THE ECONOMIC APPROACH TO CONFLICT

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In racing for a prize you can better your chances by running faster yourself, or by making your opponents run slower. More generally there are two main classes of strategies in life's contests: improving your own performance, or hindering your competitors. When one or more competitors adopt hindrance strategies, the result is <u>conflict</u>. The term conflict does not necessarily imply actual violence — for example, we speak of industrial conflicts (strikes) and legal conflicts (lawsuits). But my discussion will mainly be directed to the use of violence.

A rational decision-maker, the economist presumes, will engage in conflict whenever doing so represents the most advantageous way of competing in a world where prizes are scarce. My primary concern will be to show that economic analysis — i.e., models of rational choice on the decision-making level, and of equilibrium on the level of social interaction — can do much for the study of conflict. But it is also true, and this is my secondary theme, that the study of conflict can do much for economics. Attending to the darker aspects of how humans might and do compete is absolutely essential even for a proper understanding of the relatively benign nature of market competition.

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Returning to my primary theme, I want to show how the economic approach to conflict sheds light upon questions such as:

(1) What circumstances lead the parties to engage in conflict, i.e., to "agree to disagree"?

(2) In conflict interactions, when do we observe an interior or balanced solution, and when a tendency toward corner outcomes — total victory for the one side, unrelieved defeat for the other?

(3) Is conflict always or largely a mistake on the part of one side or the other, so that better information can be relied upon to promote peaceful settlement?

In this brief presentation I cannot actually answer all these questions, or even resolve any of them very adequately. I want only to show how the economic approach may permit us to effectively address them. The sequence of topics that I will follow is indicated in Table 1.

[Table 1 Here.]

I. ELEMENTARY STATICS OF CONFLICT AND SETTLEMENT[1]

Let me plunge right in with some extremely simple pictures designed to illustrate the interacting decision problems of two individuals as a function of their (1) opportunities, (2) preferences, and (3) perceptions.

Figure 1 illustrates alternative "settlement opportunity sets" QQ, drawn on axes representing consumption incomes c_B and c_R for Blue and Red respectively. (Note: These are the <u>non-conflictual</u> opportunities — what the

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[1]The discussion in this section builds upon Boulding [1962, Ch. 1], Friedman [1980], and Wittman [1979].

Table 1

SEQUENCE OF TOPICS

I. ELEMENTARY STATICS OF CONFLICT AND SETTLEMENT

II. DYNAMICS AND EQUILIBRIUM — THE UNSOPHISTICATED CASE

III. APPROACHES TO SOPHISTICATED EQUILIBRIUM

1. TIT FOR TAT as Optimal Strategy in Repeated Prisoners' Dilemma Games

2. Contingent Strategies and Commitment

3. First Move vs. Last Move

IV. ON THE TECHNOLOGY OF CONFLICT

V. CONFLICT, ECONOMICS, AND SOCIETY

parties might achieve in the absence of fighting.) Three possible shapes for QQ are illustrated: positive complementarity (dashed curve), neutral complementarity, i.e., the constant-sum case (solid 135° line), and negative complementarity (dotted curve).

Turning now to preferences, in Figure 2 the trio of indifference curves U_B suggests Blue's alternative possible patterns of "tastes" regarding interpersonal distributions of income. Similarly, the curves U_R show Red's possible "tastes". The normal-looking dashed curves in each case apply when each party has some degree of benevolence toward the other; the solid curves (a vertical line for Blue, a horizontal line for Red) indicate merely neutral preferences, where each of the two simply values his own consumption income; finally, the positively-sloped dotted curves indicate malevolence.

Finally, we need to display the parties' perceptions of the outcome in the event of conflict. Figure 3 puts together a particular settlement opportunity set QQ (complementary in this case), indifference curves for the two parties (both pictured as displaying a degree of benevolence), and two "conflict perception points" designated P_B and P_R respectively. Then the shaded area is the "potential settlement region" PSR, the set of possible income combinations representing improvements over what each perceives as attainable by conflict.

Under the plausible hypothesis that the larger the PSR the greater the likelihood of peaceful settlement, it will be evident that this likelihood is increased by: (1) greater complementarity of the settlement opportunity set QQ, (2) greater benevolence on the part of both parties, and (3) less "optimistic" perceptions of the likely outcome of conflict.

Several other possible combinations are shown in the diagrams. Figure 4 illustrates how, in a situation with complementary opportunities and agreed conflict perceptions (i.e., P_B and P_R coincide), malevolent preferences compress the size of the PSR. Figure 5 illustrates how anti-complementary opportunities (concave curvature of QQ) also tend to constrict the shaded PSR region, in a situation of neutral preferences together with agreed perceptions. As for the effect of differential perceptions, Figure 6 illustrates how in the situation of the previous diagram, a shift of P_B to a new position P_B' (P_R remaining unchanged) has enlarged the PSR by the dotted area — Blue has become more pessimistic about the outcome of conflict. On the other hand, as illustrated in Figure 7, when each party is optimistic about the outcome it may well be that the PSR entirely disappears, suggesting that conflict has become inevitable.

The effect of complementarity on the international level has recently been documented by Polachek [1980]. His data indicate that those country-pairs with the most to gain from trade tend to engage in the least conflict.[2] And of course there are many other instances on the human and animal levels. For example, some small cleaner fish operate actually inside the jaws of their bigger-fish clients; the latter forego a quick and easy meal in return for the benefits of trade in the form of grooming services.

As for interpersonal preferences, individuals and nations with close ties of culture and kinship that lead to mutually benevolent preferences very likely do less frequently engage in conflict — but again, only in an "other things equal" sense. In particular, since brothers are often close competitors for resources, fratricidal conflict is not uncommon despite the

[2] Of course, any such uni-causal explanation must not be pushed too far, lest we fall into the error of Angell [1910] who argued just before World War I that the growing web of international commerce had made war impossible.

closeness of kinship ties.[3]

As an instance displaying the role of changing perceptions and beliefs, some authors (e.g., Blainey [1973] on war, Ashenfelter and Johnson [1969] on strikes and lockouts) make the important point that conflict is in large part an educational process. Struggle tends to occur when one or both of parties is over-optimistic (see Figure 7). The school of actual struggle teaches the parties to readjust their conflict perception points to more realistic levels. Eventually, a potential settlement region PSR emerges (or an existing region grows larger) so that conflict tends to end by mutual consent.

Two qualifications must be kept in mind, however. First, as Wittman [1979] emphasizes, while the results of continuing struggle may lead the losing party to more realistic (pessimistic) perceptions, the winning party is likely to to revise his perceptions upward. The loser becomes more willing to settle but the winner tends to increase his demands — so that the conflict may well continue.[4] Second, the damage due to struggle may impoverish both parties and impair the settlement opportunities as well. The effect on prospects for settlement could go either way, depending upon the new relative

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[3]This type of consideration leads to the very interesting question of just what are the factors that tend to generate benevolent vs. malevolent interpersonal attitudes. The possible sources of human "altruism" have been much discussed by biologists and to some extent by economists (see for example Hirshleifer [1977, pp. 17-26]), but for our purposes here it is more instructive to look at the other side of the picture — malevolence or hatred. While it is quite possible to have "cold-blooded" fighting without hatred, there seems to be a feedback between the two in the human psyche. It appears that the ability to hate one's enemy has been selected in the evolution of the human species, a factor that leads to "hot-blooded," less rationally controllable warfare.

[4]Sparta, after her defeat by the Athenians at Cyzicus (410 BCE), offered peace on moderate terms, and did so once again after Arginusae (406). But the overconfident democratic party controlling Athens rejected both offers. The war continued until the irremediable naval disaster at Aegospotami culminated in the total capitulation of Athens (404).

positions of the perception points P_B and P_R and the revised QQ curve.

There is more to be said about elementary statics, for example, introducing asymmetries in the parties' preference functions (one may be benevolent, the other malevolent), or in the shape of the settlement opportunity set (Blue's non-conflictual activities may confer benefits on Red, while Red's impose costs on Blue). But I must set this topic aside in order to move on. How small a slice of our topic has been even touched on so far is suggested by Table 2, which indicates some of the directions in which the analysis needs to be extended.

[Table 2 Here.]

In what follows, I will only be able to address the first of these topics in any detail. Among other things, I will be asking, granted that a mutually advantageous settlement opportunity exists, under what circumstances can conflict actually be avoided?

II. DYNAMICS AND EQUILIBRIUM (THE UNSOPHISTICATED CASE)[5]

Under the heading of elementary statics I indicated how preferences, opportunities, and perceptions combine to influence individual decisions. But I did not progress very far toward showing how an equilibrium emerges when the parties' decisions interact. The nature of the equilibrium turns out to depend critically upon the detailed dynamics of the interaction -- or, I shall sometimes say, upon the "protocol" that specifies how and in what sequence the

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[5]The discussion here develops certain ideas in Hirshleifer and Riley [1978] and Hirshleifer [1982, pp. 13-20].

Table 2

DIRECTIONS FOR FULLER ANALYSIS

1. From statics to dynamics and equilibrium
2. From individuals to organizations
3. From 2-party to n-party interactions
4. From a-temporal to intertemporal analysis
5. Allowing for risk and uncertainty
6. Conflict at varying levels — "escalation"

parties make their choices. These specifications are most clearly expressed in the language of game theory. This language is adopted at a cost, since game theory drastically compresses the separate categories of preferences, opportunities, and perceptions into a single numerical tabulation representing the net payoffs to alternative strategies. But I will pursue this approach for the moment.

The familiar game matrix, then, is taken as summarizing the players' decision environment. I will begin with a comparative discussion of three famous elementary 2x2 games -- Battle of the Sexes (BOS), Chicken, known also in the biological literature as Hawk-Dove (HD), and Prisoners' Dilemma (PD) -- shown in Tables 3, 4, and 5. These are non-zero-sum interactions; each represents a somewhat different combination of complementary versus anti-complementary elements. While the abstract game representation fails to distinguish between conflict as such versus other types of cooperation failures (for example, those associated with "externalities"), I will assume here that whenever efficiency is not achieved, the explanation is the adoption of a conflict strategy by one or both parties.

[Tables 3, 4, 5 Here.]

The most common solution concept for the non-zero-sum game is the "Nash non-cooperative equilibrim" (NE) — sometimes called the "equilibrium point." The key idea is that there is no equilibrium so long as either player can gain an advantage by shifting his strategy. (The pure-strategy NE's are marked with asterisks in Tables 3, 4, and 5, the first two cases having also a mixed-strategy NE not shown in the Tables.) The NE equilibrium concept might or might not be objectionable, depending upon the assumptions as to the players'

Table 3

BATTLE OF THE SEXES

She

		C_1	C_2
He	R_1	*10,5	0,0
	R_2	0,0	*5,10

Table 4

CHICKEN OR HAWK-DOVE

	C_1 (DOVE)	C_2 (HAWK)
R_1(Dove)	4,4	*0,10
R_2(Hawk)	*10,0	-24,-24

Table 5

PRISONERS' DILEMMA

	C_1 (LOYAL)	C_2 (DEFECT)
R_1(LOYAL)	-2,-2	-20,0
R_2(DEFECT)	0,-20	*-10,-10

capacities or the dynamics of the interaction. I want to make these assumptions quite explicit.

To divide the difficulties I first consider equilibrium in "unsophisticated" play. The players may perhaps lack the ability to reason strategically -- i.e., to conceptualize that "if I do this, then he will do that, in which case I would respond by..." More interestingly for the economist, unsophisticated play might be appropriate even for intelligent parties in certain environmental situations, especially those associated with large numbers of players (as in the standard pure-competition model). Specifically, think of a "war of all against all," in which members of a large population encounter one another randomly in one-time pairwise interactions. This leads to a concept I shall call evolutionary equilibrium. If the average return to each strategy depends upon the population proportion adopting one or the other, a dynamic process is set up leading eventually to an equilibrium distribution of strategies in the population. This evolutionary equilibrium (EE) could be either pure (one strategy eventually drives out all the others) or else mixed. It can be shown that the evolutionary equilibria are a subset of the Nash equilibria; to wit, the EE's are the "dynamically stable" NE's.

The dynamic process and the EE's for our three cases are pictured in Figure 8, in terms of the population proportion p characterized by the strategy in the first row and column of each Table. Starting with Battle of the Sexes (BOS), as the directions of the arrows suggest there are two EE's -- at the limiting proportions $p = 0$ and $p = 1$. The mixed solution at $p = .5$ is an NE, but not being dynamically stable it is not an EE. The simplest interpretation is as follows. Assume that in each encounter the He and She roles are randomly assigned. In the initial population there are a fixed number of players having permanently chosen strategy #1, the remainder playing strategy #2. However, the population fractions will evolve in accord with the relative success of the two strategies. It follows that if more than half the population is already committed to the first strategy, that strategy will be more successful and will multiply further, and similarly in the opposite case. A possible application would be the struggle for language dominance in an initially bilingual population, there being a strong tendency toward a corner solution despite the comparative disadvantage suffered by native speakers of the losing language.

In contrast with the very mild "battle" involved in BOS interactions, Chicken or Hawk-Dove (I will usually employ the latter designation) can represent quite serious conflict. When one HAWK encounters another, a lot of feathers will fly. For the payoff numbers in Table 4, the diagram indicates a single EE at $p = .8$, a mixed solution. That is, the equilibrium strategy is to play DOVE 80% of the time and HAWK the other 20%. (Or else, there will be a mixed population, 80% Doves and 20% Hawks.) The HD game is sometimes thought to describe industrial or international conflict, the idea being that sometimes you have to play tough, for example, go out on strike, else the other party will know you are a DOVE and take advantage of you. This interpretation, involving strategy in repeated games, does not really belong under our "unsophisticated play" heading, although the analogy is suggestive. A more precise interpretation is as follows. If there are only a few tough people around, it pays to be aggressive — only rarely will you get into costly fights. But when most of the population is aggressive, the smart play is to be quiet and stay out of trouble.

As for the Prisoners' Dilemma, Figure 8 indicates that there is a unique EE, in which everyone adopts the DEFECT strategy. The international arms race is often described as a Prisoners' Dilemma, though once again this is only an analogy; the arms race corresponds to a repeated-play rather than a one-time-only game. A more accurate interpretation would be the famous "commons" problem, where it pays to impose costs upon one's neighbors whether or not they refrain from doing the same to you.

In the EE (and NE) solution to the Prisoners' Dilemma the players are trapped in their third-best (i.e., next-to-worst) outcome, even though it seems that they should be able to achieve their jointly second-best outcome (which is on the settlement opportunity frontier) by mutually LOYAL play. What prevents their doing so is assumed <u>non-enforceability of agreements</u>. Similarly in Hawk-Dove, there is a potential mutual gain on average (in comparison with the mixed-strategy equilibrium) if the parties were to agree: "In each encounter one of us will be randomly designated to play HAWK, the other to play DOVE." To escape some real-world conflictual encounters it <u>is</u> sometimes possible to make binding agreements, but not always. Lawsuits can be settled without going to trial, via an agreement that the court may (perhaps) be relied on to enforce. But, except perhaps for small nations both subject to a common suzerain, no such outside enforcement is available in international conflict. More generally, enforceability of agreements is a matter of degree, depending in part upon the motives of the "enforcer" -- which means that a 3-party game is being played. Sometimes, however, agreements are said to be <u>self-enforcing</u>. This can only be the case, under HD or PD environments, when some kind of expanded game is being played. Such considerations lead to the topic of "sophisticated" equilibrium, the subject of the next section.

III. APPROACHES TO SOPHISTICATED EQUILIBRIUM[6]

While the very unsophisticated models so far discussed are by no means devoid of applicability, to make further progress we have to consider more complex types of conflictual encounters. I can only address here topics associated with three types of complications:

(1) When there are repeated plays of the game, so that the parties can modify their choices in the light of opponents' earlier moves.

(2) When one or both parties can commit to a strategy.

(3) As a generalization of the preceding, when there are different "protocols," for example when one party or the other has the first move, or when one or the other outcome is the *status quo ante*.

1. TIT FOR TAT as Optimal Strategy in Repeated Prisoners' Dilemma Games

The topic here considered is: In the repeated-play Prisoners' Dilemma, can the "trap" outcome be escaped by having one or both parties adopt the strategy of rewarding the other for LOYAL play and punishing him for playing DEFECT?

It is a well-known result in the theory of repeated games ("supergames" in the unfortunate current jargon) that the PD trap cannot be escaped for any finite number of plays. For, DEFECT surely will always be optimal on the last round. But then LOYAL on the next-to-last round cannot be rewarded and thus will not rationally be chosen, and so on back to the very first round. The prospects are somewhat better for an infinite number of plays, or where there is merely some positive probability of play always continuing for another

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[6] This section builds especially upon Schelling [1960], Axelrod and Hamilton [1981], Thompson and Faith [1981], and Hirshleifer [1982] and [1983].

round. Each of these cases involves heavier mathematics than I want to get into here, however.

Axelrod and Hamilton [1981] have recently proposed to cut the Gordian knot via a simple conditional-cooperation strategy known as TIT FOR TAT.[7] Under TIT FOR TAT each party originally plays LOYAL, but thenceforth mirrors the other's choice on the previous round. Thus, DEFECT behavior is punished, but in a proportionate eye-for-an-eye way that leaves open the possibility of both sides reverting to more cooperative strategies. Allegedly, TIT FOR TAT is both stable and optimal, i.e., it represents an equilibrium strategy pair, and one that attains the frontier of the opportunity set.[8]

In support of this contention Axelrod and Hamilton report the results of two computer round-robin tournaments among candidate strategies for optimal play in the repeated Prisoner's Dilemma game. In the first tournament 15 entries, submitted by various experts, were paired against each other in contests lasting 200 rounds. In the second tournament there were 62 entries; this time, instead of a fixed number of rounds there was a fixed probability of continuation for another round (sufficiently high to make the average contest length about 200 rounds). In each case, TIT FOR TAT won handsomely.

This type of contest has some parallels with (and therefore may be regarded as a simulation of) the dynamic process leading to what was called an <u>evolutionary equilibrium</u> (EE) in the previous section. And in fact Axelrod

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[7]They credit TIT FOR TAT to Anatol Rapoport of the Institute for Advanced Study in Vienna.

[8]Axelrod and Hamilton make an obviously excessive claim in asserting that TIT FOR TAT is <u>the</u> explanation for the evolution of cooperation. Even if TIT FOR TAT were a satisfactory solution for the Prisoners' Dilemma, there are many other types of mixed-incentive encounters and associated cooperation failures.

and Hamilton allege that the tournament evidence supports what they anyway claim to have logically proved, that TIT FOR TAT is an "evolutionarily stable strategy" (i.e., an evolutionary equilibrium EE) for the repeated-play Prisoners' Dilemma.

While these results are of great interest, the contentions made on behalf of TIT FOR TAT are not fully warranted. First of all, notice that a paired round-robin is not the "war of all against all" needed for simultaneously comparing the numerous strategies available to the parties. Even if only pairwise encounters are taking place, it by no means follows that there are only two strategies represented at any moment of time in the population. It may well be that although strategy 1 always defeats 2 in one-on-one encounters, nevertheless 1 may not be able to drive strategy 2 to extinction -- if, for example, strategy 2 does better against some strategy 3 also present in the population.

Specifically, consider the strategy triad consisting of LOYAL, TIT FOR TAT, and DEFECT (which may respectively be termed the Golden Rule, Silver Rule, and Brass Rule). Should the population ever evolve to 100% TIT FOR TAT, followers of the Golden Rule (LOYAL) can successfully invade. So long as there are no DEFECT players in the population, the LOYAL and TIT FOR TAT strategies are indistinguishable. This suggests that there will be an indeterminate equilibrium involving only these two strategies, but such a conclusion is unwarranted. Because, once LOYAL becomes sufficiently numerous, DEFECT becomes profitable again! The upshot, contra Axelrod and Hamilton, is a mixed or cyclic equilibrium when the three strategies are permitted to compete as a triad.

The "proof" provided by Axelrod and Hamilton errs in specifying that, in order to enter, the invader strategy must actually <u>do better than</u> the incumbent. This is an unwarranted requirement; <u>doing equally well</u> suffices to permit entry, and in any case precludes extinction if there are any representatives already present in the population. Furthermore, even if (for the sake of the argument) it were granted that definite superiority is required for entry, more accurate modelling of the situation would reveal that the evolutionary equilibrium still cannot be a 100% TIT FOR TAT population. The reason is that TIT FOR TAT is a demanding strategy: it requires ability to discriminate between experienced behaviors, to remember which individuals among those encountered have displayed each type of behavior in the past, and to recognize those individuals when encountered again. Since they do not require these capacities, both LOYAL and DEFECT are less burdensome to adopt and live by. Once a proper accounting is made for the cost of the extra abilities that TIT FOR TAT requires, the economics of the situation will preclude the population evolving toward 100% TIT FOR TAT.[9]

2. Contingent Strategies and Commitment

TIT FOR TAT was an example of a contingent strategy in a repeated-game context. It is also possible to have contingent strategies even with single-play games, which leads to what is called the theory of "metagames" (another unfortunate choice of terminology).

Commitment represents the ability to foreclose one's own future freedom of choice, to guarantee to your opponent that you will not diverge from a specified chosen strategy. (Since one can only achieve any useful effect from commitment by communicating that fact to the other party, I will always be assuming that such communication occurs.) Particularly interesting results ensue from commitment to contingent strategies, which correspond to what we

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[9]For further details on these points see Hirshleifer [1982, pp. 20-35.]

call in ordinary language "threats" and "promises." But commitment to a simple strategy is also entirely possible.

Consider Battle of the Sexes (Table 3). If He can commit to strategy 1, the only rational response for She is also to play 1, allowing the committer the higher return. Correspondingly, She would like to commit to strategy 2, forcing He to go along. In either case, the one with power to commit reaps the greater benefit from the interaction (10 versus 5).

Commitment to a contingent strategy makes sense, as has been emphasized by Thompson and Faith [1981], only in a situation of sequential play -- where the parties move in some definite order over time. Such a protocol opens up a route of escape from the trap outcome of the Prisoners' Dilemma. It is important here to distinguish between "strategy" and "move." By assumption, the only actual moves are those available to the players in the original matrix -- LOYAL or DEFECT. A strategy is a plan for playing the moves in a context of a particular sequential protocol, the governing rules of the game. The "Expanded Prisoners' Dilemma" of Table 6 illustrates such a situation.

[Table 6, 7, 8 Here.]

In Table 6 we suppose that Row has the power to commit to a contingent strategy, Column being limited as before to his simple LOYAL versus DEFECT options. The interesting contingent strategy for Row is CONCUR: threaten DEFECT if Column's move is DEFECT but promise LOYAL if Column plays LOYAL. (But for completeness the rather illogical DIVERGE strategy is also shown.) Row's optimal play is to commit to CONCUR, in which case Column will surely play LOYAL -- the result being (-2, -2). Thus the Prisoners' Dilemma has been

Table 6

EXPANDED PRISONERS' DILEMMA

	C_1 (LOYAL)	C_2 (DEFECT)
R_1(LOYAL)	-2,-2	-20,0
R_2(DEFECT)	0,-20	-10,-10
R_3(CONCUR)	-2,-2	-10,-10
R_4(DIVERGE)	0,-20	-20,10

Table 7

DETERRENCE WITHOUT COMMITMENT

	C_1 (REFRAIN)	C_2 (ATTACK)
R_1(FOLD)	3,2	1,3
R_2(RETALIATE)	3,2	2,1

Table 8

DETERRENCE REQUIRING COMMITMENT

	C_1 (REFRAIN)	C_2 (ATTACK)
R_1(FOLD)	3,2	2,3
R_2(RETALIATE)	3,2	1,1

escaped; the parties achieve their second-best outcomes, as compared with the third-best (i.e., next-to-worst) results that constitute the trap solution. It is also interesting to note here that having the power to commit has not led to any comparative advantage for Row over Column.

The significance of commitment for the problem of deterrence is illustrated by Tables 7 and 8. Table 7 is another version of the Expanded Prisoners' Dilemma just discussed. In the deterrence context, for the party with the first move (the Column player) DEFECT in Table 6 becomes ATTACK in Tables 7 and 8 while LOYAL in Table 6 corresponds to REFRAIN in Tables 7 and 8. For the responding (Row) player, two strategies have been deleted. DIVERGE has been omitted because of its evident irrationality. Also, ATTACK (= DEFECT) has been dropped, since if Row can consider attacking regardless of what Column does we do not have a deterrence situation. Thus, the implication is, Row is incapable of attacking except in response. Responding to attack is of course the RETALIATE strategy. Failing to do so is the FOLD strategy, corresponding to LOYAL in the original Prisoners' Dilemma. (The actual numerical values given in the Table represent the ranking of the outcomes in the underlying Prisoners' Dilemma matrix, 1 being lowest and 3 highest.)

It is evident that deterrence succeeds even without commitment in Table 7. If attacked, Row prefers to RETALIATE, and this suffices to deter attack. But Row in Table 8 is more pacifically inclined, and if attacked really would prefer FOLD to RETALIATE. Unfortunately, that guarantees he will be attacked! Here is where the power to commit provides an escape. If Row can guarantee in advance that RETALIATE will occur, despite his aversion to that course of action, deterrence succeeds. If he can reliably threaten to do what he does not want to do, he won't have to do it!

An interesting question is: What are the mechanisms of commitment in cases like this? Here we can go back to our fundamental categories of opportunities, preferences, and perceptions. If Row is pacifically inclined, as pictured in Table 8, he can try to shift the situation toward Table 7. If possible, he might alter his preferences in the direction of bellicosity. Alternatively, he could try to manipulate elements of the opportunity set. For example he might make a wager with outsiders, staking a considerable sum that he will not choose FOLD. Or, he could make the current encounter into a visible precedent and test case, it being clear that his choosing FOLD here and now will invite future costly confrontations. Or, Row might work on Column's perceptions by putting out misleading intelligence indicators of bellicosity.

The emotion of anger, which might otherwise seem to be only a "primitive" hindrance to human rationality, appears here in a new light. Anger provides the needed commitment to RETALIATE. My psychological "loss of control," that leads me to punish aggression even where it is not to my short-run material advantage to do so, may be just what is needed to deter invasions.[10] And by a reverse argument, the same may hold for love. "Unselfish" willingness to share gains, even when not required to do so, can be not only psychologically but materially rewarding when cooperation on the part of others is elicited

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[10] On this see Simmel [1955(1923)]. More generally, an outraged sense of justice which leads to "moralistic aggression" (Trivers [1971]) by third parties may be an important force in maintaining the possibility of social cooperation. Again, it is essential that justice be pursued even where not in accordance with cost-benefit analysis. ("Let justice be done though the heavens fall.")

thereby.[11] Thus, both anger and love can serve as "enforcers" of implicit contracts between two parties.

3. First Move vs. Last Move

With outcomes specified by a given game matrix, quite different results may ensue depending upon whether the players choose simultaneously or sequentially — and if the latter, depending upon which moves first and which moves last. The latter topic has some suggestive implications for the choice between offense and defense in war, or pre-emptive moves in diplomacy. Without getting into these applications here it will be of interest to look at some of the advantages and disadvantages of priority.

Consider a sequential-move single-round game. In such a game it may pay a player to follow a so-called "dominated" strategy of the corresponding simultaneous-move game. (Since the Nash equilibrium NE cannot involve playing a dominated strategy,it follows that the NE will not be an appropriate solution concept here.)[12] In Table 9 Column is supposed to be the first-mover. His strategy 2 is clearly dominated by strategy 1. Nevertheless, he does better at the sequential-play equilibrium R2,C2 (marked with a +) than at the Nash equilibrium R1,C1 (marked with an asterisk) that would be reached had he played his dominant strategy.

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[11]The "Rotten-Kid" paradigm (Becker [1976]) is a famous instance under this heading. Benevolent willingness of a parent to share the mutual gains can induce a merely selfish Kid to act in the overall family interest — with material benefit to all concerned.

[12]It is true that if the choice situtlon were written in expanded-matrix form, allowing second-mover to employ contingent strategies, the correct solution would always be one of the Nash equilibria. But since these equilibria rapidly become excessively numerous with larger ranges of strategy choice, the NE remains not very useful as a solution concept. (On this see also Brams and Wittman [1981].)

[Tables 9, 10, 11, 12 Here.]

A more central question for our purposes is, who has the advantage, first-mover or second-mover? In Battle of the Sexes (BOS), as has already been noted, first-mover can force achievement of the common-strategy outcome that favors him or her (see Table 10). And in Chicken or Hawk-Dove (HD) also, by playing HAWK the first-mover can force his opponent into DOVE with an inferior outcome (Table 11). Can last-mover ever have the advantage? Yes, as illustrated in Table 12. Here, if Column has the <u>last</u> move he can force R2,C2, with outcome (2,3) — whereas Row having the last move leads to R1,C2 with returns (3,2). Thus, here the last-mover has the advantage.

Interpreting these results, notice that both BOS and HD are characterized by strong parallelism of interest between the players. In contrast, Table 11 is a constant-sum case (if we interpret the tabulated numbers as cardinal magnitudes). The players' interests being strictly opposed, the first-mover knows that his opponent's final move will be entirely adverse to his interests. Hence, the non-terminator is induced to settle for a "safe" but relatively unsatisfactory intermediate payoff. I.e., he must accept the bad to avoid the worst. But when the parties' interests are not strictly opposed, first-mover can commonly adopt a strategy such that he will benefit more by second-mover's optimal response than second-mover can gain himself.

A nice illustration of the relative advantages of first- versus last-move arises in oligopoly theory. In the homogeneous-product duopoly case, with <u>quantity</u> as the decision variable, the first-mover has the advantage -- the so-called "Stackelberg solution". Being able to predict and therefore allow for his competitor's subsequent constrained optimization, the first-mover can produce a level of output such as to pre-empt most of the joint duopoly gain.

Table 9

"DOMINATED"-STRATEGY EQUILIBRIUM

		First-mover	
		C_1	C_2
Second-	R_1	*4,2	2,1
mover	R_2	1,4	+3,3

Table 10

BATTLE OF THE SEXES

		She	
		C_1	C_2
He	R_1	3,2	1,1
	R_2	1,1	2,3

Table 11

HAWK-DOVE (OR CHICKEN)

	C_1 (DOVE)	C_2 (HAWK)
R_1(DOVE)	3,3	2,4
R_2(HAWK)	4,2	1,1

Table 12

LAST-MOVE ADVANTAGE

	C_1	C_2
R_1	1,4	3,2
R_2	4,1	2,3

If however <u>price</u> is the decision variable (as might be the case if the duopolists' products were not identical), then the last-mover clearly has the advantage. For, regardless of the price selected by his opponent, the last-mover can undercut it so as to engross most of the joint sales. Thus once again the first-mover tends to have the advantage where there is strong parallelism of interest — the case where quantity is the decision variable, the parties having a strong joint interest in keeping the common price high. But the last-mover has the advantage where interests are more strictly opposed, as when he can largely deprive the other of sales by undercutting on price.

IV. ON THE TECHNOLOGY OF CONFLICT[13]

Conflict is a kind of "industry" — a way in which economic agents compete for resources. Just as the economist without being a manager or an engineer can apply certain broad principles to the processes of industrial production, so, without claiming to replace the military commander he can say something about the possibilities for "producing" desired results through violent conflict.

Under this heading I will only address one topic here: <u>increasing versus decreasing returns in the sphere of conflict</u>.

As an historical generalization, <u>battles</u> generally proceed to a definitive outcome — victory for the one side, defeat for the other. <u>Wars</u>, while sometimes terminating in complete overthrow of one side or the other, are somewhat more likely to end inconclusively or with a compromise

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[13]This section makes use of discussions by Tullock [1974, Ch. 9], Boulding [1962, Ch. 12-13], and especially Lanchester [1956 (1916)].

settlement. I argue that this is related to the scope of increasing versus decreasing returns to the application of violence. A related phenomenon is the fact that the world is divided into a system of nation-states: while each government has a near-monopoly of power within a limited region, the struggles that continue to take place along the frontiers reveal that there is typically a periphery along which forces are about equally balanced.

Thus, there seem to be two general principles at work. (1) Within a given geographical region, as the scale of military effort grows there tend to be increasing returns — and hence a "natural monopoly" of military power within each sufficiently limited base area. (2) But in attempting to extend military sway over larger regions, diminishing returns are encountered to the projection of power away from the base — hence we do not see a single universal world-state.

What is it that underlies the scope of the increasing-returns principle? Simply that the stronger contender can steadily inflict a more-than-proportionate loss upon his opponent, thus becoming (relatively) stronger still. In a situation where only pairwise relative strength counts, this process tends to proceed to the limit of total annihilation (unless flight or surrender intervenes).

Simple yet important special cases of this process are modelled in Lanchester's equations. In linear warfare, for example, the military units (soldiers, ships) arranged in line distribute their fire equally over the enemy's line. Symbolizing the Blue force size as B and the Red force size as R, the relevant process equations are:

$$dB/dt = -k_R\, R$$

$$dR/dt = -k_B\, B$$

where k_B and k_R are the respective attack efficiencies (reflecting factors like vulnerability versus accuracy of fire). The condition for equality is:

$$k_B \ B^2 = k_R \ R^2$$

Thus, military strength in linear warfare varies proportionately with force effectiveness but as the square of force size. And even where this exact rule does not apply,[14] it still is quite generally the case that in the combat process the strong become stronger and the weak weaker, ending in total victory for the one side and defeat for the other.

The logic of this is so compelling[15] that we may well wonder why it sometimes fails to hold. Among the possible complicating factors are:

(1) Force effectiveness may not be uniform in time or in scale. The initially more powerful army may fatigue more rapidly. Or, the initially losing commander may turn out to have a comparative advantage in handling the smaller forces that remain once both sides have suffered attrition.

(2) Actual battle is of course typically too complex to be modelled in a simple linear way. For one thing, the field of combat may be inhomogeneous: the losing side may have an "area of refuge" within which it retains sufficient strength to avoid annihilation.

(3) In the fog of war, sometimes the winning general does not know he has won. Hence he may withdraw the forces capable of achieving total victory.

(4) While battles are almost always two-sided interactions, wars normally are at least potentially multi-sided. Rather than suffer further losses in order to annihilate a defeated enemy, the winning commander may choose to conserve the forces needed to meet other opponents.[16]

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[14]Lanchester shows, for example, that where forces occupy areas, rather than extend in lines, relative strengths vary linearly with rather as the square of force sizes.

[15]Exactly the same logic underlies what is known as "Gause's exclusion principle" in evolutionary theory: when two species compete to occupy any single niche, the more effective competitor must drive the other to extinction. This principle is subject to much the same qualifications as those which limit the scope of increasing returns in conflict interactions (see text below).

[16]Harold II of England, having totally defeated the invading Norwegians at Stamford Bridge on September 15, 1066, was left with insufficient strength to avoid disaster at Hastings on October 14.

(5) But by far the most important of the disturbing factors is the fickle finger of Fate. Recognizing the multitude of unpredictable chance events in warfare that sometimes favor one side, sometimes the other, the prudent commander may be happy to settle for "good enough" rather than push matters to the extreme.

Allowing for these moderating factors, Figure 9 illustrates the applicability of the increasing-returns principle. There will be some critical ratio of forces, indicated by the dashed vertical line, where the probabilities of victory are equal. In the neighborhood of this critical ratio, small changes in the balance of forces tend to bring about disproportionately large effects upon the chances of victory.

My second broad generalization, that decreasing returns apply to the geographical extension of military power, is pictured in Figure 10.[17] Writing the military strengths at the parties' respective home bases as M_B and M_R, for a balance of power over distance to exist the following must hold:

$$M_B - s_B d_B = M_R - s_R d_R$$

Here s_B and s_R are the loss-of-strength gradients in geographically projecting power. And d_B and d_R are the respective distances from base over which each of the two has dominant power, where $d_B + d_R = D$, D being the total distance between the two bases.

This analysis suggests that the size of nations, for example (on this see Friedman [1977]), will depend upon two somewhat distinguishable abilities: (1) to organize power at the base and (2) to project power over distance. Major historical trends in the partition of the earth's surface — independent city-states in some eras, huge superpowers in others — could be analyzed in terms of changes in factors like population sizes, technology, and organizational forms that affect the parameters of the equation.

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[17] Such a diagram appears in Boulding [1962, p. 230].

This simplistic discussion of the decreasing-returns principle once again requires a long list of qualifications, parallel to those which hedge the applicability of the increasing-returns principle. I will mention here only one additional factor — the crucial distinction between offensive and defensive power. In technological environments where the defense is relatively strong, decreasing-returns to distance are intensified while increasing-returns to force size tend to be moderated. So a stable system of smaller sovereign states tends to emerge. But where offensive technology overbalances the defensive, as in present-day strategic warfare, the world appears to be in a fragile if not downright unstable equilibrium — the driving tendency being toward a single world-state dominated by whichever power is sufficiently ruthless to use its offensive strength.

I must leave the topic of the technology of conflict here, having discussed only one of the many crucial factors involved in the "production" of desired outcomes through exercise of violence. Some of the omitted factors are listed for reference purposes in Table 13.

[Table 13 Here.]

V. CONFLICT, ECONOMICS, AND SOCIETY

So far I have been able only to drop hints about what I described as my secondary theme — to wit, that the study of conflict is important for economics. I can only expand a little bit on those hints here.

We have seen that the technology of conflict helps explain the size and shape of nations. Apart from the overwhelming importance of that fact, the underlying principle has even broader applicability. Many types of competitions among individuals and organizations have conflictual aspects, and

Table 13

ILLUSTRATIVE ADDITIONAL TOPICS IN THE TECHNOLOGY OF CONFLICT

1. Offense versus defense forces and weaponry
2. First-strike vs. second-strike moves/Counterforce vs. countervalue targets
3. Trade-offs: Mobility vs. fortification, accuracy vs. rate of fire, forces in being vs. mobilization potential, etc.
4. Maintaining organizational integrity under stress — military and civilian
5. Risk and its control

violence always remains as a coercive threat in the background. While the law may attempt to prevent thieves from stealing, business firms from sabotaging competitors' premises, attorneys from filing groundless lawsuits, or trade unions from intimidating non-members, control of such behaviors will never be perfectly effective. And in consequence, even entirely law-abiding individuals and organizations must, at the very least, plan on devoting some resources to extra-legal (not necessarily illegal) ways of protecting themselves. It will be evident that these invasive and counter-invasive efforts surely absorb a very substantial fraction of society's resources.

A related set of implications concern the internal structures of organizations. Thompson and Faith [1981], for example, make the extreme assertion (to put it mildly) that democracy is always an illusion, that every state is ultimately a military dictatorship (p. 376).[18] But inspection of the world reveals an enormous range of social structures adopted by animals and humans -- ranging from extremes of hierarchical dominance to highly egalitarian systems. A more profitable line of inquiry is to ask what the factors are that affect the steepness of the social dominance gradient. Where there is a single concentrated key resource, as in the irrigation systems of ancient empires, we might expect the struggle for its control to lead to a highly hierarchical social structure.[19] And, concentrated populations can be dominated without excessive diminishing returns to the geographical projection of military power. On the other hand, more broadly distributed resources and

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[18]This conclusion only very doubtfully follows from their analysis, which is in any case of a highly special sequential-play game protocol. The games being played in the network of associations that comprise a society are many times more complex than they allow for.

[19]This point is the key theme of Wittfogel [1957].

populations, as in the pioneer days of America settlement, conduce toward egalitarian social systems. It is also well-known that <u>external</u> conflict promotes the adoption of internal command economies and dictatorship. The explanation of this fact is, I believe, connected with the increasing-returns aspect of war and the consequent urgency of controlling free-riding, but unfortunately space does not permit development of this theme here.

My main message can be simply summarized. The institutions of property and law, and the peaceful process of exchange, are highly beneficient aspects of human life. But the economist's inquiries should not be limited to such "nice" behaviors and interactions. Struggle, imposing costs on others, and downright violence are crucial phenomena of the world as we know it. Nor is the opposition between the "nice" and the "not nice" by any means total. Law and property, and thus the possibility for peaceful exchange, can only persist where individuals are ultimately willing to use violence in their defense.

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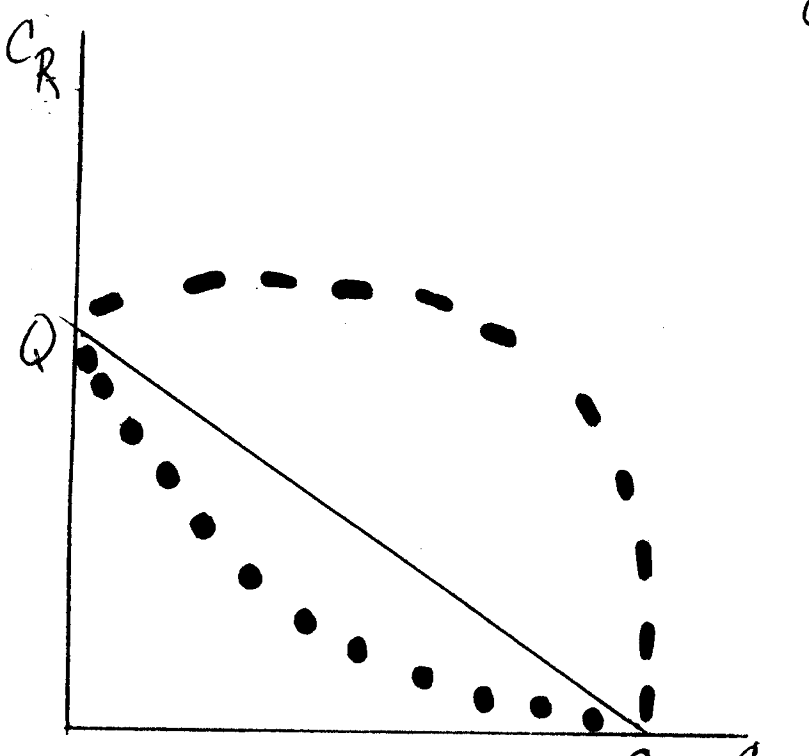


FIG. 1

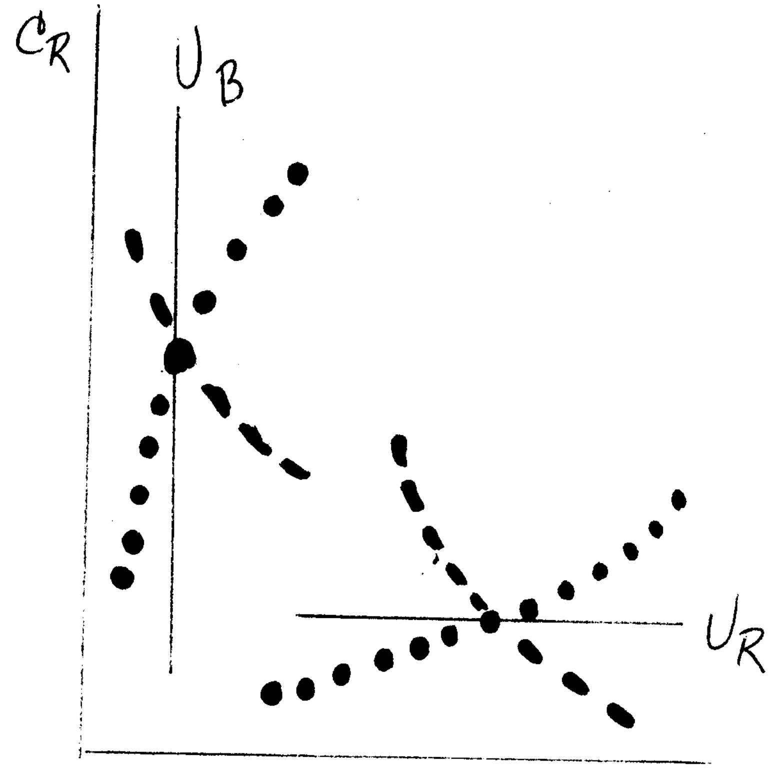


FIG. 2

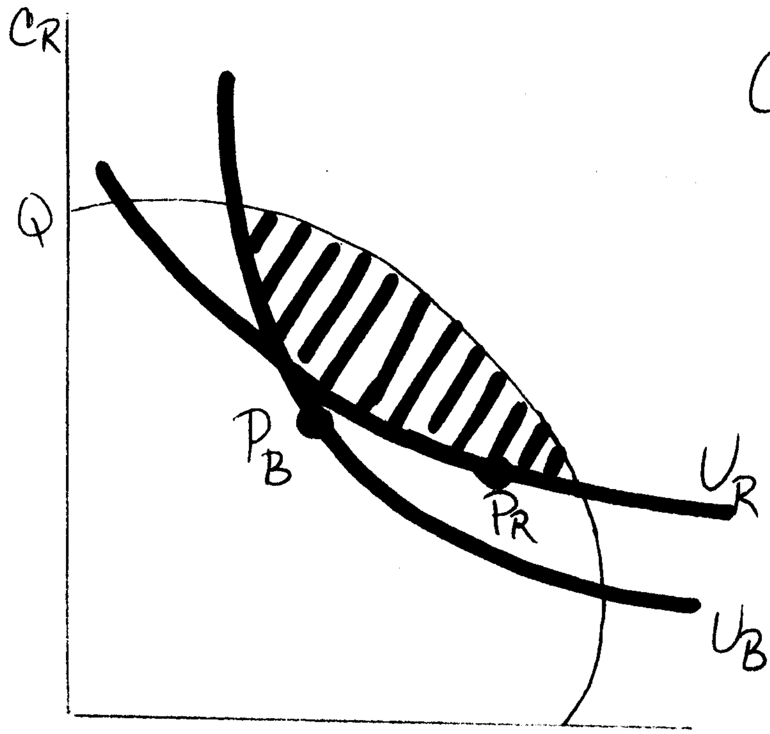


FIG. 3

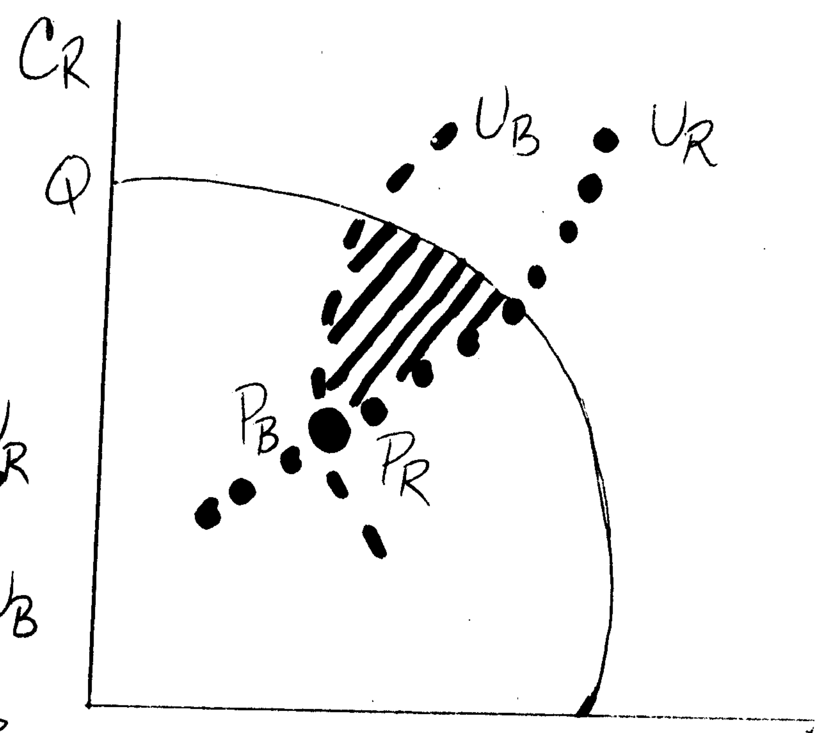


FIG. 4

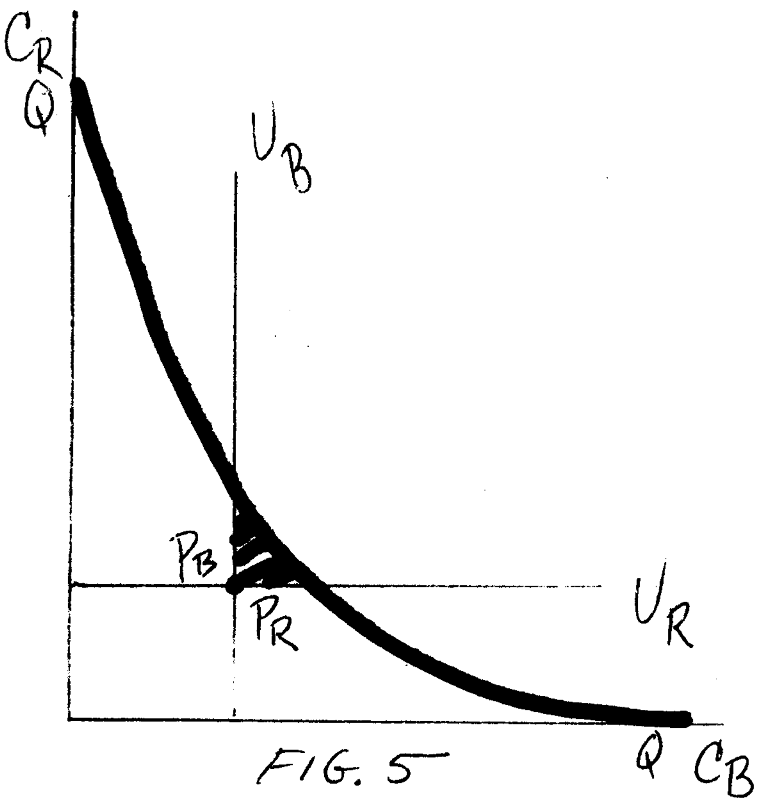


FIG. 5

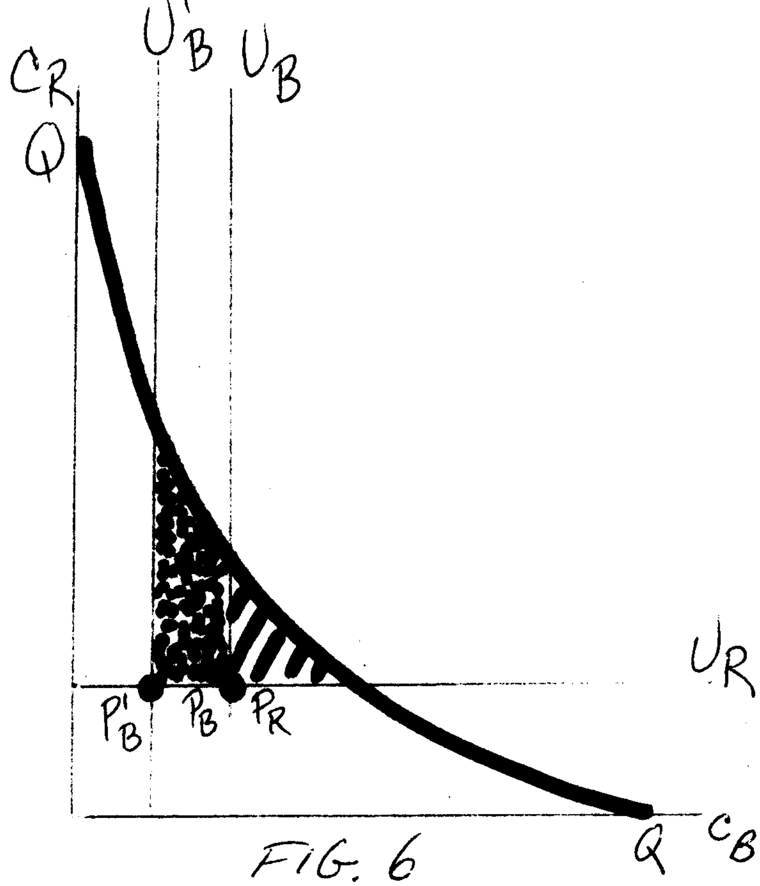


FIG. 6

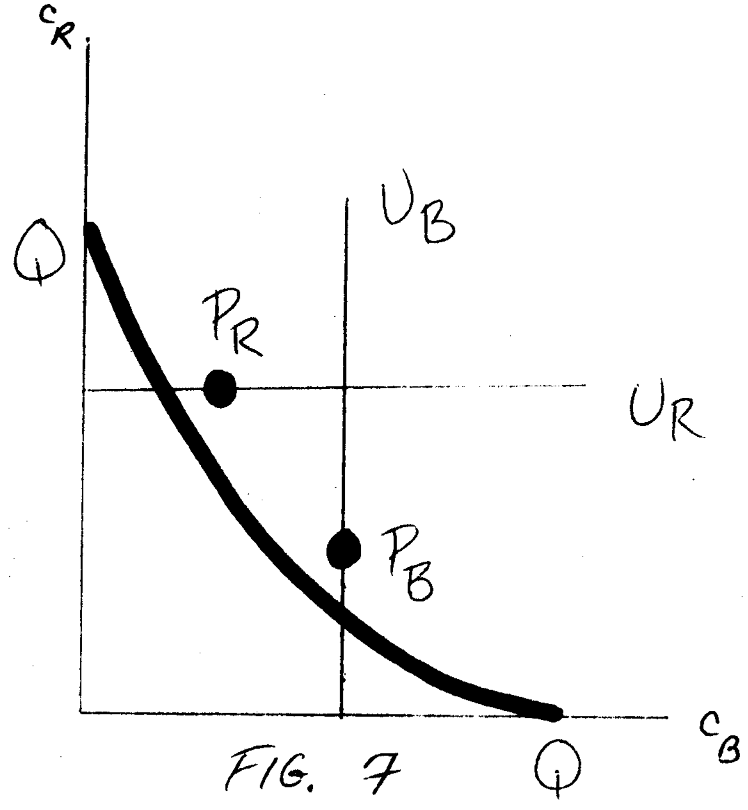


FIG. 7

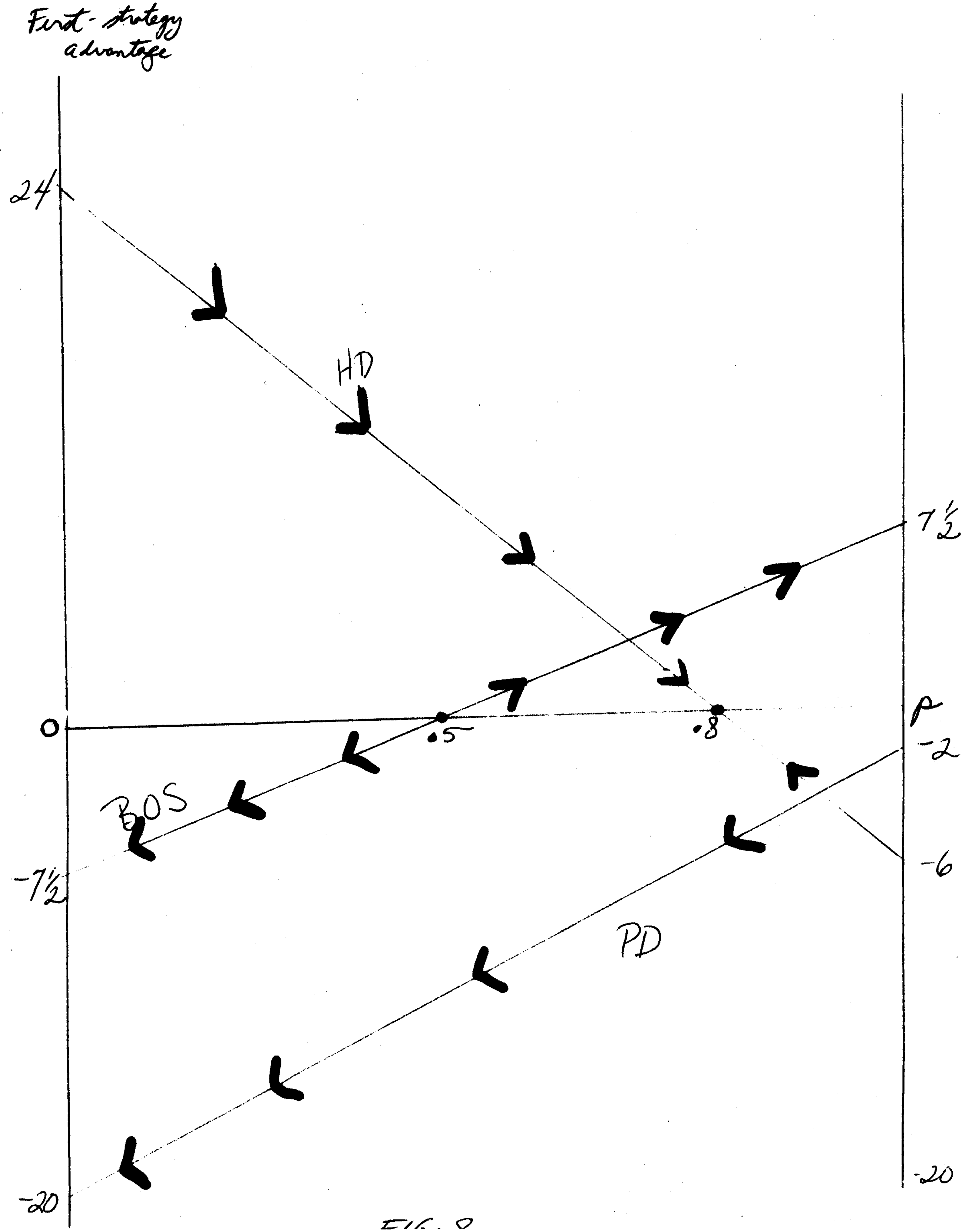
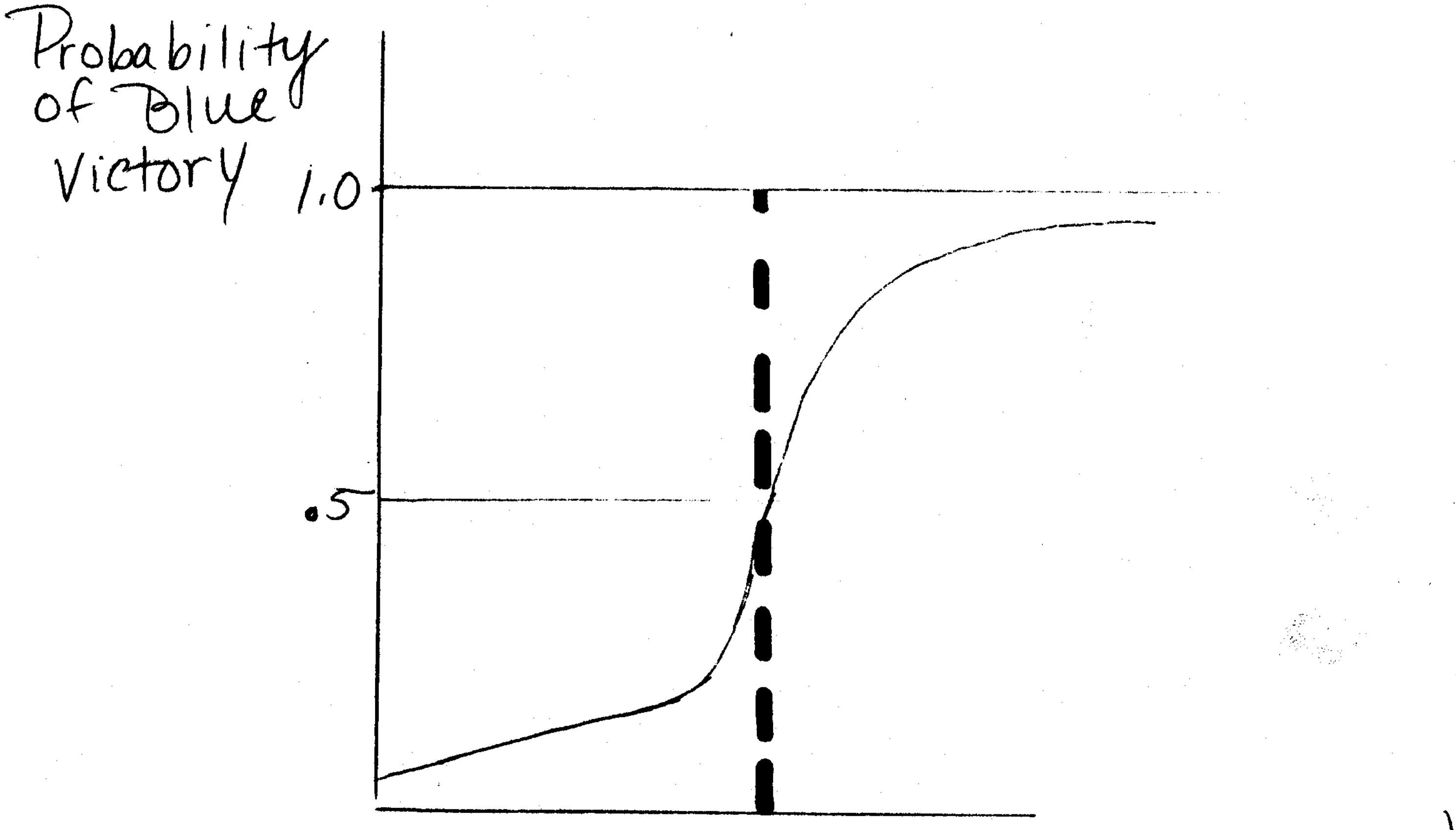
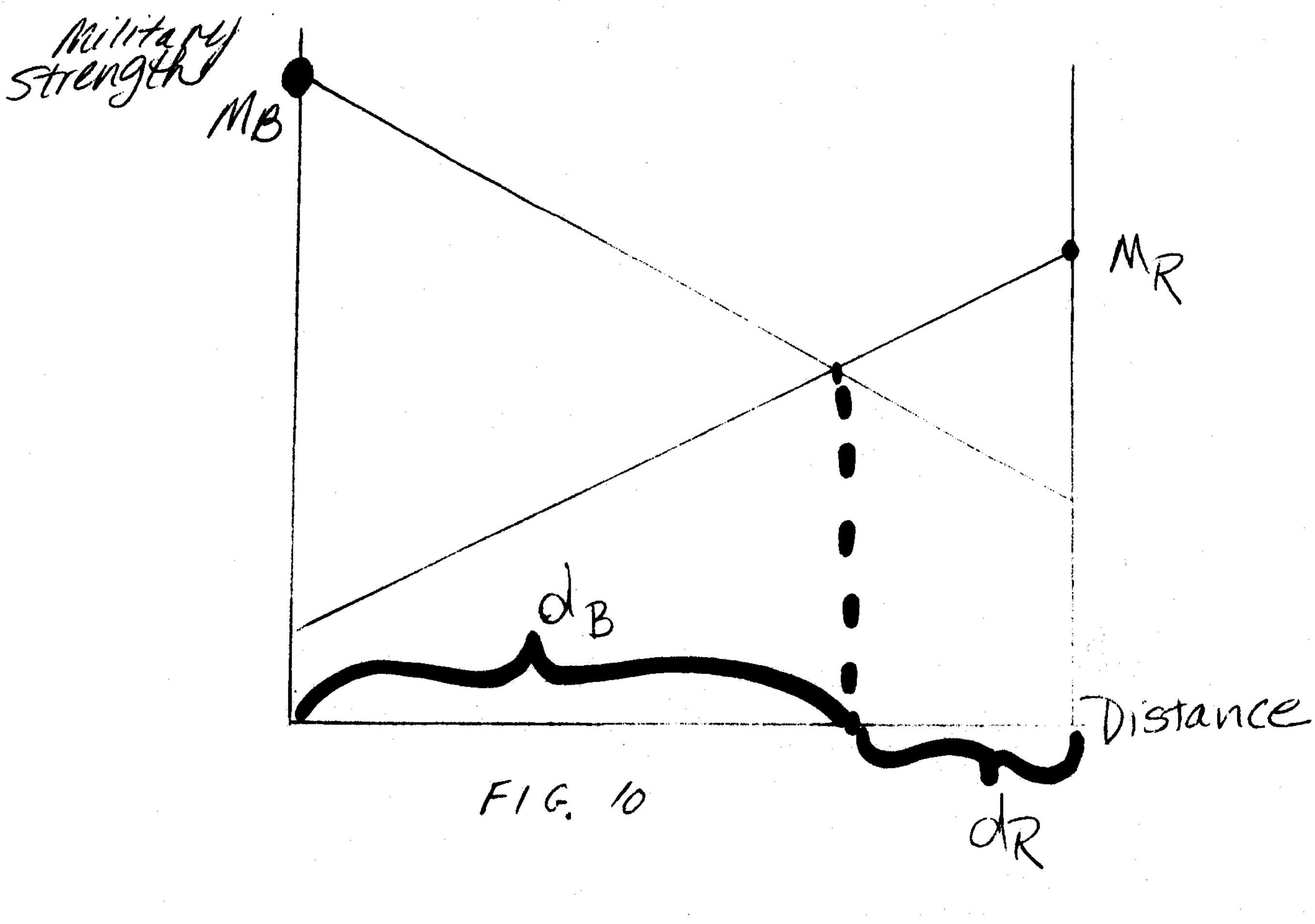


FIG. 8



Probability of Blue Victory
1.0
.5
FORCE RATIO (B/R)

FIG. 9



Military strength
M_B
M_R
d_B
Distance
d_R

FIG. 10