THEORIZING ABOUT CONFLICT

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Working Paper #727
February 1995

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Abstract

The category of conflict encompasses not only war but also crime, litigation, strikes and lockouts, and redistributive politics. Exchange theory and conflict theory constitute two coequal branches of economic analysis, the first based upon contract and mutual gain, the second upon contest for asymmetric advantage. A number of the analytic options for modelling conflict are reviewed. Preferences, opportunities, and perceptions are shown to determine the choice between conflict and settlement. The technology of conflict as an economic activity is surveyed. Two illustrative models are presented, the first involving actual fighting and the other armed peace.

THEORIZING ABOUT CONFLICT

1. Introduction

Living beings everywhere compete for the means of existence. Competition takes the more intense form we call conflict when, instead of merely utilizing available resources for productive or consumptive purposes, contenders try to hamper, disable, or destroy rivals. Conflict theory has to deal not only with the standard technology of production, but also with the technology of struggle. There is a technology for tilling the land, and quite a different technology for capturing land and defending it.

(While I will be using military terms like 'capturing' and 'fighting', these are to be understood as metaphors. Conflict encompasses not only warfare but also activities that do not necessarily involve physical violence, e.g., litigation. Commercial competition becomes conflict when, instead of merely vying for consumers' favor, firms act to raise rivals' costs or hinder their market access.)

Among the different modes of social interaction, economists of course emphasize market exchange. But all exchange, all cooperation, all compromise take place in the shadow of conflict [Cooter, Marks, and Mnookin (1982)]. What a nation can achieve by diplomacy depends upon the damage it could inflict should war occur. What a person has to pay for a piece of property depends upon the chances of seizing it without paying. More generally, decision-makers accede to others' wishes to the extent that they fear the consequences of failing to do so.

While economists have devoted attention to a number of topics in the conflict domain -- among them crime, litigation, strikes and lockouts, rent-seeking, warfare, and redistributive politics -- it is remarkable that these literatures within economics have remained almost entirely disjoint.

Specialists in one or another of these branches have hardly been cognizant of the logical parallels among them, and even less aware that there are general underlying principles applicable to all conflictual interactions.

Imagine that international trade, industrial organization, resource economics, public finance, etc., had all developed as entirely separate fields with no recognition of their intellectual resemblances or of their common foundation in microeconomics. A failing of exactly this type has occurred here. A first aim of conflict analysis is therefore to provide an underlying microtheory that would be applicable to all the topical areas of application such as warfare, litigation, etc. More sweepingly, exchange theory and conflict theory constitute two coequal branches of economic analysis: the former based upon two-sided advantage and contract, the latter upon one-sided advantage and struggle.

Section 2 below examines some of the analytic distinctions that need to be made in modelling conflict. Section 3 more explicitly addresses the choices between conflict and settlement, while Section 4 surveys the technology of conflict. Sections 5 and 6 describe two illustrative models of conflictual equilibrium, the first involving actual fighting and the other armed peace. Section 7 concludes briefly.

2. Analytic choices in modelling conflict

2.1. Conflict versus settlement: Dichotomy or continuum?

Conflict and settlement are usually interpreted as dichotomous. Rival nations are said to be at war or else at peace; a trade union may call a strike or else sign a collective-bargaining contract; a lawsuit may be settled or else litigated in court.

Alternatively, we might think in terms of a continuum. Very often what looks like a dichotomous decision on a small time-scale becomes a continuous choice taking a longer time-perspective. A primitive tribe may alternate between peace and war, but over the long term its actions can be interpreted as a steady-state division of its efforts between productive exploitation of its own territory versus appropriative struggles against other tribes.

Thinking in dichotomy terms suggests searching for special causes of war. Continuum thinking suggests instead that conflict and settlement are equally normal and coexistent; the analytic question is the balance between the two. In dichotomy models, the guns versus butter decisions on both sides typically determine a yes/no (peace/war) outcome together with an estimate of the respective chances of victory. In continuum models the same choice variables determine the intensity of conflict and the proportionate division of the stakes.

An awkward modelling problem arises in dichotomy models: once war has occurred, what next? In such models the advent of war means 'the end of history'. But wars, not to mention other forms of conflict, only rarely have such drastic consequences. Continuum models, by way of contrast, imply ongoing histories: persisting interactions in which the parties remain balanced between cooperative and conflictual activities.

2.2. Plays, rounds, and moves

In strategic interactions it is important to distinguish among moves, rounds, and plays of the game. Think of an auction. A play corresponds to sale of a single item in the auction catalog. Within a given play, each round of bidding allows every participant to make an offer. And of course a

move is a single player's bid-or-pass choice.

Completion of a play generates payoffs. A multiple-play game therefore entails a series of payoff disbursements. (Successive plays might all possibly have the same payoff structure, as in the repeated Prisoners' Dilemma, but that would be a special case.) Within a given play there may be a succession of rounds, consisting of bargaining or negotiation moves by the players. But moves and rounds do not generate payoffs until the play is completed.

Players may move either sequentially or simultaneously. Simultaneity refers to the state of knowledge rather than clock time: a move later in time, but in ignorance of the opponent's choice, is considered simultaneous with the latter. In a sequential-move situation, the last-mover necessarily has an informational advantage. But the first-mover's choices can constrain the options available, so whether or not there is on balance a first-move or last-move advantage (or neither) depends upon the detailed structure of the game [see, e.g., Dixit (1987), Baik and Shogren (1992)].

In some cases the sequence of moves is exogenously determined. In the American political system, for example, only the Congress can initiate legislation, which the President may or may not then veto. But the sequence of moves might also be determined endogenously. One interesting possibility would be a 'pre-play' interaction in which the players simultaneously indicate a preference for moving first or last. If these preferences match up, the sequence is determined accordingly. In the event of a mismatch, e.g., if both sides seek to move first, then they must move simultaneously instead.[1]

Finally, there has to be a termination rule closing the rounds of

negotiations and allowing payoffs to be made. Again there are quite a number of modelling options. There might be a fixed number of rounds (in the simplest case, only a single round) or perhaps bargaining ends at some pre-fixed hour of the clock. In an auction, rounds of bidding continue until 'naturally' terminated when no-one chooses to raise the last bid made. And finally, it may be that certain types of move serve to terminate play. Think of a crisis in which nations are negotiating by successive rounds of threats. This negotiation game terminates, among other ways, whenever some nation chooses to declare war.

2.3. Binding agreements possible?

Since fighting is essentially always Pareto-inefficient,[2] settlement remains an attractive alternative. But settlement agreements are of no use unless fulfillment can be guaranteed. Binding agreements normally require a third party to serve as enforcer.[3] Absent such an enforcement authority, as for example in territorial struggles among animals or international contentions among major powers, the chances of peace are considerably less. Yet the availability of binding agreements does not suffice to rule out conflict. Litigation remains a big industry even where the judicial system stands ready to enforce negotiated settlements.

2.4. Limited stakes? Restricted means?

Conflict may be to the death, or for a narrowly circumscribed prize. The aim of a war may be extermination of the opponent, or a mere border adjustment. Paralleling the possible limits upon the magnitude of the stakes are restrictions upon the means or instruments of conflict.

In both dimensions, the limits may be externally imposed. In litigation, a plaintiff can normally claim reimbursement only for damages actually incurred (limited stakes), and cannot lawfully bribe judge and jurors (restricted means). In electoral struggles, the victorious majority is checked by constitutional protections for the minority (limited stakes), while campaign efforts may be subject to legal restrictions like caps on aggregate expenditures. But sometimes the limitations may be the result of an explicit or implicit agreement among the parties, in which case the constraint is subject to reneging. A contestant dissatisfied by the outcome in a limited conflict may be tempted to escalate to a level where its chances are better [Kahn (1965)]. In the Vietnam war, the U.S. long refrained from bombing North Vietnam, but eventually decided to do so in the hope of forcing a more favorable settlement. (This represented an escalation both of stakes and of means.)

2.5. Varying the number of contenders

In traditional microtheory, perfect competition involves many buyers and many and sellers. At the opposite extreme is bilateral monopoly: one buyer, one seller. Ordinary monopoly is a one seller/many buyers situation. Then there are duopoly (two sellers, many buyers), monopoly with a fringe of smaller sellers, and other interesting combinations.

All of these have analogs in conflict theory. One-on-one warfare corresponds to bilateral monopoly. A tyrant-versus-subjects situation corresponds to ordinary monopoly: while the tyrant's decisions can influence citizens' choices (e.g., whether or not to rebel), no single citizen can expect to influence the overlord's choice -- how much he invests in

repression. (Yet the citizens are not 'price-takers'; there is no exchange in a pure conflict model.)

The struggle between Bolsheviks and Czarists in revolutionary Russia -- or, to take a more limited conflict, between Republicans and Democrats in the U.S. -- are analogs of market duopoly. In such cases the ordinary citizenry correspond to the passive buyers of standard duopoly theory, i.e., they are 'non-strategic' players. It may sometimes be useful to think of each side as divided between an activist leader and a passive body of followers. Then there would be two strategic players (the leaders) and two distinct groups of non-strategic players. In wartime, for example, political leaders on each side have to balance between fighting the enemy versus countering internal dissension.

With two or more strategic players, alliances become possible [Sandler (1993)]. One major type is an alliance of the strategic against the passive players. It is not too difficult to imagine Republican and Democratic leaders conspiring to pass legislation against the interests of the general citizenry. Or, a leader on one side may 'sell out' his non-activist constituency. But more familiarly, alliances are combinations of some strategic players against others. Since an ally today may be an enemy tomorrow, such combinations are often fragile. Alliance games are played not only in warfare and politics but in all the competitions of everyday life, e.g., promotion ladders in business hierarchies.

2.6. Actual versus threatened conflict

Since all settlement takes place in the shadow of conflict, threats may have a vital role in the preservation of peace. It will be useful to

distinguish between 'profitable threats' and 'unprofitable threats'.

In either case a threat aims to force the opponent to comply with the threatener's desires. If executing a threat would be profitable for the threatener, in comparison with the status quo, the opponent need have no doubt that it will be carried out. The range of possible profitable threats on each side define the 'threat point' of cooperative game theory [Friedman (1986, p. 153)]. Any achieved agreement has to be Pareto-preferred to the threat point, else one or the other side could issue a profitable threat to go its own way instead.

'Unprofitable threats' are more puzzling. Here the threat is to do something to the disadvantage not only of the threatened party but of the threatener as well. The classic example is the MAD ('mutual assured destruction') strategy intended to deter nuclear war. Once a nation has suffered nuclear attack, it might be thought there is little to be gained by retaliating. While unprofitable threats fail the test of sequential rationality, in some circumstances they might have a degree of credibility. To mention just a few: (i) It may be possible to make an irrevocable commitment ('burning your bridges behind you'); (ii) if the present interaction is linked to future possibilities, concern for reputation may make it costly not to retaliate; (iii) a contender may pretend to be, or actually be, sufficiently irrational as to retaliate regardless of profitability considerations. Indeed, any positive perceived probability of such irrationality may suffice to deter attack.[4]

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I have by no means surveyed the entire range of analytic categories that may be important in designing conflict models.[5] Others that might

have been mentioned include: (i) the effects of geography and distance [Boulding (1962, Ch. 12)]; (ii) allowing for economic growth and other changes over time, and the implications thereof for economic warfare and the sustainability of arms races [Wolfson (1985), and see Chapter 6 above]; (iii) complementarities in production and consumption between the contending parties (which serve to increase the payoff from peaceful settlement); and, a truly huge topic, (iv) the informational assumptions (are both sides fully informed, or perhaps symmetrically though not fully informed, or are there informational asymmetries?).

3. Sources of conflict[6]

While failure to come to agreement does not necessarily imply actual fighting -- the parties could simply go their own separate ways -- it is certainly a precondition for conflict. Why do parties fail to agree, and how does the conflict option affect the prospects of settlement? I shall consider three interacting determinants: preferences, opportunities, and perceptions. These correspond to traditional issues debated by historians and political scientists as to the causes of war: Is war mainly due to hatred and ingrained pugnacity (preferences)? Or to the prospects for gain at the expense of weaker victims (opportunities)? Or is war mainly due to mistakes in evaluating others' motives and capacities (perceptions)?[7]

The two panels of Figure 1 illustrate how these elements come together. On axes I_B and I_R representing Blue's income and Red's income, the curve QQ bounds the 'settlement opportunity set' -- what the parties can jointly attain by peaceful agreement or compromise. The points P_B and P_R indicate, in contrast, the parties' separate perceptions of the income

distribution that would result if they fail to agree, i.e., if they come to blows. (P_B and P_R correspond to the 'threat point' referred to earlier, but note that the parties' estimates thereof may differ.) In each diagram the curve U_B is a member of Blue's family of indifference curves, and similarly for U_R. The shaded area in each diagram is the Potential Settlement Region (PSR).

Figure 1a shows a relatively benign situation. Opportunities: the shape of the QQ boundary indicates that the parties' settlement opportunities are complementary and harmonious: both sides can gain by working together, and the largest aggregate of income is achieved when the parties have relatively equal shares. Preferences: the negatively-sloped indifference curves reveal a degree of benevolence on each side; Blue, for example, regards not only his own income as a good but Red's income as well. Perceptions: the perceived incomes in the event of failure to settle are relatively small, and also agreed (P_B and P_R coincide). These considerations combine to form a large settlement region PSR, which plausibly implies a high probability of agreement.

Figure 1b shows a less pleasant situation. The settlement opportunities are disharmonious, since relatively equal distributions of income aggregate to a smaller total than unequal distributions. (While ex-post transfers could conceivably share out the aggregate more equally, any such possibilities will already have been incorporated into the shape of the settlement opportunity set bounded by QQ.) Second, the positively-sloped indifference curves indicate malevolent preferences (the other party's income enters utility functions as a bad rather than a good). Third, the two sides have discordant and optimistic perceptions of the outcome from

non-settlement; in the event of failure to agree, each believes he will do relatively better. The overall effect is to shrink the Potential Settlement Region, making the prospects for settlement poor. (In fact, worsening on any of the three scores could eliminate the PSR completely. Settlement opportunities a bit more disharmonious, preferences a bit more malevolent, perceptions a bit more divergently optimistic -- or some combination of the three -- would make rational agreement impossible.)

Going a bit more deeply, let us start with preferences. Economists have notoriously taken 'tastes' as arbitrary data. But preferences, and in particular benevolence or malevolence toward specified others, are not totally incapable of explanation. As determinant of an individual's willingness to sacrifice for others, evolutionary biologists have emphasized genetic relatedness r -- measured by the proportions of shared genes. (For siblings $r = 1/2$, for half-siblings 1/4, for first cousins 1/8, etc.) So, it has been said, an individual 'should' be willing to sacrifice his life to save 2 siblings, 4 half-siblings, or 8 cousins! More generally, Hamilton's rule [Hamilton (1964)] says that evolution will select for actions such that:

$$b/c > r$$

where b is the benefit to recipient, c the cost to donor, and r is degree of relatedness -- benefit and cost being scaled in terms of contributions to reproductive success (RS).[8]

For interactions within and between small groups, relatedness is indeed an extremely important determinant of conflict or cooperation. Parents notoriously sacrifice more for their own children than for others' offspring. On the negative side, children are much more likely to be abused

by a step-parent than by a natural parent [Daly and Wilson (1988, pp. 86-87)]. And indeed, among animals and primitive humans, practically all cooperative association is founded upon the biological family.

In large modern economies, on the other hand, biological relatedness is hardly important at all -- among other reasons because r falls off very rapidly to negligible values beyond the immediate family. In fact, in modern times relatedness r may play on the whole an anti-social role. Reason: relatedness favors cooperation within but conflict between groups.[9] In any case, while malevolence and benevolence remain important sources of international and other conflicts even in modern times, they stem largely from cultural and ideological factors in ways not yet successfully modelled by social science.

Turning to opportunities, economists generally postulate settlement opportunity sets with the more 'harmonious' shape represented by Panel (a) of Figure 1 rather than Panel (b). This favorable situation reflects the potential benefits from specialization and joint production, especially as might be arranged through market exchange. But if exchange is not an available option, as when binding agreements are costly or impossible, these benefits may be hard to achieve by peaceful means. At the extreme, joint production might be feasible only if one side submits to a very asymmetrical distribution of the benefits, as under slavery or serfdom.

Taking up perceptions, the discussion here deals only with estimates of what might happen in the event of failure to arrive at peaceful settlement, i.e., with the location of the threat point. If these estimates were correct on both sides, and if malevolence were absent, conflict would be Pareto-dominated: a Potential Settlement Region PSR would necessarily exist.

Traditional economics tends to minimize the importance of perceptual divergences, among other reasons because incorrect beliefs are normally unprofitable and hence subject to adjustment by experience. In conflict situations as well, contenders do presumably learn from experience. The school of actual struggle teaches parties to readjust their perceptions to more realistic levels. But the same evidence teaching one side to be less confident (for example, a defeat in battle) may well teach the winning side to be more optimistic [Wittman (1979)]. The many long wars reported by history reflect the difficulty of adjusting perceptions to reality.

4. The technology of conflict[10]

As indicated earlier, a key element of the economics of conflict is choosing a balance between two distinct technologies: the familiar technology of production versus the quite separate technology of conflict and appropriative struggle.

In dealing with productive technology, economists do not concern themselves with the design of pipes, girders, beams, engines, or transistors -- these matters lie in the province of engineers and technicians. And the proper employment of technology is the task of the businessman. Our job is to analyze what might be called the <u>macro-technology of production</u>: are there increasing or decreasing returns to scale, are labor and capital complements or substitutes, and so forth. When it comes to the technology of conflict, the situation is very similar. Guns, bombs, missiles, etc. are designed by technical experts, while their proper employment is the responsibility of military leaders. (And even in non-military conflicts, there are decision-makers with corresponding roles: politicians hire speech-

writers and media consultants, litigants hire attorneys.) These practitioners are, in effect, the engineers and entrepreneurs of the conflict industry. The economist's role is not to replace these players, but rather to address the macro-technology of conflict. Increasing versus decreasing returns, economies of scale and scope, complementarity of labor and capital are as applicable in the conflict domain as in the productive domain.

In analyzing the macro-technology of conflict, one would like to have plausible functional forms analogous to the Cobb-Douglas or CES formulas of production theory. These functions would describe how 'inputs' of fighting efforts on the two sides generate 'outputs' in the form of victory or defeat, or more generally relative success. Two canonical families of such 'Contest Success Functions' have been described [Hirshleifer (1989)]. In the one family, the outcome depends upon the ratio of the fighting efforts, in the other family upon the difference.[11]

Specifically, in a two-party contest suppose each side divides its resources R_i between productive effort E_i and fighting effort F_i. For the moment we are considering only how the F_1 and F_2 determine p_1 and p_2 -- interpreted here as the proportions of the prize won in a continuum model of conflict.[12] The ratio form of the 'Contest Success Function' (CSF) is:

$$p_1 = F_1^m/(F_1^m + F_2^m) \quad \text{and} \quad p_2 = F_2^m/(F_1^m + F_2^m) \tag{1}$$

The alternative version, in which success depends upon the difference between the fighting efforts, can be written as the logistic functions:

$$p_1 = 1/[1 + \exp\{k(F_2 - F_1)\}] \quad \text{and} \quad p_2 = 1/[1 + \exp\{k(F_1 - F_2)\}] \tag{2}$$

The parameters m for the ratio form and k for the difference form

may be termed "decisiveness coefficients". They represent the degree to which greater fighting effort translates into battle success.[13] [14] As logically required, p_1 and p_2 sum to unity.[15]

Panel (a) of Figure 2 pictures the ratio version of the CSF for player 1, the fighting effort of player 2 being held constant at $F_2 = 100$. As can be seen, after a possible initial range of increasing returns, there are diminishing marginal returns throughout. Panel (b) is a corresponding picture for the difference version. Here there are increasing returns up to $F_1 = F_2$, and decreasing returns thereafter. This last feature reflects a 'stylized fact' of warfare: the great importance of being at least a little bit stronger than the enemy in the field.

It will be evident from equation (1) and Panel (a) of Figure 2 that, using the ratio version for the CSF, zero conflict effort F_i implies zero success p_i. In contrast, from equation (2) and Panel (b) of Figure 2 we see that the difference version of the CSF implies that a player investing zero F_i might still retain some positive fraction p_i of the prize. These considerations help the analyst choose one or the other version in specific applications. In litigation, for example, we would expect the ratio version to be applicable: an aggrieved party who makes no effort (fails even to file suit) has zero prospect of success, while a respondent who offers no defense must expect an adverse judgment.

In military combats the ratio form of the CSF is applicable when clashes take place under theoretically ideal conditions such as a uniform battlefield, full information, and absence of fatigue. In the more realistic case where what Clausewitz called <u>friction</u> [see Rothfels (1943, p. 103)] plays a role -- where there are sanctuaries and refuges, information

is imperfect, and even the victor is subject to disorganization and exhaustion -- a non-resisting side need not lose absolutely everything.

Despite not yet having a complete model to deal with, some inferences can be drawn intuitively about the implications of conflict technology. When decisiveness is low the parties are more likely to choose peace or, at any rate, to reduce the intensity of struggle. In domestic politics, constitutional protections for minorities reduce the decisiveness of majority supremacy, thus softening the intensity of electoral struggle. If election defeat doesn't entail deprivation of life and property, people need not invest as much effort in political contests. (While often deplored, the low voter turnout in American elections may actually signal a healthy polity.)

Economic conflict theory helps explain a major paradox of modern politics. We are so used to seeing wealth redistributed from the rich to the poor that it no longer seems surprising. Yet the half of the population above the median wealth surely has greater political strength than the half below. How can the lower half gain at the expense of the upper half, the weak defeat the strong in the redistributive struggle? The main answer -- note that I set aside sheer generosity on the part of the rich -- is that the poor have a <u>comparative advantage</u> in conflict as opposed to production. Or looking at it from the other point of view, when it comes to appropriative struggles the rich constitute an attractive target while the poor do not.

In military contests similarly, sometimes the weaker side unexpectedly 'wins', at least in the relative sense of improving upon its initial position. The Vietnam War is an evident instance. As will be seen below,

this is most likely to occur when the decisiveness of conflict is low. In Vietnam, topography and international relations combined to make for low decisiveness. (U.S. nuclear weapons could of course have been totally decisive, but diplomatic considerations precluded their use.)

On the other hand, if the decisiveness parameter is sufficiently high, i.e., if a preponderance of force makes an enormous difference for the outcome, the advantage tilts heavily to the stronger side. This corresponds to a 'natural monopoly' in the conflict industry, leading very likely to a struggle to the death -- as between Rome and Carthage, or Czarists versus Bolsheviks in revolutionary Russia.

Many other aspects of conflict technology cry out for investigation, most notably perhaps the modelling of offense versus defense.[16] But at this point I must break off in order to examine two specific models.

5. A first illustrative model -- does conflict promote equality?[17]

There is no single best or universal model of conflict, any more than there can be a universal model of an exchange economy -- one that would cover perfect competition and monopoly and their various admixtures, one-period and multi-period interactions, production under increasing and decreasing returns, conditions of symmetrical or asymmetrical information, etc. Among the indefinitely large number of modelling choices, the analyst has to select with a view toward the intended application. One conflict model may be appropriate when the parties stand in a relation of equality, another may better illustrate the struggle between inferiors and superiors in a hierarchical situation.

The model described below is designed to address the question: does

conflict make the rich grow richer and the poor poorer, or the other way about? It shows how, with variation of only a single parameter, conflictual interactions may tend either to mitigate or alternatively to exacerbate any pre-existing condition of inequality.

5.1. Elements of an economic model of conflict

All economic models have certain common features. There has to be provision for optimizing decisions on the level of the decision-makers, and a resulting equilibrium when all these decisions interact on the aggregate level. In addition, choices must be subject to some kind of resource constraint.

When we consider possible conflictual interactions in addition to the more familiar production and exchange activities, two broad generalizations tend to hold: (i) The resources devoted to productive activity mainly determine the social aggregate of income available, and (ii) the relative commitments to conflictual activity mainly determine how the aggregate income will be distributed between the parties.

An equation system reflecting these considerations has four classes of logical elements.

First, each side $i = 1,2$ must divide its exogenously given resources R_i between productive effort E_i and fighting effort F_i:

$$E_1 + F_1 = R_1 \quad \text{and} \quad E_2 + F_2 = R_2 \tag{3}$$

Second, the productive technology is summarized by an Aggregate Production Function showing how the productive efforts E_1 and E_2 combine to determine income I -- the social total available for division between the two parties. A convenient form for our purposes is:

$$I = A(E_1^{1/s} + E_2^{1/s})^s \qquad (4)$$

This type of production function is characterized by constant returns to scale and constant elasticity of substitution. Parameter A is a total productivity index: as the overall yields of the resource inputs rise over time, owing to technical progress, A increases. Parameter s is a complementarity index: as nations become more closely and synergistically linked, for example by international trade, s rises.[18]

The third element is the Contest Success Function (CSF), the ratio form being used here:

$$p_1 = F_1^m/(F_1^m + F_2^m) \quad \text{and} \quad p_2 = F_2^m/(F_1^m + F_2^m) \qquad (5)$$

The CSF summarizes the technology of conflict: the inputs are the fighting efforts F_1 and F_2 and the outputs are the distributive shares p_1 and p_2 (where of course $p_1 + p_2 = 1$).

Finally, there are Income Distribution Equations defining the achieved income levels I_1 and I_2:

$$I_1 = p_1 I \quad \text{and} \quad I_2 = p_2 I \qquad (6)$$

Equations (5) and (6) together imply that all income falls into a common pool available for capture by either side. (More generally, the contenders might also have opportunities for generating invulnerable income, but this consideration is set aside here.)

5.2. Optimization and Cournot equilibrium

On the assumption that the underlying strategic situation justifies the Cournot solution concept, the Reaction Curves RC_1 and RC_2 of Figure 3 illustrate each side's optimal fighting effort given the corresponding choice on the part of the opponent. The Cournot solution occurs at the

intersection where each party's decision is a best response to the opponent's action.

Decision-maker 1's optimizing problem can be expressed:

$$\text{Max } I_1 = p_1(F_1|F_2) \cdot I(E_1|E_2) \quad \text{subject to} \quad E_1 + F_1 = R_1 \tag{7}$$

and similarly for side 2. Using equations (5) and (6), and assuming interior solutions ($F_i < R_i$), we can solve for the Reaction Curves RC_1 and RC_2:

$$\frac{F_1}{F_2^m} = \frac{m(E_1 + E_2)}{F_1^m + F_2^m} \qquad \text{and} \qquad \frac{F_2}{F_1^m} = \frac{m(E_1 + E_2)}{F_1^m + F_2^m} \tag{8}$$

Note that the parameter A of the Aggregate Production Function has cancelled out and does not enter into the Reaction Curve equations at all. Thus, in this model an increase in overall economic productivity leaves the proportionate allocation of resources between producing and fighting unchanged. Intuitively, an increase in A raises the marginal profitability of productive activity and of conflictual activity in the same proportion.[19]

There is no convenient general analytical solution, but in the <u>symmetrical</u> case where resource endowments are equal (that is, when $R_1 = R_2$), for any s the equilibrium is simply:

$$F_1 = F_2 = Rm/(1 + m) \tag{9}$$

Thus the fraction of the available resources dissipated in mutually wasteful fighting effort rises for higher values of m; at $m = 1$, exactly half the resources on each side are so dissipated.

Such an equilibrium is illustrated in Figure 3. The inner pair of Reaction Curves RC_1° and RC_2° and their intersection correspond to a symmetrical situation with resources $(R_1,R_2) = (100,100)$ and parameter

values $A = s = m = 1$. From equation (9), half the endowments on each side are dissipated in conflict: $(F_1, F_2) = (50,50)$. The remaining resources are put to productive use: $(E_1, E_2) = (50,50)$. These generate an aggregate income of $I = 100$, which is then equally divided between the contenders: $(I_1, I_2) = (50,50)$.

5.3. Resource disparities: The paradox of power

The paradox of power (POP) emerges when a preponderant resource ratio $R_1/R_2 > 1$ is not reflected in a correspondingly large achieved income ratio I_1/I_2. I shall be examining strong versus weak forms of the paradox:

POP (strong form): In mixed conflict-cooperation interactions, the contending parties end up with exactly identical incomes $(I_1/I_2 = 1)$ regardless of the initial resource ratio R_1/R_2.

POP (weak form): In mixed conflict-cooperation interactions, the final distribution of income will have lesser dispersion than the initial distribution of resources. Thus, assuming contender 1 is initially the better-endowed side: $1 < I_1/I_2 < R_1/R_2$.

Returning to Figure 3, the dashed curves RC_1' and RC_2' represent an asymmetrical endowment situation: in comparison with the solid curves RC_1° and RC_2°, 1's resources R_1 have now doubled in size while 2's remain as before. Despite the resource asymmetry, at the intersection of the RC_1' and RC_2' curves the fighting efforts F_1 and F_2 -- though both larger than before -- remain equal to one another! It follows, of course, that the richer party must now be devoting absolutely and relatively more resources to productive effort. The equality of F_1 and F_2 dictates that the final

incomes remain equal: $(I_1,I_2) = (75,75)$. This illustrates the strong form of the paradox of power.

An intuitive interpretation is as follows. With an increase in endowment, contender 1 (he) will surely want to spend more on each of the two types of activity: his E_1 and F_1 will both be greater. Knowing this, side 2 (she) then has both offensive and defensive incentives to shift toward spending more than before on fighting (choosing a larger F_2), which necessarily means spending less on production (her E_2 must be smaller). The offensive incentive for making F_2 larger is that, E_1 being greater, there is more social income available to be seized. Her defensive incentive is that, the opponent's F_1 being greater, she would have to choose an F_2 larger than before even if only to maintain her previous level of income.

Conflict is therefore a relatively more attractive option for the poorer side.[20] Fighting effort permits you to "tax" the opponent's production, while your own production is "taxed" by his fighting effort. When your rival is richer it becomes relatively more profitable to tax him (to capture part of his larger production) and relatively more burdensome to be taxed by him (to devote effort to production which will be largely captured by him anyway). Thus rational behavior in a conflict interaction, under the assumptions here, is for the poorer side to specialize more in fighting, the richer side more in production.

However, this qualitative argument supports only the weak form of the paradox of power, whereas the numerical data above illustrated the strong form: incomes on the two sides remained exactly equal despite initial resource disparities. It turns out that the strong form holds only for the limiting case of $s=1$ (zero complementarity in production).

Figure 4 shows the results of a number of simulations with the decisiveness coefficient set at $m = 1$, and assuming positive complementarity (specifically, $s = 1.25$), over a range of resource ratios R_1/R_2. As this resource ratio grows, the richer side's success fraction p_1 does rise, but only quite slowly. The reason: consistent with the preceding discussion, as the resource ratio becoming more favorable the richer side will be devoting relatively less and less effort to fighting -- as shown by the rapidly declining F_1/R_1 curve. The opposite of course applies for the poorer side.

The effect upon relative incomes is shown in Figure 5, in particular the curve labelled $I_1/I_2(m=1)$. This curve is rising, but only very slowly in comparison with the resource ratio R_1/R_2. Hence, the paradox of power continues to hold, but in its weak form.

5.4. <u>When conflict becomes more decisive</u>

Figure 5 shows also that, even in the weak form, the paradox of power does not <u>always</u> hold. The decisiveness coefficient m in the Contest Success Function is the key. For $m = 4$, we can see, the income ratio I_1/I_2 does ultimately rise faster than the resource ratio R_1/R_2.

<u>Conclusion</u>: Whether conflict interactions are equalizing or non-equalizing depends upon two countervailing influences. On the one hand the rich <u>can afford to</u> devote more effort to fighting, on the other hand the poor <u>are motivated to</u> fight harder. The balance between the two influences is determined by the decisiveness parameter m. When conflict is only moderately decisive, the second factor overshadows the first, and conflict is equalizing: the eventual achieved income ratio is closer to unity than

the initial resource ratio. But when conflict is extremely decisive, the rich can so easily buy a higher success fraction that they find it advantageous to do so: the rich do become richer and the poor poorer.

While the analysis needs to be extended beyond the single time-period described here, it is evident that a suggestive basis has been provided for explaining the steepness of the hierarchy gradient in different societies.[21]

6. A second illustrative model: armed settlement under threat

I shall more briefly summarize a second model, aimed at a different question: specifically, can <u>threatened</u> fighting succeed in maintaining peace?

Consider two symmetrically situated contenders. As before each side will be choosing a level of fighting effort F_i. But here I will be slighting the productive aspect of the interaction between the parties. Instead, I simply assume a fixed prize of value V, to be divided between the two in accordance with the ratio version of the Conflict Success Function (CSF) in equation (1). Thus, side i will be maximizing:

$$I_i = p_i V - c(F_i) \tag{10}$$

where $c(F_i)$ is the cost function for fighting effort. For utmost simplicity here, let $c(F_i) = F_i$.

The special feature of this threat model is that in the first round the players simultaneously commit to some chosen F_i, <u>but currently lay out only some proper fraction γ of the cost thereof.</u> Thereafter, these commitments are mutually revealed and the players proceed into a second round in which they simultaneously choose whether or not to Attack. Play then ends and

payoffs are received.

The payoffs of course vary depending upon whether there is war or peace. Suppose neither side attacks. Then there is peace and, by assumption, each side receives half the prize (V/2), i.e., the success fractions are .5 each. Furthermore, given peace the contingency requiring additional military expenditures does not obtain, hence only the 'down payment' costs γF_i are ever incurred. So, peace is very attractive. On the other hand, if <u>either</u> side attacks (or if both do) there is war. The contingent commitments then translate into the full pre-committed expenditures and fighting efforts F_i. The success fractions p_i are determined as before by the CSF, and the associated incomes I_i are generated in accordance with equation (10).

Figure 6 illustrates the solution. The dashed Reaction Curves RC_1 and RC_2 are generally similar to those in Figure 3. They show each side's best fighting response, in the event of war, to the whole range of the opponent's possible F_i choices. However, the solid curves picture a new aspect of the situation. Consider contender 1's solid curve RC_1'. There will be some critical opponent's F_2^* such that he would be indifferent between an optimal fighting response along his dashed RC_1 curve <u>or</u> having made an $F_1 = 0$ commitment and having peace obtain. Below this critical level, at any $F_2 < F_2^*$, war would be profitable; he would attack even if 2 preferred peace. And conversely, for any F_2 greater than F_2^*, he would strictly prefer $F_1 = 0$ under conditions of peace. The solid curve labelled RC_2' is the corresponding construction for contender 2.

The two solid RC_i' curves intersect along their respective vertical and horizontal legs, specifically at $F_1 = F_1^*$ and $F_2 = F_2^*$. Furthermore,

owing to the assumed symmetry, $F_1^* = F_2^*$. This suggests that the (F_1^*, F_2^*) combination might be the Nash-Cournot equilibrium first-round choices, followed by second-round choices for peace.

We are not yet entitled to draw this conclusion, however. We need to know whether the parties' having chosen $F_1^* = F_2^*$ in the first round is indeed consistent with a mutual preference for peace in the second round. However, recalling that war takes place if either side attacks, Table 1 demonstrates that DON'T ATTACK is a (weakly) dominant strategy for both. The crucial point is that, if war occurs after the parties have made symmetrical commitments in the first round, each side would get half the value of the prize less fighting costs -- whereas under conditions of peace each still receives half the prize while incurring only the fraction γ of the fighting costs.

So the equilibrium strategy for contender 1 has the following features:

In the first round: choose $F_1 = F_1^*$;

In the second round: (i) if contender 2 in her first round had chosen $F_2 < F_2^*$, then ATTACK; (ii) if contender 2 had chosen $F_2 \geq F_2^*$, then DON'T ATTACK.

If 2 adopts the corresponding strategy, these are mutually best responses to one another and hence constitute a Nash equilibrium consistent with sequential rationality.

Conclusion: First-round choices that adequately and symmetrically prepare for war, can maintain the peace![22]

Implicit in the payoffs of Table 1 is the assumption that the relevant military technology provides no advantage for attacking over defending (or vice versa). Without providing the details here, it is evident that any

offensive advantage would raise the attractiveness of ATTACK in the second round and thus tend to destabilize the equilibrium. A defensive advantage would, correspondingly, make the equilibrium more robust.

Turning to a more general issue, it might be asked to what extent this model of maintained peace undercuts all the preceding analysis premised upon the existence of war. If peace is a Nash-Cournot equilibrium, how does war ever come about?

This question brings us full circle back to Section 3. The discussion there indicated that malevolent preferences, disharmonious opportunities, and optimistic perceptions (of the returns from conflict) all tend to reduce the size of the Potential Settlement Region (PSR), or may even eliminate it completely. Applied to the model of this section:

Malevolent preferences: These mean, essentially, that a party would be willing to pay something to reduce the opponent's income. That is not the case in the model here, which presumes neutral preferences. Malevolent preferences would lessen the payoffs (in utility units) of DON'T ATTACK relative to ATTACK second-round choices, thus obviously increasing the likelihood that one or both sides would choose ATTACK instead.

Disharmonious opportunities: When opportunities are harmonious, peaceful payoffs on the two sides are positively correlated. That certainly applies to the model of this section, since peace means that both parties can avoid expending the fraction $1-\gamma$ of the fighting commitments. Suppose instead that the value of the entire prize had to go entirely to one side or the other -- no sharing allowed. If so, opportunities would be much less harmonious, greatly increasing the

likelihood of war.

Optimistic perceptions: In the model of this section full information (accurate and agreed perceptions) was assumed. Any optimistic bias as to the outcome of conflict would of course increase the likelihood of ATTACK. We also saw, however, that an offensive advantage in military technology could lead to a kind of warranted optimism about the consequences of initiating conflict. This factor can evidently also destabilize the 'armed peace' equilibrium.

Thus, this section did not prove there has to be peace, any more than the previous discussions demonstrated the inevitability of war. Before jumping to any such conclusions about the real world, it will always be necessary to take account of the limitations of the model employed. These limitations include not only the assumptions about preferences, opportunities, and perceptions just mentioned above but also the many other specific modelling postulates: e.g., that each side is a unitary actor, that a one-time decision is to be made, etc. Nevertheless, handled with tact and caution, this and others of the theoretical models here described have suggestive implications not only for warfare but for conflict realms such as redistributive politics, animal dominance hierarchies, and family disputes.

7. Concluding remarks

Conflict theory is not a mere peninsula barely connected to the mainland of economic analysis. Even less is it only an assemblage of loosely similar topics like crime, strikes and lockouts, and litigation. Rather, I have maintained, microeconomics should be regarded as having two main branches: one dealing with the search for mutual advantage by means of

exchange, the other and relatively neglected branch dealing with the pursuit of one-sided advantage through conflict.

Common to both branches are the standard elements of economic reasoning: (1) on the level of the decision-maker, optimization subject to resource constraint and (2) on the aggregate level, determination of an equilibrium balancing and integrating these separate private decisions. In standard theory, such an equilibrium must (subject to the usual qualifications) satisfy Coase's Theorem. In conflict theory the analogous proposition might be called Machiavelli's Theorem (Hirshleifer [1994]). Coase's Theorem says that, in equilibrium, no-one will ever pass up an opportunity for mutually advantageous exchange; Machiavelli's Theorem says that no-one will ever fail to capitalize on a profitable opportunity to exploit anyone else.

Also common to both main branches of economic analysis are the ordinary processes of production, whereby resource inputs are converted to desired goods. Superimposed upon this, conflict theory introduces a technology of combat and struggle. In the latter process, 'inputs' consisting of the fighting efforts on all sides generate 'outputs' in the form of a final distribution of resources and income.

There is one other implication I want to emphasize: the broadened microeconomics that integrates conflict theory and exchange theory is essentially coextensive with social science as a whole! The revolutions and electoral campaigns now studied by political scientists, the resource competitions and mating strategies dealt with by social biologists and anthropologists, crime and social cohesion as investigated by sociologists -- none of these topics should be out of bounds for economic analysis.

In sum, there really is only one social science. Furthermore, the analytical categories of economics -- scarcity, cost, preferences, opportunities, equilibrium, etc. -- constitute a universal grammar for dealing with all social processes. Most of the excellent works by biologists, political scientists, anthropologists, etc. cited elsewhere in this paper illustrate successful use, conscious or unconscious, of these economic techniques. As economists come to appreciate this broadened conception of their mission, we can expect benefits to flow both ways. Not only will we be 'exporting' our analytic methods, but insights from other social sciences about the nature of man and of social interactions will help us better understand even our traditional topics of optimizing behavior and market equilibrium.

Endnotes

1. Baik and Shogren (1994) have conducted an experimental investigation of such an 'endogenous timing' model.

2. Though some people may enjoy bar-room brawls for their own sake.

3. As a major exception, the prospect of a continuing mutually advantageous association between the parties does provide a motive for not defecting from a current agreement. But this mutual forbearance is subject to the well-known last-period problem, and even on other grounds tends to be rather fragile. See, e.g., Telser (1980).

4. For a related idea in a more general context, see Kreps et al (1982).

5. Intriligator (1982) attempts to provide a systematic survey, though limited to war, threatened war, and preparation for war.

6. This discussion expands upon portions of Hirshleifer (1987).

7. While my terminology suggests a dichotomy between conflict and settlement (see Section 2), this is only an expository short-cut. In a continuum model, the chosen intensities of fighting efforts would similarly be determined by the parties' preferences, opportunities, and perceptions.

8. An individual's reproductive success (RS) is measured by the number of his/her genes carried by the next generation. Since relatedness r between any two persons is fixed, Hamilton's rule implies that 'evolutionary indifference curves' on reproductive success axes have to be straight lines. But straight-line indifference curves on RS axes translate to normally convex indifference curves on income axes, given diminishing returns in the connection between income and reproductive success.

9. See Wilson (1978). In evolutionary terms, Hamilton's formula in the

simple form above is applicable only where the sum of costs and benefits is unrestricted. If competition constrains their net total, an adjustment is called for. Under sufficiently severe competitive constraints, to maximize reproductive success an individual 'should' help only those more closely related to him than the average in the population -- and 'should' act to hurt all others! [See Hamilton (1970), Hirshleifer (1978).]

10. This section is based in part upon Hirshleifer (1994).

11. For a somewhat related categorization in terms of logit and probit functions, see Dixit (1987).

12. in a dichotomy model, the p_i would be interpreted as the respective probabilities of victory.

13. It would be possible to generalize these equations in various ways, for example by attaching 'combat efficiency coefficients' to the respective fighting efforts F_i.

14. Skaperdas (1994) has shown that these ratio and difference forms are the only two possibilities meeting all the plausible criteria appropriate for a Contest Success Function, for example that p_1 be rising with F_1 and falling with F_2, that $p_1 + p_2 = 1$, and so forth.

15. If the p_i are interpreted as proportions of the prize, it would be possible to adjust for battle destruction by writing $p_1 + p_2 + \delta = 1$, where $\delta(F_1,F_2)$ is the non-negative fraction of the prize destroyed. Fighting will evidently be less profitable for both sides, the higher is δ. For present purposes, the assumption $\delta = 0$ will be maintained.

16. Approaches to this deceptively difficult problem have been suggested in various ways by Skogh and Stuart (1982), Powell (1993), and Grossman and Kim (1994).

17. This section is adapted from portions of Hirshleifer (1991).

18. Values of s below 1 have the unacceptable implication that the marginal products of productive input are increasing throughout.

19. The result would be quite different if the difference version of the CSF, as in equation (2), had been employed. In that case an overall productivity improvement would redound to the relative benefit of the richer contestant, who can then more easily afford to increase the absolute size of his fighting effort.

20. Compare Becker (1983, p. 385): "Politically successful groups tend to be small relative to the size of the groups taxed to pay their However, Becker employs an entirely different line of reasoning to arrive at this result.

21. See Vehrencamp (1983) for an application to animal dominance hierarchies, and Betzig (1992) for a somewhat parallel analysis of human societies.

22. Somewhat analogous results have been obtained, though by quite different techniques, by deterrence theorists, e.g., Intriligator (1975).

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Table 1: Second-round Payoffs after First-round (F_1^*, F_2^*) Choices

	DON'T ATTACK	ATTACK
DON'T ATTACK	$V/2-\gamma F_1^*,\ V/2-\gamma F_2^*$	$V/2-F_1^*,\ V/2-F_2^*$
ATTACK	$V/2-F_1^*,\ V/2-F_2^*$	$V/2-F_1^*,\ V/2-F_2^*$

LIST OF FIGURES

Figure 1

(a) Large Potential Settlement Region (PSR)

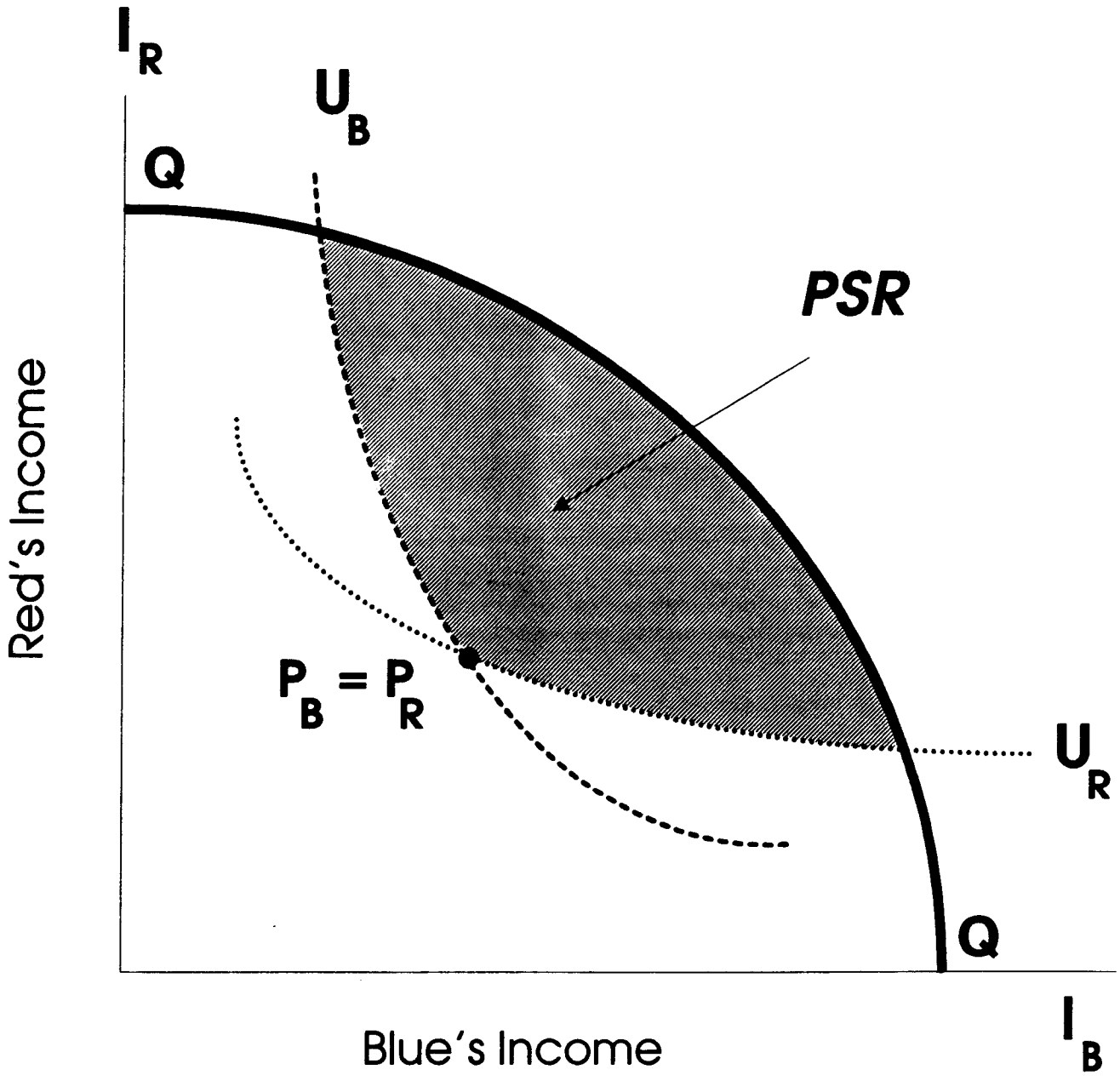

Figure 1

(b) Small Potential Settlement Region (PSR)

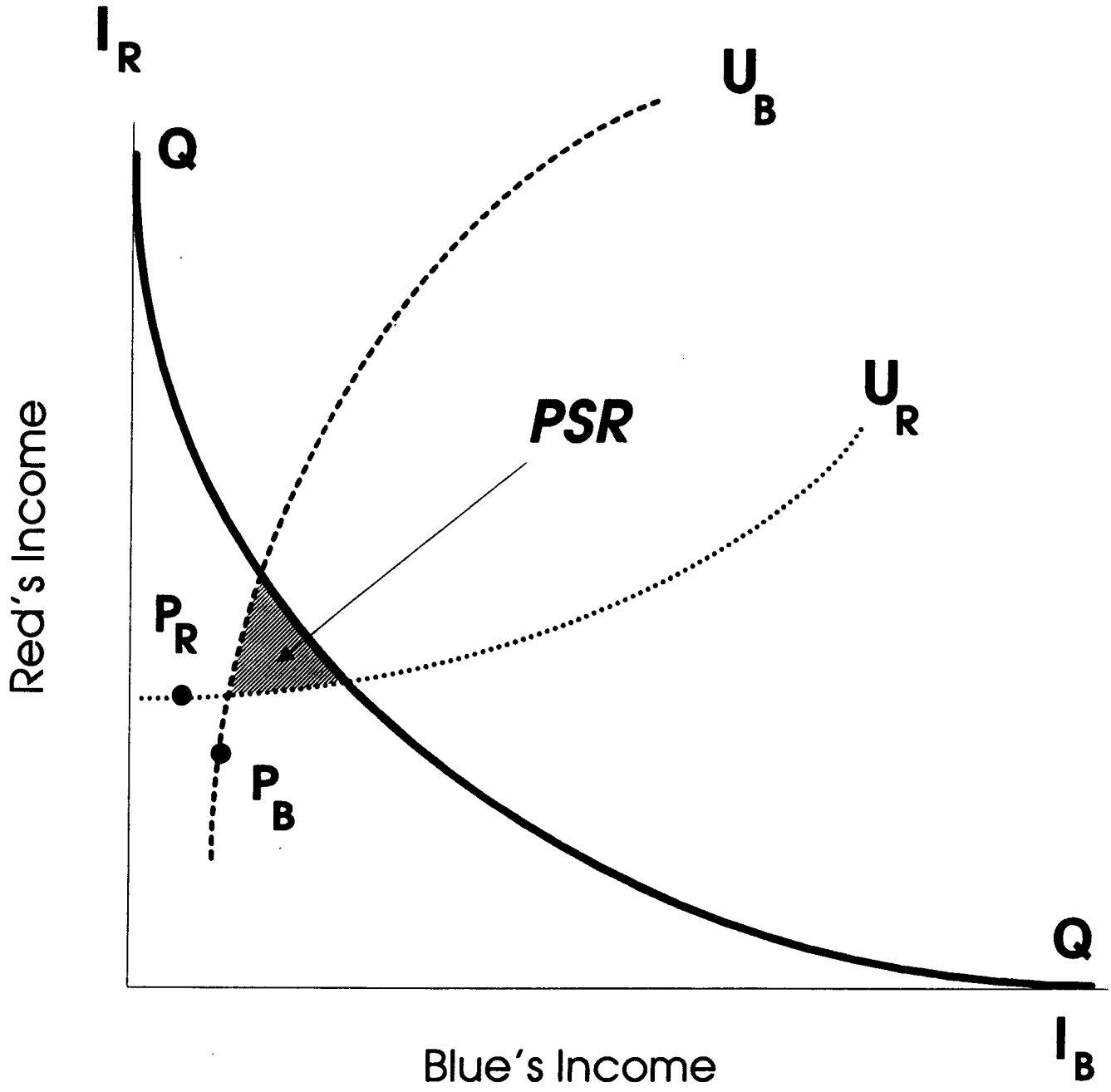

Figure 2

(a) Contest Success Function -- Ratio Form

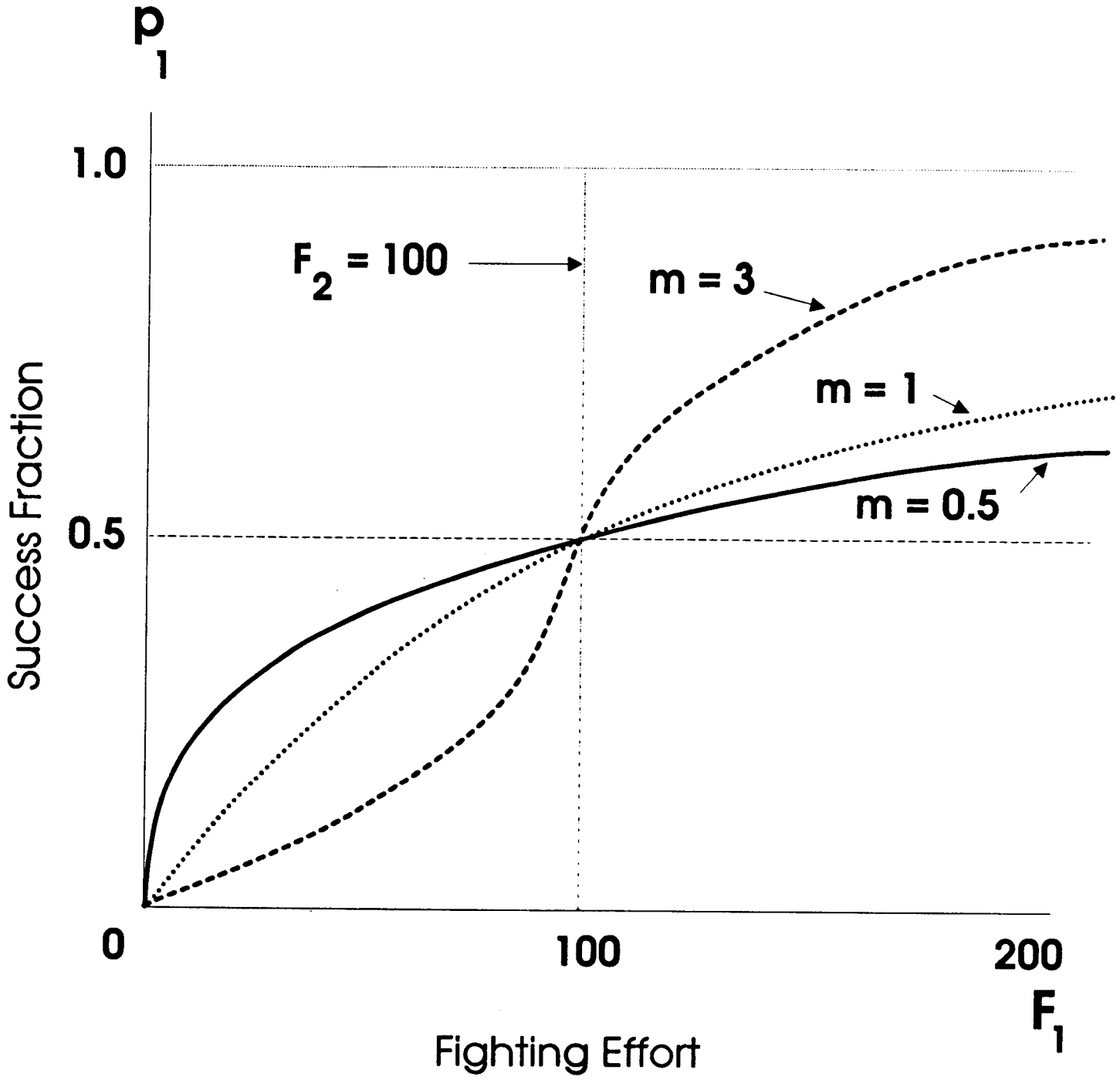

Figure 2

(b) Contest Success Function -- Difference Form

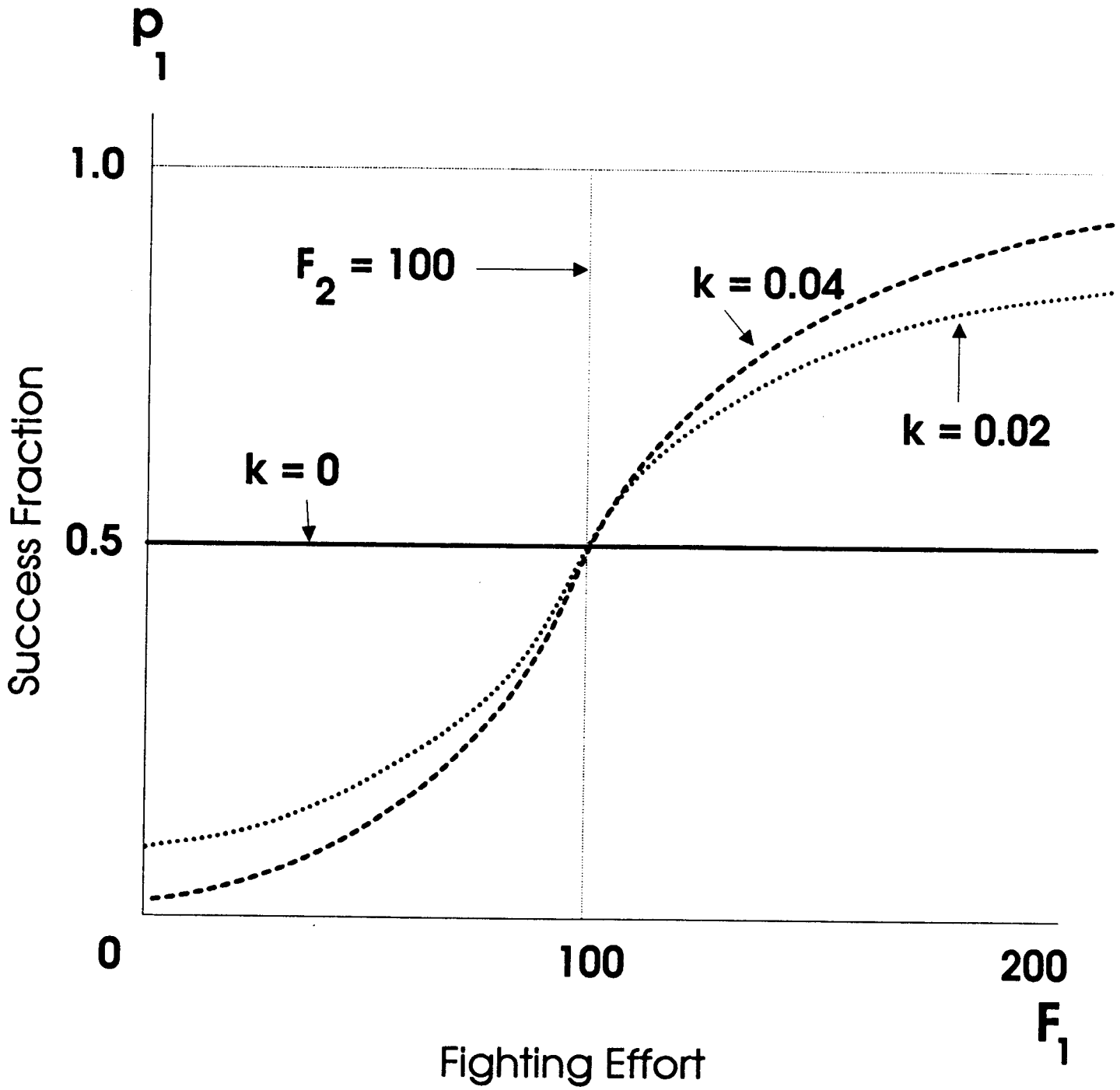

Figure 3

Reaction Curves -- First Model

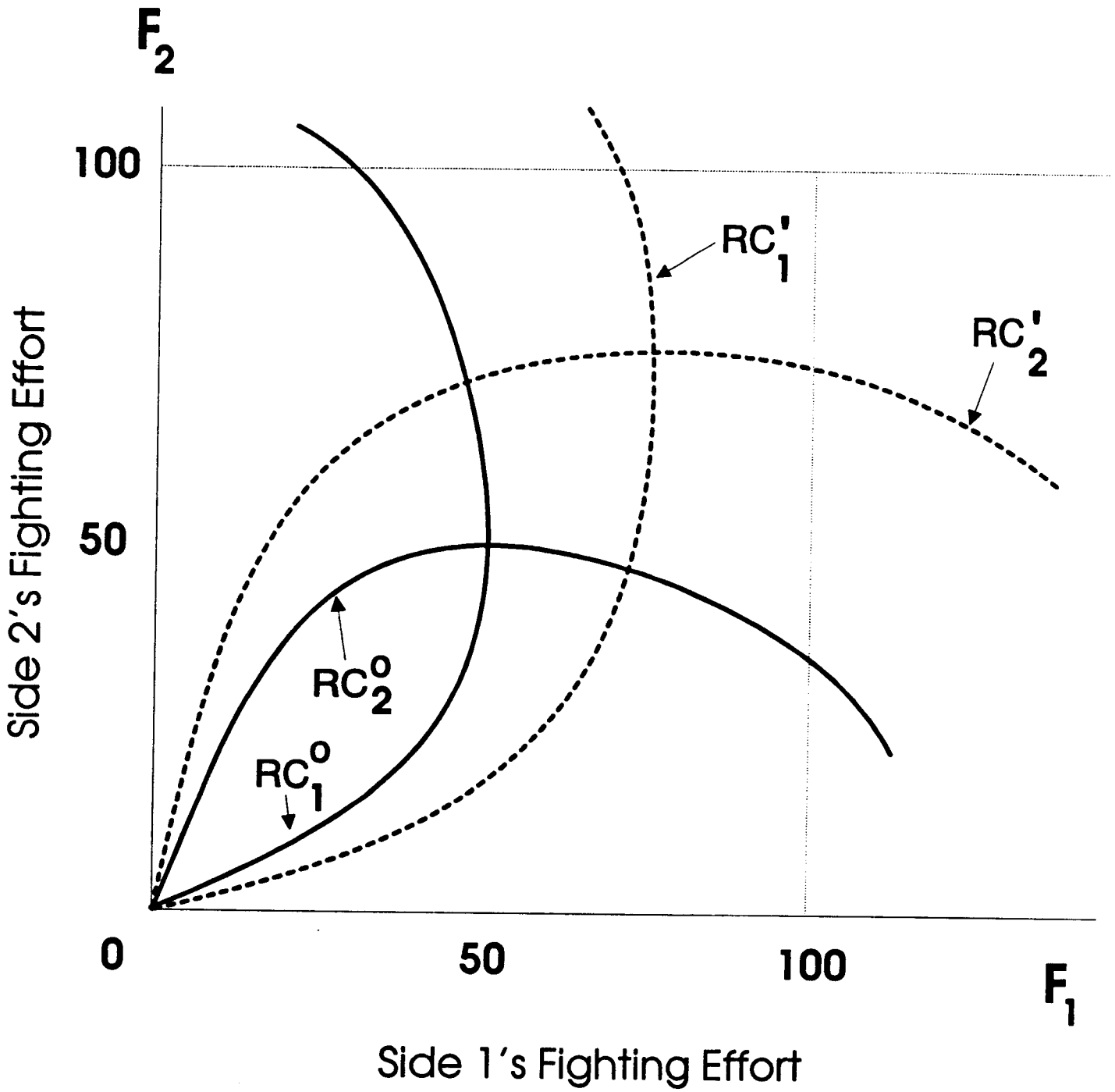

Figure 4

Fighting Efforts and Relative Success
as Resource Ratio Varies (s=1.25, m=1)

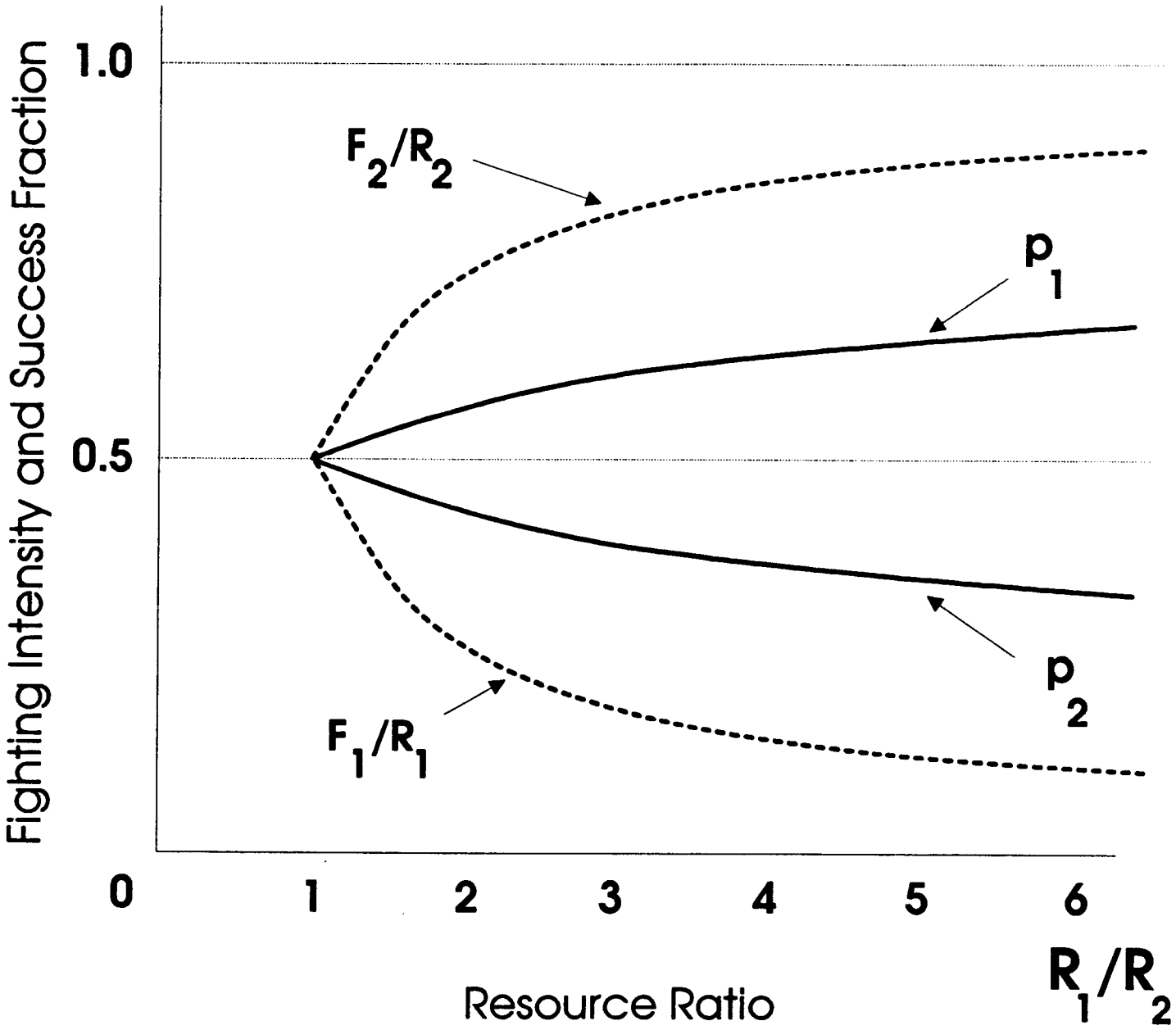

Figure 5

Income Ratio versus Resource Ratio,
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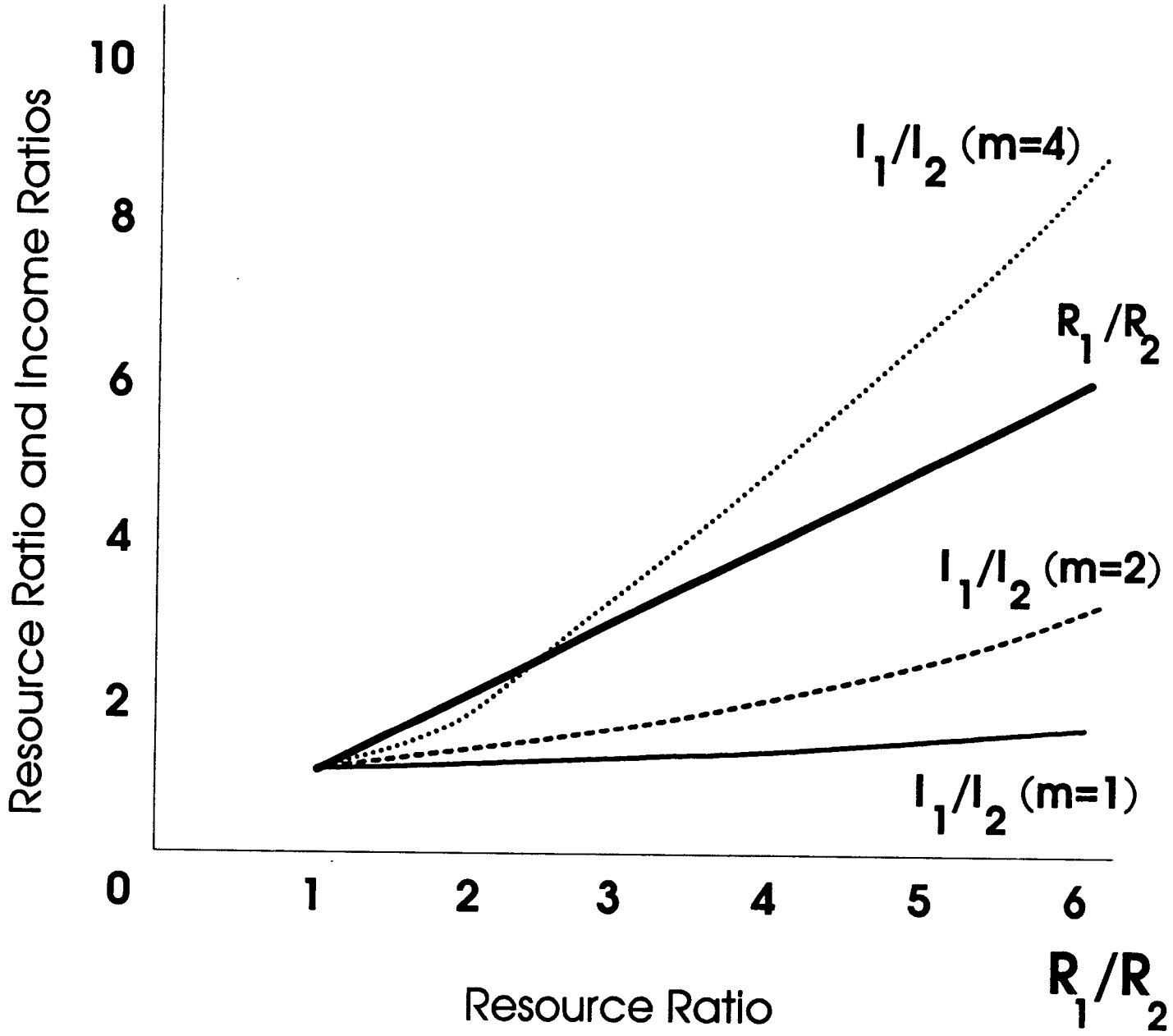

Figure 6

Reaction Curves -- Second Model