CONFLICT AND SETTLEMENT*

by

Jack Hirshleifer

University of California, Los Angeles

UCLA Dept. of Economics
Working Paper #360
January 1985

---

*Submission to THE NEW PALGRAVE: A Dictionary of Economic Thought and Doctrine.

J. Hirshleifer January 14, 1985

CONFLICT AND SETTLEMENT

Economics cannot forego the study of conflict. Property, in the last analysis, can be held only by individuals and groups able to repel or deter invasions. The strategy and tactics of conflict are optimizing choices, and the partition of the world's resources that is the final outcome of actual or threatened conflict is an economic equilibrium.

I. THE NATURE AND SOURCES OF CONFLICT

Economics, Alfred Marshall declared, is a "branch of biology broadly interpreted." From the bioeconomic viewpoint all living beings are competitors for the means of existence. Competition takes the more intense form we call conflict when contenders seek to disable opponents, or even convert them into a source of resources. Conflict need not always be violent; we speak, for example, of industrial conflicts (strikes and lockouts) and legal conflicts (lawsuits). But physical struggle is a relevant metaphor for these ordinarily non-violent contests.

Involved in a rational decision to engage in conflict, economic reasoning suggests, will be the decision-maker's preferences, opportunities, and perceptions. These three elements correspond to traditional issues debated by historians and political scientists about the "causes of war": Is war mainly due to hatred and ingrained pugnacity (hostile preferences)? Or to the opportunities for material gain at the expense of weaker victims? Or is war mainly due to mistaken perceptions, on one or both sides, of the other's motives or capacities?

Of course it is quite a leap from the choices of individuals to the war-making decisions of collectivities like tribes or states. Group choice-making processes notoriously fail to satisfy the canons of rationality. The most fundamental reason is that a multi-person entity cannot generally have a well-defined set of goals to be rationally aimed at, since there will almost always be disparities among the interests of its individual members. Thus the internal decision-making structures of the interacting groups may also be implicated among the causes of war.

Setting aside this last complication, Figures 1 and 2 are alternative illustrations of how preferences, opportunities, and perceptions might come together in a simple dyadic situation. In each diagram the curve QQ bounds the "settlement opportunity set" drawn on axes representing Blue's income I_B and Red's income I_R. The interior points P_B and P_R indicate the parties' respective perceptions of the outcome of conflict. And, of course, the families of curves labelled U_B and U_R are the familiar utility indifference contours.

[Figures 1 and 2 about here.]

Figure 1 shows a relatively benign situation: settlement opportunities are complementary, preferences display benevolence on each side, and perceptions of returns from conflict are conservative and agreed (P_B and P_R coincide). The "Potential Settlement Region" PSR (shaded area in the diagram), the set of income partitions such that both parties regard themselves as doing better than by fighting, is therefore large -- which plausibly implies a high probability of coming to an agreement. Figure 2 shows a less pleasant situation: antithetical opportunities, mutually malevolent preferences, and divergently optimistic estimates of the returns from conflict. The

PSR is therefore small, and the prospects for settlement much poorer.

Having organized the elements of the fight-versus-settle decision, we are next led to explore the forces underlying and determining the parties' opportunities, preferences, and perceptions.

Opportunities and Conflict

Conflict, the bioeconomic viewpoint suggests, is ultimately due to opposed material interests. Primitive tribes attack one another for land, for hoards of consumables, or for slaves. Similar aims evidently motivated barbarian invasions of civilized cities and empires in ancient times, and European colonial imperialism in the modern era. Yet, between contending parties there will almost always be some element of complementary interests, an opportunity for mutual gain represented by the potential settlement region PSR. Orthodox economics has always emphasized the scope of mutual benefit, even to the point of losing sight of conflict -- while certain dissident schools, notably the Marxists, have committed the opposite error.

The factors governing the parties' opportunities for gain from conflict or settlement include:

Malthusian pressure: Multiplication of numbers leads to jostling against neighbors, to competition for Lebensraum. There is also a technological factor. Warfare being pre-eminently an increasing-returns industry (see below), as numbers grow so does comparative advantage in conflict. Among the many historical instances: population growth in western Europe was a driving force behind the overseas expansion that largely eliminated or displaced indigenous populations in North and South America and Australia.

Enforceability of agreements: The prospects for peaceful settlement are gravely weakened if agreements cannot be enforced against later defection.

Within a national state the legal system serves as guarantor of contracts. But since there is no effective international law, two nations may go to war even in circumstances where both realize that a settlement would be mutually beneficial — if only it could be enforced.

Presence of third, fourth, etc., parties: Additional contenders open up new types of opportunities: e.g., forming alliances, employing a "balance of power" strategy, or inducing discord among one's opponents.

Technology: The current states of the arts of peace and war strongly influence the decision between them. The technology of war tends to be the more volatile, precipitating element. First, as will be seen below, because an innovation causing a relatively small shift in military advantage can have an enormously disproportionate effect upon the outcome. And second, since such innovations can be copied their effect is only temporary — hence the temptation to seize any momentary advantage.

Wealth: Increasing wealth has mixed effects. On the one hand it makes an aggressive strategy more affordable. But the prosperous evidently have more to lose from conflict, and relatively less to gain. So we are not surprised by the characteristic historical pattern, of civilized cities and empires besieged by hungry barbarians.

Preferences and Conflict

Modern neoclassical economics takes preferences as unexplained brute facts. But from a broader bioeconomic point of view preferences cannot be arbitrary. They are, rather, ultimately adaptive factors in the struggle for existence. Biological considerations suggest that the fundamental determinant of benevolence toward some fellow-beings and antipathy toward others is

kinship.

Modern sociobiological theory, in explaining the mutual tolerance and self-sacrifice that make social life possible, has quantified this factor. Other things equal, an animal should undertake an act that hurts itself and helps another only if the benefit-cost ratio b/c (where b and c are measured in terms of contributions, positive or negative, to reproductive survival of the organism's genetic endowment) exceeds 1/r, where r is the degree of relatedness. For example, since relatedness between siblings is $r = 1/2$, other things equal an animal should be willing to sacrifice its life to save two of its brothers or sisters.

Can advanced organisms like humans really be driven by any such "wisdom of the gene"? To a degree the point may be debated, but that parents willingly make sacrifices for their offspring, that blood is thicker than water, is a near-universal of human social life. The implication is that xenophobic wars of family against family, of tribe against tribe, of race against race are to some degree "normal" in the human species. Of course, preferences are only one element in the picture. Wars of brother against brother are far from unknown -- usually because, outweighing the relatedness factor, your brother may be a very close competitor for the resources your require. (Domestic sibling rivalry is an apt example.)

Perceptions and Conflict

Neoclassical economic theory tends to minimize the importance of differing perceptions or beliefs. From a large-numbers point of view, for example in the analysis of competitive markets, divergences of belief do tend to cancel out. And in the long run, incorrect beliefs are adjusted by experience. But conflict and war are pre-eminently small-numbers problems of the here and now. Thus, over-optimistic perceptions of the gains, tending to

shrink or even eliminate the Potential Settlement Region, are a potent source of conflict.

Indeed, conflict may be regarded as in a sense an educational process. The school of actual struggle teaches the parties to readjust their perceptions to more realistic levels. Wars end by mutual consent when the potential settlement opportunities become more attractive than continued fighting. (But there may be an asymmetry here; while the school of struggle does generally teach losers to be satisfied with less, it may also encourage winners to demand more.)

II. THE DYNAMICS OF CONFLICT

Static analysis examines the underlying sources of conflict. The processes whereby the parties interact, by negotiation or struggle, constitute the subject matter for dynamic analysis.

Game Theory and the Dynamics of Negotiation

Game theory helps explain why, even where a Potential Settlement Region PSR does exist, the parties may fail to achieve agreement. In game modelling, the payoff environment, represented by the familiar normal-form matrix, is the static element. The dynamic element may be called the protocol of play; it specifies the allowable step-by-step moves in the light of the players' information at each stage. (The protocol is pictured by the game tree or extensive-form representation.)

A few of the many distinguishable payoff environments are shown in Matrices 1 through 4. The numbers in each cell indicate ordinally ranked payoffs for each player, 1 being the poorest outcome in each case. In Matrix 1, LAND OR SEA, the environment is characterized by completely antithetical payoffs. The other three matrices -- CHICKEN, SILVER RULE, and PRISONERS'

DILEMMA -- represent different possible mixed-motive situations combining an element of opposition of interests with an opportunity for mutual gain (i.e., a PSR exists).

[Matrices 1 through 4 about here.]

As for protocols, the simplest to analyze is one-round sequential play: Row first selects one of his options, then Column makes his move in the light of Row's choice, and the game ends. In a sequential-play protocol it is always possible to find a "rational" solution. If Column can be relied to choose his best final move then Row, knowing this, can calculate his best first move accordingly. (This process results in what is called a "perfect equilibrium.") In the alternative single-round protocol where the players choose simultaneously -- or, equivalently, where each chooses in ignorance of the other's move -- solution concepts are harder to justify. The most commonly employed is called the "Nash equilibrium" (or "equilibrium point"), a pair of strategies from which neither player would want to unilaterally diverge.

In the LAND OR SEA payoff environment, under the one-round sequential-move protocol, it is the second-mover or defender (Column here) who has the advantage. Whichever strategy Row chooses, Column will respond appropriately: i.e., if Row attacks by land, Column will defend by land. Hence the (1,2) payoff-pair is the outcome regardless of Row's initial choice. In military terms the defense has an intrinsic advantage when the attacker must visibly commit his forces to one or another line of attack. And, of course, where the defense has such an advantage neither party is motivated to initiate warfare through aggression. When, on the other hand, LAND OR SEA is played under the simultaneous-move protocol, both parties are groping in the dark and little can be said with confidence. (Technically, here the Nash equilibrium would

have each side choosing its strategy at random, in effect tossing a coin.)

In the payoff environment of CHICKEN (Matrix 2), while the opportunities remain highly antithetical there is now a mutual interest in avoiding the disastrous (1,1) outcome which comes about when both play Tough. In contrast with LAND OR SEA, the CHICKEN payoff environment favors the first-mover (in the one-round sequential-move protocol). Specifically, Row would rationally play Tough knowing that Column has to respond with Soft. Column must accept the bad (payoff of 2) to avoid the worst (payoff of 1). If the protocol dictates simultaneous moves, however, once again the players are groping in the dark. Under the Nash equilibrium concept they choose probabilistically, so that the disastrous (1,1) outcome will indeed occur a percentage of the time. (The simultaneous-play CHICKEN game has been said to describe industrial conflict. Should union or management ever become known to be a Soft player, that side will be at a disadvantage. But if both are sure to play Tough, no settlement could ever occur. Hence the two sides might each plausibly adopt a "mixed" strategy, so that strikes and lockouts occur in a certain fraction of the interactions.)

The SILVER RULE payoff environment is friendlier than CHICKEN. In SILVER RULE each player would like to answer Soft with Soft -- leading to the mutually preferred (4,4) payoffs -- but failing this, would respond to Tough with Tough. If the sequential-move protocol applies, the first-mover will then always rationally choose Soft, and so the ideal (4,4) payoff-pair will be achieved. But under the simultaneous-move protocol, with the parties groping in the dark, once again the outcome is quite unclear. In fact there are three Nash equilibria: pure-strategy solutions at (4,4) and (2,2), and a mixed-strategy solution as well.

Finally, in the famous PRISONERS' DILEMMA payoff environment (Matrix 4) the parties are likely to find themselves in the Defect-Defect "trap" with (2,2) payoffs, even though (3,3) could be achieved were each to play Cooperate. The "trap" comes about under both sequential-move and simultaneous-move protocols. (Here we need not rely upon the problematic Nash equilibrium concept in the simultaneous-move game. Defect play is actually dominant for both parties, and is thus one's best choice even in ignorance of your opponent's move.)

The preceding discussion could only be suggestive, limited as it was to 2-player games, within that category to only a few 2-strategy symmetrical payoff environments, and finally to the very simplest protocols — excluding, for example, all negotiations and communications between the parties. Space limitations permit comment upon only a few additional points.

Perceptions: Standard game models assume that players know not only their own payoffs but also their opponents'. But unintentional error on this score, or else deliberate deception, may play a crucial role. Suppose two parties in the SILVER RULE payoff environment of Matrix 3 find themselves initially playing Tough-Tough with outcome (2,2). Imagine now they are given a chance to shift strategies under a sequential-move protocol. As first-mover, Row would be happy to change from Tough to Soft if only he could rely upon Column to respond in kind. But Row may, mistakenly, believe that Column's payoffs are as in CHICKEN, from which he infers that Column would stand pat with Tough. Row would therefore not shift from Tough, hence Column in his turn would not change either. (Some authors have gone so far as to attribute all or almost all of human conflict to such mistaken "self-fulfilling beliefs" about the hostility of opponents, but of course this pattern is only one of many possibilities.)

Commitment and deterrence: In some circumstances the second-mover in point of time (Column) may be able to commit himself to a given response strategy before Row makes his first move. While Column thereby surrenders freedom of choice, doing so may be advantageous. Consider threats and promises. A threat is a commitment to undertake a second-move punishment strategy even where execution thereof is costly. A promise similarly involves commitment to a costly reward strategy. Matrices 5 and 6 illustrate how a threat works. Row's choices are Attack or Refrain, while Column's only options are to Retaliate or Fold if Row attacks. Column's problem, of course, is to deter Row's attack. In Matrix 5 Column prefers to Retaliate if attacked, a fact that -- given Row's preferences -- suffices for deterrence. Commitment is not required. (Since Column prefers to Retaliate, there is no need to commit himself to so so.) In Matrix 6 the Column player prefers to turn the other cheek; if attacked, he would rather Fold than Retaliate. Unfortunately, this guarantees he will be attacked! (Note that here it is not excessive hostility, but the reverse, that brings on conflict.) But if Column could commit himself to Retaliate, for example by computerizing the associated machinery beyond the possibility of his later reneging, then deterrence succeeds. In short, if a pacific player can reliably threaten to do what he does not really want to do, he won't have to do it! (Needless to say, so dangerous an arrangement is not to be casually recommended.)

[Matrices 5 and 6 about here.]

The Technology of Struggle

Conflict is a kind of "industry" in which different "firms" compete by attempting to disable opponents. Just as the economist without being a manager or 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 principles governing how desired results are "produced" through violence.

Battles typically proceed to a definitive outcome -- victory or defeat. Wars on the whole tend to be less conclusive, often ending in a compromise settlement. These historical generalizations reflect the working of increasing versus decreasing returns applied to the production of violence: (1) Within a sufficiently small geographical region such as a battlefield, increasing returns to military strength apply -- a small military superiority is typically translated into a disproportionately favorable outcome. (2) But there are decreasing returns in projecting military power away from one's base area, so that it is difficult to achieve superiority over an enemy's entire national territory. The increasing-returns factor explains why there is a "natural monopoly" of military force within the nation-state. The diminishing-returns factor explains why a multiplicity of nation-states have remained militarily viable to this date. (However, there is some reason to believe, the technology of attack through long-range weapons has now so come to prevail over the defense that a single world-state is indeed impending.)

Going into the basis for increasing returns, at any moment the stronger in battle can inflict a more-than-proportionate loss upon his opponent, thus becoming progressively stronger still. Important special cases of this process are modelled via Lanchester's equations. In combat, where all the military units distribute their fire over the enemy's line, the process equations are:

$$dB/dt = -k_R R$$

$$dR/dt = -k_B B$$

Here B and R are the given force sizes for Blue and Red, and the per-unit

military efficiencies are given by the k_B and k_R coefficients. It follows that military strengths are equal in linear warfare when:

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

But even where military strength varies less sensitively than as the square of force size, it remains quite generally the case that in the combat process the strong become stronger and the weak weaker, leading to annihilation unless flight or surrender intervene. (Of course, a skillful commander finding himself with an adverse force balance will attempt to change the tactical situation -- by timely withdrawal, deception, or other maneuver.)

One implication of increasing returns may be called the "last-push principle." In the course of a conflict each side will typically not be fully aware of the force size and strength that the opponent is ultimately able and willing to put in the field. Hence the incentive to stand fast, even at high cost, lest a potentially won battle be lost. (Foch: "A battle won is a battle in which one will not confess oneself beaten.") This valid point unfortunately tends to lead to battlefield carnage beyond all reasonable prior calculations, as experienced for example at Verdun.

A related, equally crucial implication of increasing returns to force size is the importance of organization. An integrated military unit is far more powerful than an equally numerous conglomeration of individual fighters, however brave. Organizational superiority, far more than superiority in weapons, explains why small European expeditionary contingents in early modern times were able to defeat even vast indigenous forces in America, Africa, and Asia. Battles are thus often a contest of organizational forms; the loser is the side that first cracks under pressure.

As for diminishing returns, in the simplest case an equilibrium is achieved at a geographical boundary such that:

$$M_B - s_B x_B = M_R - s_R x_R$$

Here M_B and M_R are military strengths at the respective home bases, s_B and s_R are decay gradients, and x_B and x_R are the respective distances from base. The condition of equality determines the allocation of territory.

The "social physics" of struggle is of course far more complex than these simplistic initial models suggest. There are more or less distinct offense and defense technologies, first-strike capability is not the same as retaliatory strength, countering insurgency is a different problem from central land battle, etc.

III. CONFLICT, SOCIETY, AND ECONOMY

The actuality and potentialities of conflict help explain, evidently, the size and shape of nations. Analogous factors govern balances of power in the more metaphorical conflicts that occur in many aspects of life: contests among social classes, among political factions and ideologies, between management and labor, among contenders for licenses and privileges ("rent-seeking"), between plaintiffs and defendants in lawsuits, among members of cartels like OPEC, between husband and wife and sibling and sibling within the family, and so on in indefinite variety. In all these dimensions of life aggressions and invasive attempts will inevitably be occurring, in turn calling forth defensive resistance and punishments. Invasive and counter-invasive efforts absorb a very substantial fraction of society's resources in every possible social structure -- egalitarian vs. hierarchical, liberal vs. totalitarian, centralized vs. decentralized, etc. Furthermore, every form of human social organization, whatever else can be said for or against it, must ultimately meet the survival test of internal and external conflict.

NOTES ON THE LITERATURE OF CONFLICT (OF SPECIAL RELEVANCE FOR ECONOMISTS)

Classical military thought from Machiavelli to Clausewitz to Liddell Hart, though rarely analytical in the economist's sense, remains well worth study. An excellent survey is Edward Mead Earle (1941). Modern work in this classical genre understandably concentrates upon the overwhelming fact of nuclear weaponry and the problem of deterrence; the contributions of Herman Kahn (1960, 1962) are notable. There is of course a huge historical literature on conflict and war. An interesting economics-oriented interpretive history of modern warfare is Geoffrey Blainey (1973). William H. McNeill (1982) examines the course of military organization and technology from antiquity to the present, emphasizing the social and economic context. On a smaller scale John Keegan (1976) provides a valuable picture of how men, weapons, and tactics compete with and complement one another on the battlefield. There is also a substantial body of statistical work attempting in a variety of ways to summarize and classify the sources and outcomes of wars; the best known is Lewis F. Richardson (1960b). Mathematical analysis of military activity, i.e., quantifiable modelling of the clash of contending forces, is surprisingly sparse. The classic work is Frederick William Lanchester (1916 [1956]).

The modern analysis of conflict, typically combining the theory of games with the rational-decision economics of choice, is represented by three important books by economists: Thomas C. Schelling (1960), Kenneth E. Boulding (1962), and Gordon Tullock (1974). Works by non-economists that are similar in spirit include Glenn H. Snyder and Paul Diesing (1977) and Bruce Bueno de Mesquita (1981). A tangentially related literature, making use of the rather mechanical psychologistic approach of Richardson (1960a), includes a very readable book by Anatol Rapoport (1960).

WORKS CITED

Blainey, Geoffrey. The Causes of War. New York: The Free Press, 1973.

Boulding, Kenneth E. Conflict and Defense: A General Theory. New York: Harper & Brothers, 1962.

Bueno de Mesquita, Bruce. The War Trap. New Haven and London: Yale U. Press, 1981.

Earle, Edward Mead, ed. Makers of Modern Strategy: Military Thought from Machiavelli to Hitler. Princeton, NJ: Princeton U. Press, 1941.

Kahn, Herman. On Thermonuclear War. Princeton, NJ: Princeton U. Press, 1960.

_____. Thinking About the Unthinkable. New York: Avon Books, 1962.

Keegan, John. The Face of Battle. New York: the Viking Press, 1976.

Lanchester, Frederick William. Aircraft in Warfare: The Dawn of the Fourth Arm. London: Constable, 1916. Extract reprinted in James R. Newman, ed. The World of Mathematics, v. 4. New York: Simon and Schuster, 1976, pp. 2138-57.

McNeill, William H. The Pursuit of Power: Technology, Armed Force, and Society since AD 1000. Chicago: U. of Chicago Press, 1982.

Rapoport, Anatol. Fights, Games, and Debates. Ann Arbor, MI: U. of Michigan Press, 1960.

Richardson, Lewis F. Arms and Insecurity: A Mathematical Study of the Causes and Origins of War. Pittsburgh: Boxwood; Chicago: Quadrangle, 1960.

_____. Statistics of Deadly Quarrels. Pittsburgh: Boxwood; Chicago: Quadrangle, 1960.

Schelling, Thomas C. The Strategy of Conflict. Cambridge, MA: Harvard U. Press, 1960.

Snyder, Glenn H. and Paul Diesing. Conflict Among Nations: Bargaining, Decision Making, and System Structure in International Crises. Princeton, NJ: Princeton U. Press, 1977.

Tullock, Gordon. The Social Dilemma: The Economics of War and Revolution. Blacksburg, VA: University Publications, 1974.

MATRIX 1

LAND OR SEA

	Defend by Land	Defend by Sea
Attack by Land	1,2	2,1
Attack by Sea	2,1	1,2

MATRIX 2

CHICKEN

	Soft	Tough
Soft	3,3	2,4
Tough	4,2	1,1

MATRIX 3

SILVER RULE

	Soft	Tough
Soft	4,4	1,3
Tough	3,1	2,2

MATRIX 4

PRISONERS' DILEMMA

	Cooperate	Defect
Cooperate	3,3	1,4
Defect	4,1	2,2

MATRIX 5

DETERRENCE WITHOUT COMMITMENT

	Fold (if attacked)	Retaliate (if attacked)
Refrain	2,3	2,3
Attack	3,1	1,2

MATRIX 6

DETERRENCE REQUIRING COMMITMENT

	Fold (if attacked)	Retaliate (if attacked)
Refrain	2,3	2,3
Attack	3,2	1,1

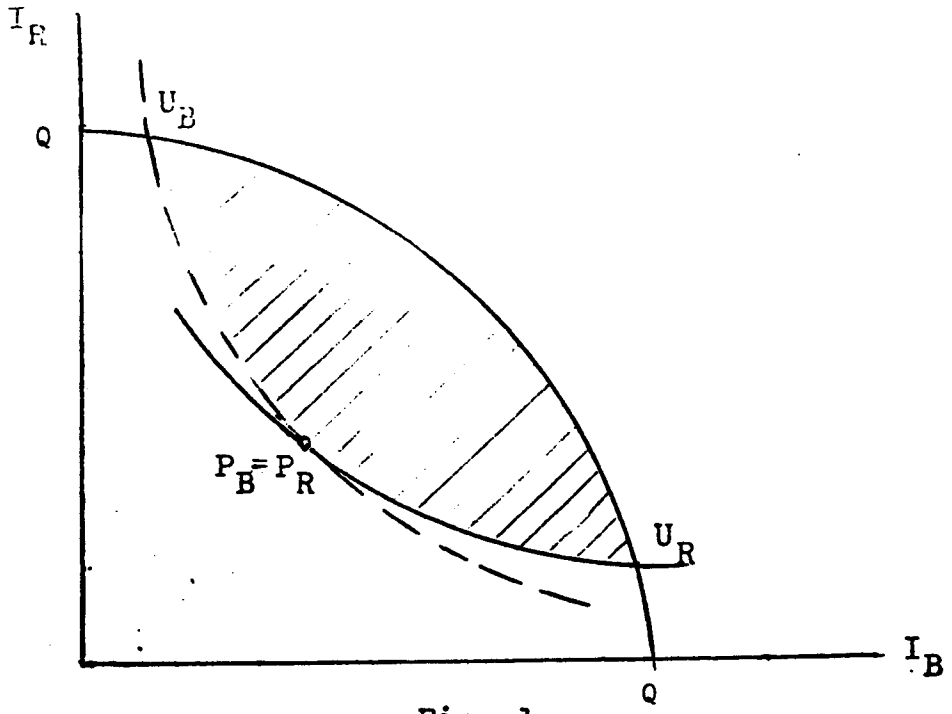

Fig. 1
Statics of Conflict -- Large Potential Settlement Region

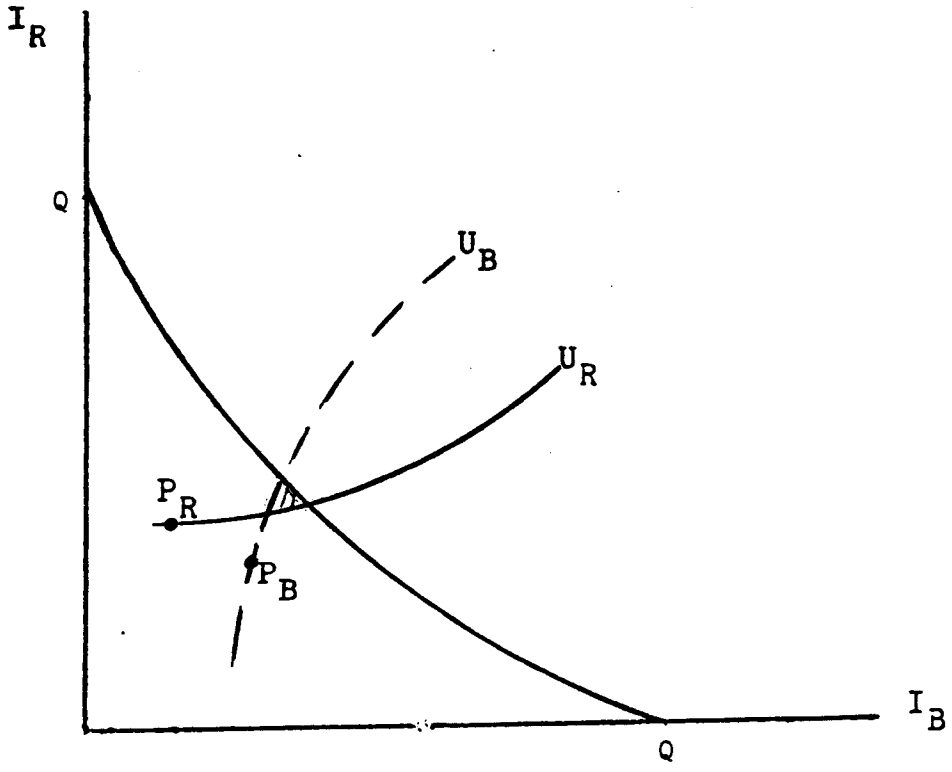

Fig. 2
Statics of Conflict -- Small Potential Settlement Region