of real players, caught in cycles of conflict, is ultimately an empirical question.

To address this question, I define "cycles of conflict" to include the alternation of periods of relative calm with major disruptive events over many years, such as the 36 years spanning the six wars between Arabs and Israelis from 1948 to 1984. But I also include as cycles alternating periods *within* a single war or prolonged period of conflict, such as the intermittent use of bombing by the United States, and of ground offenses by North Vietnam, in the Vietnam war between 1965 and 1972.

Indeed, it is this empirical case to which I apply the cyclic-conflict model. The game I posit that was played is a moderately cyclic one, in which neither player can gain from the exercise of moving power. What, then, explains the long duration of the war?

I believe that North Vietnam, lacking complete information about U.S. preferences, misperceived that "real game." Instead, it thought it was playing a game in which moving power is effective in inducing a better outcome for the player who possesses it. This misperception forced both players, each thinking it could outlast the other, to reject any settlement until January 1973. Ironically, the peace treaty that was finally signed differed little from that which had been proposed several years earlier.

2. Cyclic Games and the Theory of Moves

Consider the ordinal versions of Prisoners' Dilemma (PD) and Chicken shown at the top of Figure 1. In each game, I assume that the two players,

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Figure 1 about here

Row and Column, can rank the four outcomes from best to worst. (Ignore for now the arrows in these games.) Because the players do not rank any two outcomes the same—that is, there are no ties between ranks—these are *strict* ordinal games.

In each game, Row and Column are assumed to be able to choose between the strategies of cooperation (C) and noncooperation ($\bar{C}$). The choices of strategies by each player lead to four possible outcomes, ranked by the players from best (4) to worst (1). The first number in the ordered pair that defines each outcome is assumed to be the ranking of Row, the second number the ranking of Column. Thus, outcome (3,3) in both games is considered to be the next-best for both players, but no presumption is made about whether this outcome is closer to each player's best (4) or next-worst (2) outcome.

Figure 1

Two Noncyclic Games: Prisoners' Dilemma and Chicken

Prisoners' Dilemma

		Column		
		C		$\bar{C}$
	C	(3,3)	→	(1,4)
Row		⤒		↓
	$\bar{C}$	(4,1)	←	(2,2)

Chicken

		Column		
		C		$\bar{C}$
	C	(3,3)	→	(2,4)
Row		⤒		↓
	$\bar{C}$	(4,2)	←	(1,1)

Key: (x,y) = (payoff to Row, payoff to Column)

C = cooperate; $\bar{C}$ = not cooperate

4 = best; 3 = next best; 2 = next worst; 1 = worst

Nash equilibria in pure strategies underscored

Arrows indicate direction of cycling (with blockages indicated)

The dilemma in PD is that both players have a *dominant strategy* of choosing $\overline{C}$: whatever strategy the other player chooses (C or $\overline{C}$), $\overline{C}$ is better; but the choice of $\overline{C}$ by both players leads to (2,2), which is *Pareto-nonoptimal*, or worse for both players, than (3,3). In addition, (2,2) is a *Nash equilibrium:*[2] neither player has an incentive to move unilaterally from this outcome because it would do worse if it did, whereas (3,3) is not stable in this sense.

In Chicken, there are two Nash equilibria in pure strategies, (4,2) and (2,4), both of which are *Pareto-optimal* since there are no other outcomes better for both players. But each player, in choosing its $\overline{C}$ strategy associated with the Nash equilibrium favorable to itself [(4,2) for Row, (2,4) for Column], risks the disastrous (1,1) outcome (should the other player also choose $\overline{C}$).

Whereas the unique Nash equilibrium in PD is Pareto-nonoptimal, in Chicken there is a conflict between two Pareto-optimal Nash equilibria, (4,2) and (2,4), one favoring Row and the other Column. Moreover, in both games the (3,3) "compromise" outcome is not a Nash equilibrium, making it difficult to justify as a rational outcome in either game.

Important as PD is for modeling destructive stalemates like arms races, and Chicken for modeling confrontation situations like international crises, these games are not apt models of situations in which players may cycle in and out of conflict. Moreover, repeated play of these games offers little insight into such cycles. Rather, the emphasis in the repeated-play literature is on how cooperation might evolve over time—and the robustness of

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[2]Technically, this equilibrium is defined by the strategies that yield this outcome, not the outcome itself.

strategies like "tit-for-tat" in sustaining this evolution (Axelrod, 1984)—rather than on what strategic factors might induce cycling.

The very nature of cycles suggests that any models to explicate them must be dynamic in nature. For this purpose, I will build on the *theory of moves* (TOM), whose application to 2 x 2 strict ordinal games is developed in detail elsewhere (Brams, 1992; for an overview, see Brams and Mattli, 1993).

One tenet of TOM is that if players have complete information and recognize that a game will cycle, they will act strategically to prevent this from occurring, under the assumption that they will be no better off, and perhaps worse off (e.g., because of transaction costs), returning to the initial outcome. Although I abandon this tenet here in order to try to explicate a rational basis of cycling, I retain the framework of TOM, substituting rule 6 (given in section 4) that permits cycling for a rule that forbids cycling.

Classical game theory, by assuming that players choose strategies simultaneously in the normal (matrix) form, does not raise questions about the rationality of moving or departing from outcomes—at least beyond an immediate departure, à la Nash's concept of an equilibrium. In fact, most real-life games do not start *with* simultaneous strategy choices but commence *at* outcomes. One question TOM raises is whether a player, by departing from an outcome, can do better not just in an immediate or myopic sense but, instead, in an extended or nonmyopic sense.

I illustrate the perspective TOM offers on this question with PD and Chicken later and also show that these games are not cyclic. These are only two of the 78 2 x 2 strict ordinal games that are structurally distinct in the sense that no interchange of the players, their strategies, or any combination of these can transform one of these games into any other.[3] These 78 games represent *all* the different configurations of payoffs in which two players, each with two strategies, may find themselves embedded. The first four rules of play of TOM that I apply to these games are the following:

1. Play starts at an outcome, called the *initial state*, which is at the intersection of the row and column of a 2 x 2 payoff matrix.
2. Either player can unilaterally switch its strategy, and thereby change the initial state into a subsequent state, in the same row or column as the initial state.[4] Call the player who switches player 1 (Pl).
3. Player 2 (P2) can respond by unilaterally switching its strategy, thereby moving the game to a new state.
4. The alternating responses continue until the player (Pl or P2) whose turn it is to move next chooses not to switch its strategy. When this happens, the game terminates in a final state, which is the *outcome* of the game.

Note that the sequence of moves and countermoves is *strictly alternating:* first, say, Row moves, then Column moves, and so on, until one player

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[3]For complete listings of the 78 games, see Rapoport and Guyer (1966) and Brams (1977); for a partial listing that excludes the 21 games with a mutually best (4,4) outcome, see Brams (1983, pp. 173-177; 1992).

[4]I do not use "strategy" in the usual sense to mean a complete plan of responses by the players to all possible contingencies allowed by rules 2–4, because this would make the normal form unduly complicated to analyze. Rather, *strategies* (C and $\overline{C}$ in PD and Chicken) refer to the choices of players that define a state, and *moves and countermoves* to their subsequent strategy switches from an initial state to a final state in an extensive-form game, as allowed by rules 2–4. This framework is developed in detail in Brams (1992) and illustrated in Brams and Mattli (1993). For other approaches to combining the normal and extensive forms, see Hamilton and Slutsky (1988) and Mailath, Samuelson, and Swinkels (1991).

stops, at which point the state reached is final and, therefore, the outcome of the game.[5]

The use of the word "state" is meant to convey the temporary nature of an outcome, before players decide to stop switching strategies. I assume that no payoffs accrue to players from being in a state unless it is the final state and, therefore, becomes the outcome (which could be the initial state if the players choose not to move from it).

To assume otherwise would require that payoffs be cardinal rather than ordinal, with players accumulating them as they pass through states. I eschew this assumption in part because I think payoffs to players in real-life games cannot generally be quantified and summed across the states visited. More significant, payoffs in most political games I know depend overwhelmingly on the final state reached. Thus, it is not the arduous task of running for office that most politicians prize but the reward of getting elected.

Rule 1 differs radically from the corresponding rule of play of a normal-form game, in which players simultaneously choose strategies that determine an outcome.[6] Instead of starting *de novo* with strategy choices, I assume that players are already *in* some state at the start of play and receive payoffs from this state *if they stay*. Based on these payoffs, they must decide, individually, whether to change this state in order to try to do better.

To be sure, some decisions are made collectively by players, in which case it would be reasonable to say that they choose strategies

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[5]Although one could allow for backtracking, I do not do so here because my purpose is to analyze conditions under which cycles—not just back-and-forth movements—occur.

[6]Consequently, games like PD and Chicken are not the same games when played according to the new rules, which explains why the outcomes predicted by TOM may differ considerably from the Nash equilibria, as I will illustrate later.

simultaneously, or coordinate their choices. But if, say, two countries are coordinating their choices, as when they agree to sign a treaty, the important question is what individualistic calculations led them up to this point.[7] The formality of jointly signing the treaty is the culmination of their negotiations, covering up the move-countermove process that preceded it. This is precisely what TOM is designed to uncover.

To continue this example, the parties who sign the treaty were in some prior state, from which both desired to move—or, perhaps, only one desired to move and the other could not prevent this move without hurting itself. Eventually they may arrive at a new state (e.g., after treaty negotiations) in which it is rational for both countries to sign the treaty that has been negotiated.

Put another way, almost all outcomes of games that we observe have a history. *My interest is in explaining strategically the progression of (temporary) states that lead to a (more permanent) outcome, which may include cyclical behavior.*

Of course, what is "temporary" and what is "more permanent" depends on one's time frame. I use the phrase "more permanent," rather than simply "permanent," to underscore the obvious point that nothing in the world is permanent. Less obvious, a state that persists for a week, say, in a crisis may

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[7]By focusing on the calculations of individual players, I eschew the "cooperative" viewpoint in game theory, which assumes that players can make an agreement that is binding and enforceable. If this is the case, they need only be concerned with how to divide up the surplus, accruing from their cooperation, in some equitable or otherwise reasonable manner. But their decision to cooperate in the first place, in my view, should emerge as the result of "noncooperative" individualistic calculations, which would inform the players, for example, that such an agreement is stable instead of just assuming this to be the case. Building cooperative game theory on noncooperative foundations is what is known as the "Nash program" in game theory. It is a program that I endorse and consider consistent with TOM, which primarily offers a different *basis* for making the individualistic calculations of noncooperative game theory.

be permanent enough to represent an outcome in the analysis of crisis behavior, whereas a week for most historians is not long enough to qualify as even a state (unless it is exceedingly eventful and gives payoffs to the players for being there).

However defined empirically, I start play of a game *in a state*, at which players accrue payoffs only if they remain in that state so that it becomes the outcome of the game. If they do not remain, they still know what payoffs they *would have accrued* had they stayed; hence, they can make a rational calculation of the advantages of staying or moving. They move precisely because they calculate that they could do better by switching states, anticipating a better outcome when the move-countermove process finally comes to rest.[8]

The choice of a state, and what constitute future states and eventually an outcome, depends on what the analyst seeks to explain. The time perspective of most political scientists probably ranges between about a week (e.g., in analyzing a crisis) and a generation; journalists are more likely to think in terms of hours and days, whereas the span of most historians varies from a few years to a century or two.

Rules 1–4 say nothing about what *causes* a game to end but only when: termination occurs when a "player whose turn it is to move next chooses not to switch its strategy" (rule 4). But when is it rational not to continue moving, or not to move from the initial state at the start? The next rule of play provides a sufficient condition for cycling *not* to occur:

5. If, at any state in the move-countermove process, a player whose

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[8]I assume that their *mental* calculations of advantage and disadvantage precede, and therefore serve as the basis of, their actual *physical* moves. Whether physical moves are necessary is discussed later.

turn it is to move next receives its best payoff (i.e., 4), it will not move from this state.

Rule 5, in fact, precludes cycling in 42 of the 78 2 x 2 games, 21 of which contain a mutually best (4,4) state. As illustrations of other *noncyclic games*, consider PD and Chicken in Figure 1, wherein the arrows indicate moves and countermoves in a clockwise direction. In PD, for example, starting at (3,3), note that Column does immediately better by moving to (1,4), and Row by moving from (1,4) to (2,2). Although Column does not do immediately better moving from (2,2) to (4,1), the real problem is that (4,1) is Row's best state, so Row would never have an incentive to move on if the process reached this state from (2,2). I refer to this halt in cycling as *blockage*, which is shown by the blocked arrow from (4,1) to (3,3) in Figure 1.

Similarly, if play moves in a counterclockwise direction, there will be blockage when Column tries to move from (1,4) to (3,3). According to rule 5, therefore, neither Column nor Row will move initially from (3,3), because each will eventually encounter blockage. Moreover, if either player stops the process at (2,2) before there is blockage, it does worse than at (3,3).

This is the kind of argument I and others have developed, based on the rules of TOM, to show that (3,3) in PD is a "nonmyopic equilibrium."[9] But my point here is a different one—namely, that PD is a game that will never

[9]The original argument can be found in Brams and Wittman (1981)), which was extended in, among other places, Brams (1983), Kilgour (1984, 1985), and Zagare (1984). Marschak and Selten (1978), Brams and Hessel (1982), and Hirshleifer (1985) have investigated related equilibrium concepts, based on different rules of play that define a game (Gardner and Ostrom, 1990). Almost all the so-called refinements of Nash equilibria, including subgame perfection, assume a finite extensive-form game. By contrast, the building block of the present analysis, a cyclic game (to be defined in the text), is not finite—it may cycle indefinitely. Hence, the extensive-form game is not defined, so most of the Nash refinements are not applicable.

cycle. *Independent of the initial state*—it need not be (3,3)—players will, as they move, run into blockage at either (4,1) or (1,4), depending on whether the direction of their movement is clockwise or counterclockwise. From these states, according to rule 5, Row and Column will never move on.

Likewise in Chicken, as shown by the arrows in Figure 1, if Column moves initially from (3,3) to (2,4), Row from (2,4) to (1,1), and Column from (1,1) to (4,2), blockage will occur at (4,2) before returning to (3,3); blockage will occur in a counterclockwise direction at (2,4). Cycling, therefore, is not rational in this game either, making both PD and Chicken noncyclic.

But what about the 36 2 x 2 *cyclic games*, in which blockage does not occur according to rule 5? I next show that in these games cycling can occur in only one direction.

Theorem 1. *If a 2 x 2 strict ordinal game is cyclic, cycling can occur either in a clockwise direction or in a counterclockwise direction but not in both directions.*

Proof. On the left-hand side of Figure 2, I show the four

Figure 2 about here

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placements of the best payoffs for Column (4) that preclude cycling in either a clockwise direction (top matrix) or a counterclockwise direction (bottom matrix), as indicated by the blockages of the arrows. In the top left-hand matrix, for example, where Column obtains a 4 at both the main-diagonal entries, cycling in a clockwise direction is irrational, because the process will stop when Column obtains its best payoff, as shown by the blockages of the arrows emanating from these states. Likewise, in the bottom left-hand

Figure 2

Cycling Possibilities in a 2 x 2 Game

No Clockwise Cycling Possible

(,4)	→|	(,)		(,)	→	(4,)
↑		↓		⤒		⤓
(,)	|←	(,4)		(4,)	←	(,)

No Counterclockwise Cycling Possible

(,)	|←	(,4)		(4,)	←	(,)
↓		↑		⤓		⤒
(,4)	→|	(,)		(,)	→	(4,)

matrix where Column obtains a 4 at both the off-diagonal entries, cycling in a counterclockwise direction is irrational, because the process will stop when Column obtains its best payoff, again as shown by the blockages.

But Column *must* obtain its best payoff in one of the four states of the two left-hand matrices, so one of the four entries must contain a 4. Depending on which entry, cycling either in a clockwise or in a counterclockwise direction, but not both, will be precluded. A similar argument holds for why clockwise and counterclockwise cycling, based on the placement of 4's for R in the right-hand matrices, cannot both be precluded.

Now the placement of a 4 by Column and a 4 by Row gives rise to three mutually exclusive and exhaustive possibilities:

(1) Both players' 4's prohibit clockwise cycling but not counterclockwise cycling;
(2) Both players' 4's prohibit counterclockwise cycling but not clockwise cycling;
(3) One player's 4 prohibits clockwise cycling, and the other player's 4 prohibits counterclockwise cycling, which makes the game noncyclic.

Whichever of (1), (2), or (3) obtains, cycling cannot occur in *both* directions at the same time. Q.E.D.

Define a game to be *symmetric* if there is an arrangement of the payoffs to the players so that the payoffs along the main diagonal are the same, whereas the off-diagonal payoffs are mirror images of each other (i.e., those for Row and Column are interchanged). Twelve of the 78 2 x 2 games are symmetric, which are illustrated by PD and Chicken in Figure 1.

Corollary 1. *If a 2 x 2 strict ordinal game is symmetric, it is noncyclic.*

Proof. By Theorem 1, the payoffs of one player prohibit cycling in one direction. Because either the mirror-image off-diagonal payoff of the other player is a 4, which causes blockage in the other direction, or a main-diagonal payoff is (4,4), which causes blockage in both directions, the game does not cycle in either direction. Q.E.D.

To summarize, no symmetric game is cyclic; if an asymmetric game is cyclic, cycling can go in only one direction. In section 3, I divide the 36 cyclic games into different classes, depending how much "friction" the players encounter in cycling.

3. Three Classes of Cyclic Games

A game may be cyclic either in a clockwise direction, in which case the 4's for Row and Column fit the pattern of the bottom two matrices in Figure 2 (which preclude counterclockwise cycling), or in a counterclockwise direction, in which case the 4's for Row and Column fit the pattern of the top two matrices in Figure 2 (which preclude clockwise cycling). The 36 cyclic games I present in this section all fit the latter pattern, so cycling always occurs in a counterclockwise direction.[10]

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[10]I have written the games so that cycling is counterclockwise principally because Rapoport and Guyer (1966) list the 36 cyclic games in this manner. To facilitate linking their taxonomy of the 78 2 x 2 strict ordinal games with the 36 that are cyclic, I include in parentheses, after the numbers I assign to the 36 cyclic games, the Rapoport-Guyer numbers.

I next divide the 36 cyclic games into three mutually exclusive classes, depending on the number of "impediments" that player encounter in moving, in a counterclockwise direction, around the matrix:

1. No player has an impediment—strongly cyclic games. The 9 games in this category are shown in Figure 3.[11] At every state in these games, one

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Figure 3 about here

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player does immediately better by switching its strategy. In game #1, for example, assume the initial state is (2,3) in the upper left-hand cell. Then Row does better moving to (3,2), whence Column does better moving to (1,4), whence Row does better moving to (4,1), whence Column does better returning to state (2,3). In other words, there is no *impediment* to cycling: at every state a player does immediately better moving in a counterclockwise direction.

2. One player has an impediment—moderately cyclic games. The 18 games in this category are shown in Figure 4. At one state in these games,

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Figure 4 about here

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which is always the upper left-hand cell in each matrix in Figure 4, Row always does worse moving to the lower left-hand cell. In game #10, for example, Row does worse moving from (3,4) to (2,1). However, all subsequent moves in a counterclockwise direction are immediately

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[11]Ignore for now the r and c superscripts in these games and the games in Figures 4 and 5. I shall explain both this notation and the classification of games based on "moving power" later.

Figure 3
9 Strongly Cyclic Games

1. Moving power is effective—the outcome that each player can induce with moving power is better for it than the outcome that the other player can induce (6 games).

1 (75)

(2,3)c	(4,1)
(3,2)r	(1,4)

2 (76)

(2,3)c	(3,1)
(4,2)r	(1,4)

3 (70)

(3,4)c	(2,1)
(4,2)r	(1,3)

4 (71)

(3,3)c	(2,1)
(4,2)r	(1,4)

5 (73)

(2,4)c	(4,1)
(3,2)r	(1,3)

6 (74)

(2,4)c	(3,1)
(4,2)r	(1,3)

2. Moving power is irrelevant—the outcome induced by one player is better for both players (3 games).

7 (72)

(3,2)c	(2,1)
(4,3)r*	(1,4)

8 (77)

(2,2)c	(4,1)
(3,3)r*	(1,4)

9 (78)

(2,2)c	(3,1)
(4,3)r*	(1,4)

Key: (x,y) = (payoff to Row, payoff to Column)

4 = best; 3 = next best; 2 = next worst; 1 = worst

c = best state C can induce with moving power

r = best state R can induce with moving power

* = induced state best for both players

Figure 4

18 Moderately Cyclic Games

1. Moving power is effective—the outcome that each player can induce with moving power is better for it than the outcome that the other player can induce (8 games).

10 (49)

(3,4)^{c}	(4,3)^{r}
(2,1)	(1,2)

11 (50)

(3,4)^{c}	(4,3)^{r}
(1,1)	(2,2)

12 (51)

(3,4)^{c}	(4,2)^{r}
(2,1)	(1,3)

13 (52)

(3,4)^{c}	(4,2)^{r}
(1,1)	(2,3)

14 (53)

(3,3)^{c}	(4,2)^{r}
(2,1)	(1,4)

15 (54)

(3,3)^{c}	(4,2)^{r}
(1,1)	(2,4)

16 (56)

(2,4)	(4,2)^{r}
(1,1)	(3,3)^{c}

17 (57)

(2,3)	(4,2)^{r}
(1,1)	(3,4)^{c}

2. Moving power is irrelevant—the outcome induced by one player is better for both players (8 games).

18 (40)

(3,4)^{c*}	(4,1)
(2,2)^{r}	(1,3)

19 (41)

(3,4)^{c*}	(4,1)
(1,2)^{r}	(2,3)

20 (42)

(3,3)^{c*}	(4,1)
(2,2)^{r}	(1,4)

21 (43)

(3,3)^{c*}	(4,1)
(1,2)^{r}	(2,4)

22 (47)

(2,3)	(4,1)
(1,2)^{r}	(3,4)^{c*}

23 (48)

(2,2)	(4,1)
(1,3)^{r}	(3,4)^{c*}

24 (44)

(2,4)	(4,1)
(1,2)^{r}	(3,3)^{c*}

25 (55)

(2,4)	(4,3)^{r*}
(1,1)	(3,2)^{c}

3. Moving power is *<u>ineffective</u>*—*each player prefers the outcome that the other player can induce (2 games).*

26 (45)

<u>(3,2)</u>c#	(4,1)
(2,3)r#	(1,4)

27 (46)

<u>(3,2)</u>c#	(4,1)
(1,3)r#	(2,4)

Key: (x,y) = (payoff to Row, payoff to Column)

4 = best; 3 = next best; 2 = next worst; 1 = worst

c = best state C can induce with moving power

r = best state R can induce with moving power

* = induced state best for both players

= induced state of other player preferred

Nash equilibria underscored

beneficial to the mover: Column in going from (2,1) to (1,2), Row in going from (1,2) to (4,3), and Column in going from (4,3) back to (3,4).

3. Both players have an impediment—weakly cyclic games. The 9 games in this category are shown in Figure 5. At two states in these games,

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Figure 5 about here

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which are always the upper left-hand and the lower left-hand cells in each matrix, the players do worse moving in a counterclockwise direction. In game #28, for example, Row does worse moving from (3,4) to (1,2), and Column does worse moving from (1,2) to (2,1). Subsequently, however, Row does better moving from (2,1) to (4,3), and Column does better in returning to (3,4) from (4,3) to complete the cycle.

Theorem 2. *There are no 2 x 2 cyclic games in which there are two separated impediments. In particular, there are no games in which there are three impediments.*

Proof. Two impediments are *separated* if, after one player does worse by moving, the same player does worse by moving again (i.e., after the second player has moved). Assume the first player is Row, and it does worse moving in a counterclockwise direction on the two occasions when it has the opportunity to do so: from both the upper-left to the lower-left cell, and from the lower-right to the upper-right cell. Then it cannot receive 4 at either of the cells from which it moves, because otherwise the game would not cycle. But if Row received 4 at either of the other two cells, then moves to these cells would necessarily be beneficial, which is contrary to the supposition that there is an impediment at both. The fact that there cannot

Figure 5

9 Weakly Cyclic Games

1. Moving power is effective—the outcome that each player can induce with moving power is better for it than the outcome that the other player can induce (2 games).

28 (19)

(3,4)^{c}	(4,3)^{r}
(1,2)	(2,1)

29 (20)

(3,4)^{c}	(4,3)^{r}
(2,2)	(1,1)

2. Moving power is irrelevant—the outcome induced by one player is better for both players (5 games).

30 (13)

(3,4)^{c*}	(4,2)
(2,3)^{r}	(1,1)

31 (14)

(3,4)^{c*}	(4,2)
(1,3)^{r}	(2,1)

32 (15)

(3,4)^{c*}	(4,1)
(2,3)^{r}	(1,2)

33 (16)

(3,4)^{c*}	(4,1)
(1,3)^{r}	(2,2)

34 (21)

(2,4)	(4,3)^{r*}
(1,2)	(3,1)^{c}

3. Moving power is ineffective—each player prefers the outcome that the other player can induce (2 games).

35 (17)

(2,4)	(4,2)
(1,3)$^{r\#}$	(3,1)$^{c\#}$

36 (18)

(2,4)	(4,1)
(1,3)$^{r\#}$	(3,2)$^{c\#}$

Key: (x,y) = (payoff to Row, payoff to Column)

4 = best; 3 = next best; 2 = next worst; 1 = worst

c = best state C can induce with moving power

r = best state R can induce with moving power

* = induced state best for both players

= induced state of other player preferred

Nash equilibria underscored

be two separated impediments also proves that there cannot be three impediments, because the three must include two that are separated. Q.E.D.

Theorem 2 establishes that the three classes of cyclic games—strongly cyclic (no friction), moderately cyclic (some friction), and weakly cyclic (much friction)—are exhaustive. Although the friction of one or two impediments would seem to impede cycling, I shall next show that even the two impediments of some weakly cyclic games can be overcome if one player has moving power.

4. Moving Power

Assume that the players not only know their own payoffs but also have complete information about the payoffs of their opponents. If this is the case, when would a player have an incentive to cycle to try to outlast an opponent?

By "outlasting" an opponent, I mean that one (stronger) player can force the other (weaker) player to stop the move-countermove process at a state where the weaker player has the next move. Forcing stoppage at such a state, however, may not always lead to an outcome favorable to the stronger player. Not only may a stoppage-forcing strategy be unproductive, but it may actually be counterproductive, leading to a *worse* outcome than if the stronger player had stopped the cycling itself.

Rule 5 specified what players would *not* do—namely, move from a best (4) state when it was their turn to move. By precluding cycling in both directions in 42 of the 78 games, however, this rule did not say anything about where cycling would stop in the remaining 36 cyclic games. In these games, a final rule of play is needed to say at what, if any, state play will terminate:

6. In a cyclic game, P1 will move from an initial state, even if play returns to this state and repeatedly cycles, if it (i) has "moving power" and (ii) can induce a better outcome for itself with it.

Pl has *moving power* if it can induce P2 eventually to stop, in the process of cycling, at one of the two states at which P2 has the next move. The state at which P2 stops, I assume, is that which P2 prefers.[12]

I next describe and illustrate with examples three possible effects of moving power in cyclic games:

1. Moving power is effective—the outcome that each player can induce with moving power is better for it than the outcome that the other player can induce (16 games). To illustrate this effect, consider game #1 in Figure 3, which is a *game of total conflict*: what is best (4) for one player is worst (1) for the other, and what is next best (3) for one is next worst (2) for the other. As I showed in section 3, game #1 is a strongly cyclic game, with cycling going in a counterclockwise direction.

Now assume that Row possesses moving power in game #1. Because cycling is counterclockwise, Row can induce Column to stop at either (3,2) or (4,1), where Column has the next move. Obviously, Column would

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[12]An earlier version of this concept was proposed in Brams (1982, 1983). Other concepts of power, based on TOM, that have been developed include threat power (Brams and Hessel, 1984), staying power (Brams and Hessel, 1983; Kilgour, De, and Hipel, 1986), and holding power (Kilgour and Zagare, 1987), but none of these is relevant to the study of cycles. Neither are the empirical studies based on TOM, including Brams (1985) and Zagare (1981, 1983, 1987). On the other hand, Langlois (1992) permits cycling within a cardinal framework, rooted in expected-utility calculations; because cycling is assumed to be costly, however, both players will eventually want to desist. I do not make that assumption here but instead assume that the player with moving power is essentially indefatigable—at least compared with the player without moving power, who must eventually stop moving.

prefer (3,2), which gives Row its next-best state of 3 and Column its next-worst state of 2, which is indicated by the superscript of *r*.

On the other hand, if Column possesses moving power, it can induce Row to stop at either (2,3) or (1,4), where Row has the next move. Obviously, Row would prefer (2,3), which gives Column its next-best state of 3 and Row its next-worst state of 2, which is indicated by the superscript of *c*. In other words, the player with moving power can ensure a better outcome (3) than the player without (2), which makes this power *effective*: it is better for a player to possess moving power than for the other player to possess it.

A glance at Figures 3, 4, and 5 shows that every class of cyclic games (strongly cyclic, moderately cyclic, and weakly cyclic) includes some games in which moving power is effective. The different outcomes that Row and Column can induce are indicated by the superscripts of *r* and *c*. Notice that Row always prefers the outcome it can induce to the outcome that Column can induce, and vice-versa, in games in which moving power is effective.

2. *Moving power is* *irrelevant*—*the outcome induced by one player is better for both players (16 games).* This category of games includes those in which *both* players prefer the (Pareto-optimal) outcome that one player can induce to the (Pareto-nonoptimal) outcome that the other player can induce with moving power. The preferred outcome, which is indicated by a "*" next to *r* or *c*, is therefore the one where the move-countermove process will stop: because neither player can induce a better outcome for itself—independent of which player has moving power—moving power is *irrelevant*.

Game #7 in Figure 3 is an example of a game in which moving power is irrelevant. If Row possesses moving power, it can induce Column to stop at either (4,3) or (2,1), where Column has the next move. Clearly, Column would prefer (4,3). If Column possesses moving power, it can induce Row to stop at either (3,2) or (1,4), where Row has the next move. Clearly, Row would prefer (3,2). However, the fact that Column prefers (4,3) to (3,2) means that it would accede to Row's moving-power outcome, (4,3), which is starred, rather than induce its own, (3,2).

Observe that, moving counterclockwise, Column has the next move at (4,3) in game #7, so it would be in its interest to stop the process there without being forced to stop by Row. Indeed, it would be counterproductive for Column, if it possessed moving power, to force Row to stop at (3,2). Thus, moving power in game #7 is irrelevant—(4,3) would be the outcome to which both players would be drawn, whichever player possessed moving power. Every class of cyclic games, as shown in Figures 3, 4, and 5, contains some in which moving power is irrelevant.

3. Moving power is ineffective—each player prefers the outcome that the other player can induce (4 games). Paradoxically, an opponent's exercise of moving power in a few games leads to a better outcome than a player can induce for itself. Because this is the opposite of the situation when moving power is effective, I call moving power *ineffective* in such games and indicate it by "#" next to *r* and *c*.

As an example, consider game #26 in Figure 4. Like game #1 in Figure 3, this is a game of total conflict. Here, however, the best outcome that Row can induce with moving power is (2,3), because Column prefers this state to the other state where it can stop, (4,1), when it has the next move. Similarly, the best outcome that Column can induce with moving power is (3,2), because Row prefers this state to the other state where it can stop, (1,4), when it has the next move. Thus, although each player can induce an outcome that yields its next-worst payoff of 2, each would prefer the outcome that its opponent can induce, which yields its next-best payoff of 3.

Notice that the outcome that Row can induce in all the other power-ineffective games (games #27, #35, and #36) is (1,3), whereas Column can induce (3,1) in game #35. Not only are these the worst outcomes for the inducers, but Row can always obtain a better payoff of 2 by itself stopping at (2,4) in games #27, #35, and #36, and Column by stopping at (4,2) in game #35.

Even at the latter states, however, the player who stops does worse than at the outcomes its opponent can induce, either by inducing stoppage (3) or stopping itself (4). Thus, the possession of moving power in these games does not benefit *either* player. Moreover, unlike the games in which moving power is irrelevant, there is no single (Pareto-optimal) outcome that one of the players can induce that both would prefer to the (Pareto-nonoptimal) outcome that the other player can induce.

It turns out that moving power is never ineffective in strongly cyclic games (Figure 3). However, there are both moderately and weakly cyclic games in which the possession of moving power can lead to an outcome inferior to one that would occur if the other player possessed it (Figures 4 and 5).

The fact that moving power is of no help to players in power-ineffective games renders the use of the word "power"—which normally connotes an ability to induce better outcomes than one could obtain without it— dubious in these games. I next state three propositions that summarize properties of games in which moving power is effective or irrelevant:

Proposition 1. *In the two games that have Pareto-nonoptimal Nash equilibria and in which moving power is irrelevant (games #22 and #23 in Figure 4), the induced outcome preferred by both players is Pareto-superior (i.e., better for both players) to the Nash equilibrium.*

Thus, it is not necessary that there be an asymmetry in capabilities in order for players to achieve an outcome that classical game theory considers unstable (i.e., not a Nash equilibrium). Contemplating the possibility of cycling according to rules 1–6 in games #22 and #23, the players would realize that they have no incentive to stay at the unique Nash equilibrium in these games, because they both prefer the unique state Pareto-superior to it. Hence, even though moving power is irrelevant in these games, cycling singles out the latter state as the one where *both* players would find it rational to terminate the cycling.

The counterpart to Proposition 1, when moving power is effective, is the following:

Proposition 2. *In the one game that has a Pareto-nonoptimal Nash equilibria and in which moving power is effective (game #17 in Figure 4), one of the two induced outcomes is Pareto-superior to the Nash equilibrium.*

In game #17 in Figure 4, (2,3) is the Pareto-inferior Nash equilibrium. If Column has moving power, it can induce the Pareto-superior outcome, (3,4), whereas Column can induce (4,2), which is Pareto-optimal but is not Pareto-superior to (2,3). In either event, a player's possession of moving power obviates the choice of (2,3).

Apart from Nash equilibria, Pareto-optimality can always be achieved:

Proposition 3. *In all games in which moving power is effective or irrelevant, the induced outcomes (two when moving power is effective, one when it is irrelevant) are Pareto-optimal.*

Thus, in the vast majority of cyclic games (89%, excluding only the four power-ineffective games), a Pareto-optimal outcome can be expected, whichever player possesses moving power. Even in the power-ineffective games (games #26, #27, #35, and #36), a Pareto-optimal outcome seems likely unless a player foolishly tries to exercise moving power when it could do better by stopping play itself. Of course, these results on Pareto-optimal outcomes depend on both players' behaving according to rules 1–6 rather than the classical rules of play that assume simultaneous strategy choices.

In games in which moving power if irrelevant, one would not expect the players to cycle indefinitely but instead to stop at the Pareto-optimal induced outcome. On the other hand, in games in which moving power is effective, would players physically cycle in order to implement their preferred outcomes, or are their moves likely to be mental ones in a kind of thought experiment?

There is no reason why rational players would make physical moves in power-effective games if there is common knowledge about which player has moving power. In this case, it would be rational for the weaker player to acquiesce in the stronger player's moving-power outcome, immediately terminating play when this state is reached.

But in many real-world conflicts, there is no clear recognition of which, if either, player has moving power. In fact, there may be a good deal of misinformation. For example, if both players believe they can hold out longer, cycling is likely to persist until one player succeeds in demonstrating its greater strength, or both players are exhausted by the repeated cycling. An example of the latter situation is the conflict between Egypt and Israel from 1948 until 1979, in which the antagonists cycled in and out of five wars before they signed a peace treaty—and only then under great pressure from the United States.[13]

The case we analyze here is one in which misinformation about the relative capabilities of each side, especially its ability to endure continued punishment, was rampant. What makes this case curious, however, is that the game that was played is one in which moving power is irrelevant, so there should not have been a battle over which player possessed it.

There was physical cycling, nevertheless, because one player not only had incomplete information about its opponent's preferences but, worse, thought they were different from what they were. If there had not been this misperception, there is evidence that the same outcome might have been achieved much earlier and at much less cost to the players.

5. Bombing Campaigns in Vietnam

On December 18, 1972, President Richard Nixon ordered an all-out bombing campaign against North Vietnam.[14] "Linebacker II," as it was called, was an attempt to force the North Vietnamese seriously to negotiate an end to the Vietnam war. Nixon's decision encountered severe criticism and "stirred up a great furor amongst the anti-war elements in Congress and in the public" (Sharp, 1978, p. 252).

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[13]For a more detailed explanation of this settlement in terms of moving power, see Brams and Mor (1993), who do not equate moving power simply with military superiority.

[14]This section is based partly on a student paper of a former NYU undergraduate, Bhashkar Mazumder, to whom I am grateful.

It was not the first time that the United States had attempted to force the North Vietnamese to the negotiation table through bombing. From 1965 to 1968, President Lyndon Johnson oversaw a bombing campaign dubbed "Rolling Thunder," often choosing targets himself. It was rooted in the idea that

> carefully calculated doses of force could bring about predictable and desirable responses from Hanoi. The threat implicit in minimum but slowly increasing amounts of force . . . would, it was hoped by some, ultimately bring Hanoi to the table on terms favorable to the U.S. (Sharp, 1978, pp. 52-53).

But the campaign, gradualist in nature, failed miserably in its goal (Thompson, 1980). As early as 1965, the outgoing director of the C.I.A., John A. McCone, recognized the problem and correctly prophesized which side had the resources to hold out longer:

> We must look with care to our position under a program of slowly ascending tempo of air strikes. With the passage of each day and week we can expect increasing pressure to stop bombing. This will come from various elements of the American public, from the press, the United Nations and world opinion. Therefore, time will run against us in this operation and I think the North Vietnamese are counting on this . . .. Since the contemplated actions against the North are modest in scale, they will not impose unacceptable damage on it nor will they threaten the DRV's vital interests, hence, they will not present them with a situation with which they cannot live (quoted in Sharp, 1978, p. 73).

Eventually Rolling Thunder was called off as a result of ever-increasing domestic and international pressure as well as the campaign's failure to stem infiltration from the North, which actually increased significantly (Lewy, 1978, p. 391).

In May 1972, after more than three years of frustration in trying to work out a settlement of the war at peace talks in Paris, President Richard Nixon decided to reassess his options. He could choose between continuing his present course of secret air attacks and public "protective reaction strikes"—at more or less the level of the limited bombing campaign (L) of Lyndon Johnson—or an all-out campaign that would continue even if the North Vietnamese chose to negotiate ($\overline{L}$).

North Vietnam faced a choice of making concessions in response to Nixon's peace plan (C), which would prevent or at least delay the uniting of North and South Vietnam—the North's ultimate goal—or not conceding and, for all practical purposes, demanding U.S. surrender ($\overline{C}$). The preferences of the players for the four possible states, moving clockwise from the upper left-hand state in the "real game" (game #25) of Figure 6, are as follows:

Figure 6 about here

I. Compromise: (4,3). "Peace with honor" is achieved by the United States, its best state, because "winning" is no longer seen as feasible; also, a negotiated settlement would end domestic and international criticism of the war. Although North Vietnam would not win outright by accepting a negotiated settlement, it would not be devastated by an all-out bombing

Figure 6

Bombing Campaign (Games #25 and #11)

Real Game (Game #25)

		North Vietnam		
		Make concessions (C)		Not make concessions ($\bar{C}$)
United States	Limit bombing (L)	(4,3)r* Compromise	→	(2,4) Deadlock ← *Dominant strategy*
		↑		↓
	Not limit bombing ($\bar{L}$)	(3,2)c U.S. Military Victory	←	(1,1) Destructive Stalemate

Game as Misperceived by North Vietnam (Game #11)

		North Vietnam		
		Make concessions (C)		Not make concessions ($\bar{C}$)
United States	Limit bombing (L)	(4,3)r Compromise	→	(3,4)c Deadlock ← *Dominant strategy*
		↑		↓
	Not limit bombing ($\bar{L}$)	(2,2) U.S. Military Victory	←	(1,1) Destructive Stalemate

Key: (x,y) = (payoff to United States, payoff to North Vietnam)

4 = best; 3 = next best; 2 = next worst; 1 = worst

c = best states Column can induce with moving power

r = best state Row can induce with moving power

* = induced state best for both players

Nash equilibria underscored

Arrows indicate direction of cycling

campaign; moreover, conquering the South would probably be achievable eventually, making this the North's next-best state.

II. Deadlock: (2,4). The United States remains stymied at the negotiation table, its next-worst state, since the limited bombing campaign, because it permits the North to hold out indefinitely, does not engender serious negotiations. As a consequence, the United States is forced to withdraw without a settlement, which facilitates quick and forceful unification of Vietnam, giving the North its best state.

III. Destructive Stalemate: (1,1). This is the worst state for both sides: the United States does not achieve its aim of a settlement and risks a complete collapse of domestic political support because of the extremely adverse public reaction to the massive destruction; the North suffers greatly, with Hanoi and Haiphong leveled and the North's military forces and industrial capacity tremendously damaged.

IV. Limited U.S. Military Victory: (3,2). This is the next-best state for the United States, because there is a settlement induced by the all-out bombing. But the bombing is seen as unnecessary, even "genocidal," if North Vietnam signals its willingness to make concessions. Because the North is forced to acquiesce before a settlement is concluded that would relieve it of its suffering, this is its next-worst state.

Before analyzing this game, which is #25 (Column's two strategies are interchanged in Figure 6) and moderately cyclic, it is worth mentioning some changes that had occurred in the four years that had transpired since the conclusion of Rolling Thunder in 1968. First, the fear on the part of the United States that the Soviet Union and China might intervene (as China had done in the Korean War) was gone; indeed, these countries were now willing to try to persuade North Vietnam to negotiate a settlement. Second, North Vietnam's 1972 Easter invasion of the South had been an utter failure, casting doubt on its military threat to the South.

On the other hand, the United States was very anxious to end the war quickly and no longer insisted on an independent "noncommunist" South; "peace with honor" was sufficient. Without U.S. insistence on a non-communist South, the North could now gain more from negotiations than previously; and the United States could disentangle itself from an increasingly unpopular war. This is why Compromise is viewed as better for both sides, including the United States, than U.S. military victory.

On May 8, 1972, Nixon announced that its Linebacker bombing campaign had begun (later to be called "Linebacker I"). Although it was not totally unrestricted, it was intended to demonstrate to the North a new and far more destructive level of aerial bombardment if the North continued to be recalcitrant in the peace talks. As recorded by the White House taping system, Nixon said, "The bastards have never been bombed like they're going to be this time" (Palmer, 1978, p. 252).

The destruction, which was accompanied by the mining of Hanoi and Haiphong harbors, was indeed great. In October the North began seriously to negotiate a peace treaty in Paris. Nixon, as a show of good faith, ordered the bombing attacks discontinued on October 23.

But the subsequent negotiations bogged down, largely because of the strong objections of South Vietnamese president Nguyen Van Thieu to an agreement tentatively worked out by Le Duc Tho and Henry Kissinger, who announced on October 26 that "peace was at hand." Although "infuriated by Thieu's intransigence" (Herring, 1979, p. 247), Nixon—after further negotiations with both Thieu and Tho proved fruitless—ordered "Linebacker II," making

> absolutely clear to the military his determination to inflict maximum damage on North Vietnam. "I don't want any more of this crap about the fact that we couldn't hit this target or that one," he lectured Admiral Thomas Moorer, Chairman of the Joint Chiefs of Staff. "This is your chance to use military power to win this war, and if you don't, I'll consider you responsible" (Herring, p. 248).

The bombing commenced on December 18, and for the last twelve days of 1972, the North was continually bombarded, around the clock, with almost no restrictions in effect. The effect of this "Christmas bombing" was quickly to produce a peace agreement, which was signed on January 23, 1973, essentially ending U.S. involvement in the war.

To model Linebacker I and Linebacker II, I assume the game originates at Deadlock in Figure 6, just before the start of Linebacker I in May 1972. Although the United States had not publicly indicated a limited bombing campaign was underway at this time, there had been secret air attacks as well as a strong air response to the Easter invasion, which I interpret as L.

When the United States commenced Linebacker I, it escalated to Destructive Stalemate. Clearly, it was trying to demonstrate its ability to continue cycling—in the clockwise direction indicated in Figure 6—longer than North Vietnam. Although the war had ground on for more than seven years, there was still not the "light at the end of the tunnel" that Kissinger had foreseen earlier.

When North Vietnam responded by choosing its strategy of C in October 1972, moving to U.S Military Victory, the United States in turn responded by choosing L, moving the game to Compromise. This is not only the state that the United States can induce with moving power but also the state preferred by North Vietnam to (3,2), the state it can itself induce if it has moving power.

But either doubting the moving power of the United States after Thieu balked, or not understanding that the possessor of moving power in this game is irrelevant, the North refused to compromise further. This moved the game back to the original state of Deadlock (before Linebacker I), completing the cycle.[15]

North Vietnam acted in this manner, I believe, because it misperceived the game being played. It thought that the game was actually #11 (see Figure 6), in which moving power is effective: with it, North Vietnam can induce its best state of Deadlock.

This game occurs when North Vietnam thinks that the United States prefers Deadlock (3) to U.S. Military Victory (2)— rather than vice-versa (as in game #25)—because implementing the latter state would entail great cost to the United States. In fact, however, Nixon's later behavior indicated just the opposite, as North Vietnam ruefully was to learn when the Christmas bombing commenced.

Linebacker II was, in effect, Nixon's attempt to demonstrate U.S. moving power once and for all. The Christmas bombing was devastating; it evidently conveyed to the North the message that Nixon was still capable of continuing the cycling, this time by escalating to an unprecedented level of bombing and exerting still greater pressure:

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[15]This cycling echoes the earlier cycling under the Rolling Thunder regime, when bombing and other forms of escalation (e.g., the North's Tet offensive in 1968) were used by both sides to try to maneuver into positions of advantage.

> Such widespread devastation could not be endured. The Politburo got the message. Hanoi quickly agreed to terms, and the bombing stopped abruptly . . .. Agreement on a cease-fire for all of Vietnam was reached rapidly upon the resumption of the Paris negotiations in January of 1973 (Palmer, 1978, p. 259).

The agreement, however, did not contain "any significant concession from the North" (Papp, 1981, p. 144), differing only on minor points from that negotiated in October (Isaacs, 1983, pp. 61-62). But it had enough face-saving features to enable the United States to claim that its bombing strategy had succeeded.

The relative effectiveness of the Linebacker operations was substantially due to the fact that the United States had perfected "smart bombs" that could destroy previously indestructible targets, such as the Thanh Hoa bridge, a vital bridge in the North that had been repeatedly attacked to no avail until it was felled with several laser-guided bombs on May 13, 1972. Despite the harsh criticism Nixon faced for the renewed bombing in both Linebacker operations, he was able to make continuation of the game extremely costly for North Vietnam.[16]

Because North Vietnam misperceived U.S. preferences and, in addition, thought it had the stamina to hold out longer, it forced the United States to prove otherwise, which it did, but with practically no import on the final settlement. Perhaps the greatest tragedy is that the North apparently

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[16]In the case of the Christmas bombing, Nixon was accused of being a "madman" and waging a "war by tantrum" (Herring, 1979, p. 248). The "madman" image appears to have been calculated: "President Nixon told one columnist that he ordered the [Christmas] bombings because 'the Russians and Chinese might think they were dealing with a madman and so had better force North Vietnam into a settlement before the world was consumed by a larger war'" (Amter, 1979, pp. 288-289).

did not harbor its game #11 view of U.S. preferences when it offered to settle the war—on much the same terms that it accepted in 1973—at the start of negotiations in 1969 (Zagare, 1977, p. 683).[17]

By late 1972, however, North Vietnam had come to believe that it not only held the upper hand but also that the United States had lost its will to continue the grinding conflict. By forcing the United States to choose between U.S. Victory and Deadlock—the two states where it has the next move—it believed it could use its moving power in game #11 to induce the latter outcome.

But Nixon's preferences were not those in game #11. Moreover, even if North Vietnam possessed moving power in game #25, it would have been irrelevant in inducing Deadlock. Playing the "wrong" game, the North made what appeared to it as a rational attempt to hold out.

But then came the monumental destruction of the Christmas bombing. Forced to alter its view of the United States as a player bereft of moving power—and, relatedly, that it may have underestimated the U.S. preference for Deadlock (it was 3 rather than 2)—it offered some minor concessions. The United States, which had lost as many as 34 B-52's in the Christmas bombing and faced withering criticism from around the world, was in no position to extract more and so quickly settled (Porter, 1975, pp. 161-165).

I presume that North Vietnam would have acceded to the Pareto-superior Compromise had it realized that the real game was #25, in which moving power is irrelevant. Note in this game that there are two Pareto-

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[17]In recent testimony before the Senate Select Committee on P.O.W.–M.I.A. Affairs, Kissinger vehemently disputed the contention of Senator John F. Kerry that the terms for a settlement in 1969 were "extraordinarily close" to those in 1973 and, by implication, that the United States was the obstructive party in 1969 (*New York Times*, September 23, 1992, p. A18).

inferior states, (1,1) and (3,2), through which the players must pass as they cycle, as is also true of game #11.[18]

It is also worth noting that (2,4) is the unique Nash equilibrium in game #25, and (3,4) is the unique Nash equilibrium in game #11, which are both associated with the U.S.'s dominant strategy of L. Deadlock, then, is the (erroneous) prediction of classical game theory, with or without misperception. By comparison, moving power predicts Compromise as the outcome in both games #11 and #25, but only in game #11 is the demonstration of moving power by Row (the United States in Figure 6) necessary to induce this state. Because of North Vietnam's misperception, this demonstration occurred, resulting in physical cycling to determine which side, indeed, had greater endurance in the face of destruction.[19]

6. Conclusions

Conflicts abound in the world, but some of the most intractable are those that cycle, first abating and then intensifying in seemingly endless alternation. The Arab-Israeli dispute has been such a conflict, but conflicts

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[18]Two is the maximum number of such states in a cyclic game; 22 of the 36 cyclic games have two Pareto-inferior states, whereas 12 games have one Pareto-inferior state and 2 games (#1 and #26, the two cyclic games of total conflict) have no Pareto-inferior states. There are no cyclic games with three Pareto-inferior states, because such games must contain a (4,4) state, which causes blockage in both directions and thereby precludes cycling (21 of the 78 2 x 2 games contain such a state). Whether a cyclic game contains zero, one, or two Pareto-inferior states might be considered as an indicator of its *simultaneous* destructiveness (i.e., to both players at the same time). The greater this destructiveness, the more dramatically players will swing between states of relative cooperation and relative conflict, which makes staying in cooperative states more attractive and cycling, therefore, less likely to continue.

[19]Cycling had really begun with Rolling Thunder under President Johnson, of which I have not given a detailed account because this was only the first phase; by 1968, neither side had succeeded in demonstrating that it had moving power. Even after the Christmas bombing in 1972, the apparent supremacy of the United States is deceptive, because North Vietnam ultimately prevailed by successfully invading South Vietnam in 1975 after the withdrawal of U.S. forces.

of shorter duration, in which players move from state to state seeking to gain advantage, also must be considered.

To model these persistent conflicts, I showed that 36 of the 78 2 x 2 strict ordinal cyclic games are cyclic, meaning that no state is ever reached—in either a clockwise or a counterclockwise direction—that is best for the player with the next move. Moreover, if a game cycles, it does so in only one direction.

Cycling depends on rules of play that allow players to move and countermove in a normal-form or matrix game. The rules I postulated, based on the theory of moves, differ radically from the classical rules of play, which assume that players begin by simultaneously choosing strategies that lead to an outcome. By contrast, I assume that players always start at an outcome, which I call a state, from which cycling may commence.

Although the cycling analysis I have described can in principle be extended to larger games—with more strategies, more players, or both—it would certainly be more complex. For example, stoppage rules would probably have to be refined to reflect degrees of cyclicity, cycling in different directions via multiple paths would have to be allowed for, and cycles that never return to the initial state because they occur within a larger configuration would have to be taken into account. Because there is already considerable richness and variation in the 36 2 x 2 cyclic games, however, I believe a focus on just these games is justified now, especially because their analysis helps to lay foundations for a more general analysis later.

In the present analysis, I classified the 36 cyclic games into three three mutually exclusive categories, depending on the number of impediments players encounter in cycling. But the friction of impediments is probably less consequential in affecting cycling than whether one player has moving power *and* it is effective. If so, the player who possesses this power can induce its opponent eventually to stop at an outcome better for it than if the opponent possessed this power.

On the other hand, if moving power is irrelevant, then both players will be drawn to the (Pareto-optimal) state that one of the players can induce. This state does not necessarily coincide with the Nash equilibrium of the cyclic game, based on the classical rules of play, which may be Pareto-nonoptimal. As a third possibility, moving power may be ineffective, and neither player benefits from possessing it.

Because the moderately cyclic game I used to model U.S. bombing campaigns in the Vietnam War is one in which moving power is irrelevant, it does not explain why such a long and drawn-out conflict was needed to establish which player had the greater resources or will to fight. The explanation I offered is that North Vietnam misperceived U.S. preferences, thinking the game was one in which their moving power would be effective.[20] This forced the United States to demonstrate its strength in the "real game," even though this should not have been necessary to bring about the compromise outcome.

Thus, cycling in games may be aggravated by misperceptions. But even in the absence of misperceptions, games in which moving power is effective—but which player possesses it is not common knowledge—may engender cycling as each player struggles to gain the upper hand, or convince its opponents that it has greater stamina. This cycling may drag both players through one and even two Pareto-nonoptimal states before one player prevails at a Pareto-optimal state.

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[20]For another example of misperception, this time by the United States in the Iran hostage crisis, see Brams (1992) and Brams and Mattli (1993).

The cycling may exhaust both players, even if one has its way. This was certainly true of the United States and North Vietnam by the time they signed the Paris peace treaty in January 1973.

Perhaps the best prescription for a player to avoid a protracted and potentially castastrophic conflict is to promulgate consistent policies and develop a reputation for upholding them so that an opponent will not engage in fruitless fighting but instead negotiate (Brams, 1990). This prescription, however, is not only difficult to follow, especially in democratic countries in which there are periodic changes in leadership, but it is so general as to be banal in most situations.

More helpful, I believe, is to recognize that there are games in which the exercise of moving power does not matter—because a player cannot implement a preferred outcome even if it possesses this power—as well as games in which it does. Even in games in which moving power is effective, an all-out battle to prove who has it need not occur if the possessor of such power is evident.

The difficult situations are those in which moving power is effective but there is no common recognition of which, if either, player possesses it. It is precisely in these situations that there may be a game-theoretic rationale for physical cycling, even though both parties would be better off not having to suffer the costs of cycling.

To put this rationale in perspective, moving power is effective in less than half of the 36 cyclic games (44%), which is only about one-fifth (21%) of the 78 2 x 2 strict ordinal games. These games do not include any of the 12 symmetric games, like Prisoners' Dilemma and Chicken, which are noncyclic. Nevertheless, I would not minimize the prevalence of power-effective games: their empirical relative frequency may be greater than their numbers in the game population. In such games, as I have illustrated, the fight to ascertain who has moving power may well fuel cycles of conflict.

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