EVOLUTIONARY MODELS IN ECONOMICS AND LAW:

COOPERATION VERSUS CONFLICT STRATEGIES

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Attempting to address the combined topics of economics, law, and evolution in a single paper is _hubris_ indeed. All the more so, as I will be adopting very broad interpretations of what we might mean by both economics and law. Economics, as understood here, is _not_ limited to selfish, rational "economic man" interacting with his fellows only through impersonal market relationships. For my purposes, all human motivations and interactions constitute the subject matter of economics, so long as they respond to the pervasive fact of resource scarcity. As for law, I shall take that term as covering essentially all modes of _coercive social control_ of behavior, thus including much of what might conventionally be considered under the headings of politics or sociology. However, the evolutionary standpoint sets some bound upon the field of discussion. Also, I will be considering only one aspect of interpersonal interactions -- though that is perhaps the most important of all -- to wit, the determinants of _cooperation versus conflict_ in human affairs.

I. ECONO-LEGAL THINKING AND THE MISSING TREND TOWARD HARMONY

In recent years there has been growing intellectual interchange between legal and economic scholars. The dominant influence, it seems fair to say, has been economics -- in the sense that economic propositions have been borrowed or applied to provide new or more fundamental explanations of certain legal phenomena.[1] The influential economic ideas in question, together with their seeming legal implications, can be stated rather baldly (shorn of needed qualifications and possible adornments) as follows:

1. (Smith's Theorem)[2] Voluntary exchange is mutually advantageous for participants. Implication: The law ought, presumptively at least, to promote trade -- negatively, by removing artificial legal barriers, affirmatively, by facilitating and enforcing private exchange agreements.

2. (Coase's Theorem)[3] All available mutually advantageous exchanges will be voluntarily undertaken by the parties involved. Even where individuals impose what are said to be "external" injuries upon others, as when an upstream user of water degrades the quality of the flow to a downstream user, a resolution of the conflict will tend to take place through the exchange process. This conclusion does not depend upon the initial assignment of property rights, provided the entitlements are well-defined. If the upstream user has the legal right to degrade quality, the downstream party can offer him compensation for not doing so.

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[1] But professionals in both fields, most notably the double-threat economist-legist Posner (see especially [1977]), have contributed to these developments.

[2] Adam Smith, The Wealth of Nations, Book I, Ch. 2.

[3] Coase [1960].

If on the other hand the downstream user has a legal right to unimpaired quality, the upstream party can purchase the other's tolerance of damage. Either way, the upstream use will continue to take place if and only if it can "pay its way" in comparison with the downstream damage. Given such an assignment of property rights, and if there are no "transaction costs," the final outcome will be efficient (in a sense to be made more precise below). Implication: In addition to removing artificial barriers to transactions, the law ought to assign well-defined property rights to all resources of economic value. And if transaction costs (barriers to exchange) are absent, the law need not otherwise concern itself with regulating "external" damage.

3. (Posner's Theorem)[1] Where unavoidable transaction costs (i.e., barriers other than those due to the law itself) preclude achievement of a fully efficient result by private negotiation, some particular initial assignments of property rights may constitute or lead to more nearly efficient outcomes than others. Implication: Recognizing the presence of unavoidable transaction costs, the law ought to choose the most efficient of the possible assignments of property rights.

I have in each case stated the seeming legal implication in normative terms, the operative phrase being: "The law ought to..." An alternative positive interpretation would be indicated by the assertion: "The law will in fact tend to...." In its normative version, this entire line of econo-legal thinking might be summarized: "Market transactions among individuals operate in the direction of economic efficiency, and the law ought to aid

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[1]Posner [1977]; see also Calabresi [1961].

and where necessary supplement this trend." The positive version would go: "Market interactions tend toward economic efficiency, and the law will in fact tend to assist and supplement this tendency."

On either interpretation, a generally Panglossian aura surrounds the entire discussion. In the positive version, it would seem, we scholars need only chronicle the unfolding harmonious progress of law and economy toward the best (most efficient) of all possible worlds. The normative version of the argument, while it suggests some doubt as to the matter (why else concern ourselves with what ought to be done?), has the offsetting advantage of providing a more muscular role for savants like us. Whatever blemishes may mar its present complexion, the law can be improved, and we are the ones who know how to do so! Indeed, it seems reasonable to suppose, as scholarly understanding advances and as education of the public broadens and deepens over time, the various mistaken ideas that have in the past interfered with sound econo-legal thinking should have decreasing sway.

I have injected a note of sarcasm, for we know that there must be something seriously wrong with this picture. On the most fundamental matter, the rule of law has always fallen short of universal coverage of mankind. The potential mutual gains from cooperation have not abolished war, crime, or politics. Turning to less cataclysmic though still momentous issues, the advanced systems of law that are the proud possessions of Western nations have in fact been changing for at least a century in directions that are on the whole pernicious from the viewpoint of economic efficiency. Rather than increasingly supportive of property and exchange, the trend has clearly been in the direction of harassment, increasing uncertainty, and even confiscation. Parallel developments taking place in other aspects of

life -- rising crime rates, increasingly grave race-class conflicts, growing
political polarization -- suggest that these pernicious legal trends are due
not simply to errors in the design of laws, but rather to deeper social
realities. The forces promoting harmonious reciprocal exchanges among
individuals, and leading toward legal structures supporting and facilitat-
ing such exchanges, are evidently weaker than recent econo-legal thinking
might have led us to suppose. The central thrust of this paper will be an
attempt to see how far this unfortunate fact is explained by evolutionary
theory.

Evolutionary ideas are relevant to our question, of the scope of
harmonious interaction among men, in two main ways. First, as regards the
nature of man. What capacities for cooperation or for conflict lie innate within
members of the human species, either as universal tendencies of life or
as the particular results of the evolution of mankind? In short, are we
humans essentially fighters or lovers? Second, as regards social institu-
tions. Whatever the intrinsic pattern of individual human drives may be,
the overall outcome is also a function of the social constraints regulating
personal interactions. Adam Smith's principle of the Invisible Hand[1] has
shown us how even selfish individuals may be led by appropriate social
institutions to cooperate to their mutual advantage. Conversely, even
selfless generosity may sometimes be subverted for lack of supportive
social arrangements. The first element, our innate makeup, consti-
tutes a background which has been largely constant over the evolutionarily
brief span represented by the historical experience of mankind.

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[1] The Wealth of Nations, Book IV, Ch. 2.

Furthermore, it is also largely uniform over the human species. The second element, the institutional or cultural foreground, is in contrast highly volatile over historical time and amazingly varied among different human societies. Both elements are essential for understanding the prospects for and limits upon cooperative versus conflictual interactions among men.

II. EFFICIENCY

It is time to address the problem of "efficiency," to ask whether this concept is robust enough to bear the weight placed upon it in recent econo-legal thinking.

The root idea is Pareto-preference. A social configuration Γ is said to be Pareto-preferred to another social configuration Ω if no affected member of the society prefers Ω to Γ, and at least one member actually prefers Γ. (As we shall see, the proper interpretation to be placed upon "affected" raises difficulties, but let us set this problem aside for the moment.) Any voluntary transaction, if the participants can be assumed to be rational, leads to a Pareto-preferred outcome. In particular, since an act of voluntary exchange is mutually beneficial (the "Smith Theorem"), its outcome is Pareto-preferred to the pre-exchange situation -- provided no other members of the society are adversely "affected" thereby. Furthermore, rational decision-makers will eventually execute all mutually advantageous transactions available to them. The final outcome, when there are no further opportunities for mutual gain, is called Pareto-efficient. Note that only a small subset of the outcomes that are Pareto-preferred to some initial situation are Pareto-efficient (i.e., leave no room for further improvement in the way of mutual gain). Conversely, there will generally be Pareto-efficient configurations that are not Pareto-preferred to some particular initial situation. That is, there may be outcomes which could not be improved upon (in terms of mutual gain) once arrived at, but which are not achievable by mutually advantageous transactions from a given specified starting-point. Nevertheless, the "Coase theorem" asserts, any starting-point will eventually lead to some Pareto-efficient outcome -- if existence of property rights and absence of transaction costs permit unrestricted exchange.

Practically all important social issues, however, involve comparisons among situations that cannot be ranked by Pareto-preference considerations. That is, almost always, social changes make some parties better off but others worse off. This even holds for "voluntary" exchange, since in general third parties will be affected thereby. Suppose that women were previously barred from some line of employment, and now the barrier has been removed. The females who enter that line of employment gain from the increased scope of exchange, as do their employers. But the previously protected (male) employees will be adversely affected, yet do not have any legal entitlement to retain their old terms of employment. It is a standard proposition of economics that such "pecuniary externalities" balance out in aggregate value terms. The loss to the male workers (of receiving a lower wage) is exactly counterbalanced by the gain to their employers (in not having to pay a higher wage). Nevertheless, absent compensation it remains true that some parties are now worse off; removal of an artificial barrier to trade is thus not in general a strictly Pareto-preferred change.

To get around this difficulty, the concept of "potentially-Pareto-preferred" (PPP) social changes has been proposed.[1] Suppose everyone's well-being could simply be scaled in terms of the amount of pie he consumes. Then any way of increasing the overall size of society's aggregate pie meets the PPP criterion. For, a larger pie can potentially be redivided so that everybody gains (or, at least, so that some gain while nobody loses). Put more generally, the PPP criterion is satisfied by any change such that the gainers could (even if they do not) compensate the losers. Any such change is, in

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[1]Also known as the "Kaldor criterion" (Kaldor [1929]).

the modern econo-legal literature, called a movement in the direction of "efficiency." A final position in which no such PPP changes remain to be made is called simply "efficient."

In terms of changes from an arbitrary initial position, not every potentially Pareto-preferred change (movement in the direction of efficiency) will generally be strictly Pareto-preferred. In particular, the PPP criterion would (subject to some qualifications to be mentioned below) give a favorable response to our example of removing barriers to employment of women, where the strict Pareto criterion does not. Since the losses to the male employees are exactly counterbalanced by the gains to their employers, with a further net gain flowing to the new female workers and their employers, clearly the losers from the change could be compensated. The PPP criterion, if we accept it, thus justifies exchange even where "pecuniary externalities" are imposed on other parties (as almost always they will be).

Our discussion has suggested that there are a number of ethical or ideological problems associated with efficiency criteria, and it is time to mention three of these explicitly.

(1) Voluntarism: The key issue as between approving only strictly Pareto-preferred (SPP) changes versus approving all potentially Pareto-preferred (PPP) changes is voluntarism. The PPP criterion over-rides dissent.

There is an irony in the history of thought here: proponents of the
market process usually contend that it is a way of achieving economic
efficiency without compulsion or dictation, yet we have seen that market
transactions will be unambiguous movements in the direction of efficiency only
if we depart from a strictly voluntaristic interpretation of what "efficiency"
means. Indeed, excessive emphasis upon the saliency of the efficiency
criterion, in the non-voluntaristic PPP sense, would seem to open the gates
even to rather brutal social processes that might conceivably still operate
in accordance with a PPP rule.

(2) <u>Enshrining the status quo</u>: Matters may appear in a somewhat different
light, however, once we appreciate that "voluntary" changes are necessarily
relative to some starting-point. Why should the starting-point, the initial
distribution of wealth and talents, be given such a privileged position in
our social thinking? This objection holds with greatest force against the
strict Pareto criterion. The PPP criterion is somewhat less bound to the
status quo, as it allows some non-unanimistic departures therefrom. Never-
theless, even what is potentially Pareto-preferred may still depend upon the
initial position.

One example which has received some attention is the so-called "reversal
paradox."[1] Consider an initial social configuration Γ, with its vector of
produced goods and associated income distribution. It may be that a change to
some other configuration Ω with a different vector of produced goods and
income distribution is PPP-indicated, in that compensating payments <u>could</u>
make everybody better off in comparison with Γ. That is, Ω makes possible

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[1]Scitovsky [1941-42].

some other configuration Ω' which <u>would</u> be strictly Pareto-preferred to Γ. But it might also be the case that Γ meets the PPP criterion relative to Ω! That is, there might be a Γ' that is strictly Pareto-preferred to Ω. (It is the change in income distribution, shifting the market weights assigned to individuals' preferences, that makes this possible.) Probably a much more significant phenomenon is the paradox put in inverted form: starting at Γ a change to Ω may be ruled out as a PPP-inferior movement, yet starting at Ω the move to Γ may also be PPP-inferior! A non-trivial example: an enslaved person might not be able to afford buying his freedom from his master, yet were he free to begin with he might not be willing to sell himself into slavery at any price the master would pay. Which configuration is then the more "efficient"?

(3) <u>Meddlesome preferences</u>: Suppose that some individuals have preferences that are not "self-regarding." For example, lowering the barriers to female employment in coal mines might be found disturbing by some third parties even though the latter are unaffected in material terms. Ought such preferences to be taken into account, under either the strict Pareto (SPP) or potential Pareto (PPP) criterion? Assuming that individuals are actually willing to pay (to sacrifice their own resources or potential consumption) in order to further such "meddlesome" goals, I see no basis for excluding them from consideration. However, when non-self-regarding tastes are taken into account, it no longer follows that voluntary exchange necessarily leads to efficiency even in the PPP sense.

What is the upshot of this discussion? If you now find yourself less than fully confident as to the normative validity of efficiency (either in the SPP sense or the PPP sense) as a criterion for social policy, you're

in agreement with me. And notice that I have nowhere diverged from the

premises uf utilitarian individualism -- the idea that the proper social goal

can be expressed entirely in terms of the achievement of individual desires,

rather than (for example) the pursuit of abstract ideals like justice or

service to God -- though in fact I do have reservations about strict

utilitarianism. Nor have I attempted to bring in paternalistic arguments,

to the effect that some individuals (or all individuals at some times) do

not really know their true desires or are not able to choose what is best for them --

and I would not entirely reject paternalism either. For all these reasons

efficiency criteria fall short of being fully attractive. This is less

threatening a thought for those of us who are doubtful in any case about the

prospects of purposive social reconstruction in the pursuit of efficiency

(or indeed in pursuit of any social goal). A doubt, for reasons that will

become clear at the end of the next Section, more or less consistent with

an evolutionary approach to societal phenomena. But, as a matter of

positive analysis, the difficulties that have been revealed may partially

explain the seeming recalcitrance of the politically influential public to

the efficiency argument of modern econo-legal thinkers.

Finally, one underemphasized aspect of the efficiency criterion is

crucial for our purposes: efficiency is always relative to the boundaries

of the society or group envisaged. An act of voluntary reciprocal exchange

is beneficial for the "society" comprised by the two participants; it is

when we consider third parties that questions begin to arise. If competing

merchants were to form a cartel the move would be efficient from their

point of view, though not so when consumers are taken into account. Or

consider theft. If we set aside long-term effects upon the incentive to

produce, theft as such would be purely redistributive. It is only the resources consumed in defenses erected against theft, and the consequent increased costs of thieving, that reduce the aggregate size of society's pie. Would it then be PPP-efficient to ban defenses against theft? Presumably, the answer would be yes (apart from the aforesaid long-run problems) if the thieves are considered members of the society -- but no, if as outlaws they have placed themselves outside the social unit. (I myself prefer the latter answer!) In a broader context, outcomes efficient for our nation as a whole may be adverse to the well-being of other nations; even gains for the whole human species may be achieved at the expense of other species. My point is that no one, probably, favors efficiency in a totally universalistic sense. We all draw the line somewhere, at the boundary of "us" versus "them." <u>Efficiency thus is ultimately a concept relating to group advantage over other competing groups.</u>

III.   ELEMENTS OF EVOLUTIONARY MODELS

The word "evolution" primarily suggests to us the biological succession of living types, but the underlying concept is of course much broader. Stars evolve: initially a localized concentration of gases in space, a star goes through several stages as it burns its nuclear fuel, ending up eventually as a white dwarf or black hole. According to current cosmological theories the universe as a whole is evolving, under the sway of the second law of thermodynamics, to an eventual steady state of maximum entropy -- a uniform distribution of energy throughout space. On the human level we know also that languages evolve, though following what course I am not prepared to suggest. Thus it is by no means illegitimate to argue that patterns of economic interaction and legal structures may evolve. Yet, I want to say, not everything that changes can usefully be said to <u>evolve</u>. Evolution represents a particular type or pattern of change.

1. <u>Evolution versus randomness</u>: Evolution is not random variation (totally inexplicable change). The outcomes of successive spins of a roulette wheel vary, but do not evolve. Yet random change on a micro or component level may be an element of evolutionary change at the level of a larger entity or collection. In biology genetic mutations occur randomly, yet they contribute to the evolutionary development of species.

2. <u>Evolution versus cyclicity</u>: Regular cyclical change, which plays a role in certain theories of social processes, is best not regarded as evolution. Cyclicity is a kind of generalized stationarity. Put another way, evolutionary changes have an <u>irreversible</u> element, so that things

are never quite the same afterward.[1]

3. <u>Evolution versus revolution</u>: In evolutionary models, transitions
on the macro level result from the accumulation of small changes in micro-
elements over time. Species evolve through the gradual working of forces
contributing to variations in the characters of individual organisms, and
to differential multiplication thereof. Stars evolve via a multitude of
infinitesimal changes operating over the eons on their atomic or subatomic
constituent particles. Where custom is the dominant element, law tends to
follow an evolutionary course: the law emerges from a host of small transac-
tions. But a Moses or a Solon hands down the law from above, all at once as
a <u>revolutionary</u> change. Similarly, in earlier times the economic system
changed mainly through the gradual discovery and slow diffusion of new
techniques and new social relationships. In modern times, of course,
revolutionary economic transformations are occurring with increasing fre-
quency, often (though not necessarily) imposed from above.

Whether a change is revolutionary or evolutionary is sometimes a matter
of relevant time-span or scope of unit. Fusion of a pair of hydrogen atoms
within a star is a revolutionary change for the specific atoms involved,
but a tiny component of an evolutionary process for the star. In primitive
times, within a small human band the invention of the bow, or the promulga-
tion of a successful new law, may have been revolutionary. But among the
larger group of related bands comprising what we now perceive as a single
culture, the change may have progressed only at an evolutionary pace --

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[1]Lotka [1956], Ch. 2.

perhaps being repeatedly re-invented or slowly diffusing before becoming
characteristic of that culture.

4. <u>Evolution versus design</u>: When we speak of evolutionary changes in
human affairs, we generally have in mind "unintended" ones. Once again,
we must distinguish different levels of analysis. Purposive planning by
individuals, or by small groups, might be consistent with unintended
evolutionary change on a macro level. The inventor of the bow had an
intention, but it was only to help himself or his band; the spread of a new
technique of hunting, not to mention the more remote social consequences
following upon that spread, was surely beyond his purpose. Or, modern
statute-writers may intend some purposive redesign of the social order --
but, since "legislation is based on folk notions of causality"[1] the result
may be very different from that planned.

One of the inferences I draw from this discussion is that the applicability
of evolutionary models ought not be over-sold; evolution is not the sole
important pattern of social change. In particular, with the increasing
connectivity of the human world-system -- due mainly to advances in communica-
tion, and to the development of technology with world-wide impact (most
notably, <u>military</u> technology) -- "revolutionary" and "designed" changes are
playing larger and larger roles. Nevertheless, models of evolutionary
change have not lost all relevance. First, many areas of life continue
to be subject to evolutionary principles. Language, custom, the sphere
of private economic activity, and the common law can still be said to
evolve. Second, the <u>present-day</u> starting-point, even for revolutionary

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[1]Moore [1978], p. 7.

or designed change, is in large part the product of past genetic and
cultural evolution. The social evolution of the human species places
constraints upon the nature and pace of planned future change.

Evolutionary models share certain properties. First of all, they
concern populations. Even where we seem to be speaking of single entities,
if the course of change is evolutionary it can be described in terms of
changing populations of micro-units. Thus, the evolutionary course of a
disease within a single human body is a function of the relations among
populations of bacteria, antibodies, cells, etc. Or the evolution of a
single nation's economy is the result of changing relations among popula-
tions of individuals, trading units, etc.

Evolutionary models represent a combination of constancy ("inheritance")
and variation. There must be an unchanging as well as a changing element,
and even the changing element itself must be heritable if a system can be
said to evolve. In biological evolution, the emphasis is upon differential
survival and reproduction of organismic types or characters from one genera-
tion to the next. Here the constancy is due to Mendelian inheritance of
permanent patterns of coded genetic instructions (genes). Variation stems
from a number of forces, including internal mutations of these instructions
(genetic copying errors), recombination of genes in sexual reproduction,
and the external pressure of natural selection. Socioeconomic evolution
mainly concerns the differential growth and survival of patterns of social
organization. The main "inheritance" element is the deadweight of
social inertia, supported by intentionally taught tradition. As
for variation, there are analogs to mutations ("copying errors" as we learn
traditions). Also, natural selection is still effective. Finally, imitation

and _rational thought_ constitute additional non-genetic sources of socio-economic variation.

Biologists have been much interested in the question of the "direction" of evolution. The main principle recognized is _adaptation_. That is, organisms and their lines of descent over the generations tend to fit themsevles into niches of viability offered by their environments. They do so mainly under the pressure of selective competition from other organisms and species, all of which have an irrepressible Malthusian tendency[1] to multiply so as to fill any unsaturated places in the environment.

A number of philosophers have perceived a directional trend toward "complexity" in biological, cultural and even cosmological evolution. I believe this is mistaken. If complexity is adaptive, the trend of development will be in that direction, but often the direction of adaptation may be toward simplicity. We see movement toward complexity when, for example, a few "founders" enter and proliferate within a new environment that contains many different yet-unfilled niches. We see movement toward simplicity, on the other hand, whenever homogenization of the environment reduces the number of distinct niches available.

The adaptation principle suggests that the external environmental determinants must ultimately govern in the evolutionary process.[2] But biological evolution is opportunistic, and must work with the internal materials at hand. The available internal materials -- the genetically coded instructions -- will have been shaped by a variety of past irreversible

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[1] As is well-known, reading Malthus' _Essay on Population_ played a key role in the shaping of Darwin's thought.

[2] As emphasized, for example, by Alexander [1979], Ch. 4.

transformations. These transformations were perhaps responsive in their own day to then-current environmental requirements, but persisting today they remain more or less recalcitrant constraints upon adaptive change. Despite this, there are extraordinary examples of "parellel evolution" in Nature, for example, where traits usually associated with fishes have been independently evolved by quite different biological taxa moving into aqautic environments -- among them the mammals (seals, whales), birds (penguins), and lizards (sea-going iguanas). There are also failures of parallel evolution, however. Nothing like the kangaroo has evolved outside Australia, despite large geographical regions where kangaroo-like qualities would seem to be highly adaptive.

The second qualification of the adaptation principle is of greater interest for our purposes. What is adaptive for the individual organism (and its descendants) may or may not be adaptive for the species. Fleetness of foot helps the gazelle escape the lion, but the gain to being exceptionally fleet may largely be that some other gazelle is eaten instead. If the gazelles were making a cooperative group adaptation, presumably somewhat less fleetness than what has actually evolved would be optimal. A different type of imperfect species adaptation is illustrated by the peacock. The enormous tail pleases the female's fancy and so its bearer sires more offspring, yet a heavy price is paid. As a group adaptation, it seems that the peacocks ought to have found a mode of sexual competition involving less energy loss and vulnerability to predators. In economic terms we would say that these forms of biological competition impose <u>adverse externalities</u> upon other members of (what we perceive as) a larger potentially cooperating group -- in this case, the species.

Group adaptation remains imperfect in such cases because the biological payoff in reproductive competition depends mainly upon <u>relative</u> achievement. An organism can get ahead in evolutionary terms either by pulling itself up or by pushing its competitors down:

> It is crucial to understanding the behavior of
> organisms, including ourselves, that in evolu-
> tionary terms success in reproduction is always
> <u>relative</u>; hence, the striving of organisms is
> in relation to one another and not toward some
> otherwise quantifiable goal or optimum.[1]

The evolutionary emphasis upon <u>relative</u> reproductive competition has important implications for the question of "efficiency" discussed in section II. If it were strictly true that only relative status counted, the efficiency concept would be meaningless. If one party's advance automatically means that other parties lose, there is no scope for <u>mutual</u> gain, actual or potential.[2] In the case of the peacock, other males' reproductive survival is not even a neutral but probably on balance a harmful consideration; the descendants of other cocks will use up resources and multiply to the disadvantage of its own descendants.[3]

At the end of Section II it was argued that "efficiency" must be interpreted as relative to the boundaries of the group. We can now see that for group efficiency to be economically meaningful as a criterion, the group must be one within which individuals do <u>not</u> compete mainly in terms of relative achievement. In Nature, <u>species are mainly fields of relative</u>

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[1]Alexander [1979], p. 17.

[2]For a development of this argument, see Becker [1974].

[3]This is somewhat of an oversimplification. For one thing, descendants of other cocks would provide less-inbred mates for one's own descendants.

reproductive competition. This is why, so often, adaptations tend to be selected that are harmful to the species as a whole.

Nevertheless, truly cooperating groups within species[1] are also often evolved by Nature. Among the more evident examples are families, packs, and insect communities — extending on the human level to tribes, nations, etc. What is happening here, insofar as evolutionary reproductive competition is controlling, is that some individuals have allied together to achieve a mutual gain relative to other members of their species.

That intra-group cooperation and mutual gain typically take place within a larger context of inter-group competition and conflict is essential to keep in mind in speaking of efficiency. Failure to appreciate this fact is an important weakness of modern econo-legal thinking, which the evolutionary approach has exposed. Even within an actual or potential alliance there remain, however, mixed motives -- individual advantage is generally not wholly consistent with group advantage. The theoretical approach to the viability of cooperation strategies in such mixed-incentive situations is the topic of the next two Sections.

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[1]There are also many fascinating examples of across-species cooperation, but these are only means whereby individual members of both species compete more effectively against their own conspecifics.

IV. PATTERNS OF CONFLICT AND COOPERATION: EVOLUTIONARY EQUILIBRIUM

Cooperation and conflict are not simple opposites. The two are complexly intertwined, but in ways which fall into a limited set of mixed-incentive patterns. I shall illustrate some of these patterns here in terms of game theory matrices.[1] (I will be considering only the especially simple class of two-person binary-strategy interactions at this point.)

The most famous of these patterns is the game known as Prisoners' Dilemma. But it will be helpful to start with a simpler pattern, a game I shall call Tender Trap (Matrix 1).[2] Tender Trap illustrates the binding force of convention (of an agreed rule) even where people might all realize that the wrong convention has been chosen. We tacitly agree upon many conventions to order our daily lives: e.g., rules of the road, rules of language, rules of courtesy. Their function is to coordinate activities, so that any person can reasonably anticipate what others will do.

In Matrix 1 the parties can agree on either convention #1 or convention #2; the first is superior to the second in that each party gains 5 units of income instead of 2, but either is superior to following opposite strategies (such that each party receives 0). For example: everyone might agree that it would be better if Americans spoke Esperanto rather than English, but in any case all Americans are better off speaking the same language. I begin with this pattern because here there is no conflict of

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[1]My analysis is in the spirit of Schelling [1960, 1978] and Luce and Raiffa [1957], Ch. 5.

[2]In these matrices one player chooses a Row strategy, the other a Column. The first number in each cell is the income return to Row-player, the second the return to Column-player.

Matrix 1
Tender Trap

	C_1	C_2
R_1	5,5	0,0
R_2	0,0	2,2

Matrix 2a
Chicken

		C_1 (Coward)	C_2 (Hero)
(Coward)	R_1	0,0	-10,20
(Hero)	R_2	20,-10	-100,-100

Matrix 2b
Hawk-Dove

		C_1 (Dove)	C_2 (Hawk)
(Dove)	R_1	2,2	0,10
(Hawk)	R_2	10,0	-5,-5

Matrix 3
Prisoners' Dilemma

		C_1 (Omertà)	C_2 (Fink)
(Omertà)	R_1	-1,-1	0,-20
(Fink)	R_2	-20,0	-10,-10

Matrix 4
Generalized Symmetrical Game

	C_1	C_2
R_1	1,1	y,x
R_2	x,y	0,0

Matrix 5
Battle of the Sexes

	C_1	C_2
R_1	2,1	0,0
R_2	0,0	1,2

interests whatsoever; the problem is purely one of coordination. (The game of Tender Trap can be generalized to allow a degree of conflict of interest, however, by having the off-diagonal elements display different returns to the two players -- see below.)

The standard solution concept which mathematicians employ for such "non-zero-sum" games is the Nash equilibrium (NE):[1] A strategy-pair is an NE if, taking the strategy of the other party as given, neither player can improve his position by revising his own strategy. In Matrix 1 the two agreed "conventions" (the two cells on the main diagonal) are both Nash equilibria. If the players had chosen the first convention (Row 1 and Column 1), either would lose by shifting -- but the same holds if they had initially chosen the inferior second convention (Row 2 and Column 2).

A subtly different solution, which we will call the evolutionary equilibrium (EE), has been proposed by the biologist John Maynard Smith.[2] The idea is that the two parties are members of a homogeneous population meeting randomly in pairwise interactions. One strategy may be "defeated" by another, and therefore eventually be driven out in the evolutionary sense, if it yields on average a lower return than the other. The average returns received will be a function of the proportions of the population choosing each of the strategies, so that we are dealing with possible equilibria of a dynamic process.

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[1] Nash [1951].

[2] Maynard Smith [1976]; the biologists call this solution an "evolutionarily stable strategy" or ESS. For economic interpretations of the ESS concept, see Hirshleifer and Riley [1978], Cornell and Roll [1979], Schotter [1979].

In Matrix 1 it may be verified that if the proportion p of the population choosing strategy #1 were initially greater than 2/7, the average return from choosing #1 will exceed the return from #2. In this circumstance strategy #1 will tend to drive out #2. Then the "efficient" solution, in the potentially Pareto-preferred (PPP) sense of maximizing the "pie" of aggregate income[1] -- the upper-left corner outcome (5,5) -- will be attained as an evolutionary equilibrium EE. And furthermore the efficient solution here is also strictly Pareto-preferred in comparison with any other starting-point (it is unanimously preferred over any alternative outcome cell of matrix 1). If on the other hand the initial proportion were less than 2/7, the attained EE would be at the lower-right corner.[2] So the two NE's are also both EE's. The dividing line p=2/7 is a kind of threshhold or critical mass for reaching the mutually preferred solution. Something like a shift from a generally less-preferred to a more-preferred EE actually occurred among Jews of Palestine, who managed to put together a critical mass for shifting from Yiddish (mainly) to Hebrew as a common language. But it is unlikely that a population could shift from driving on the left to driving on the right, or from the English to the metric system of units, without support by the force of law.

Moving now to mixed-incentive interactions, Matrix 2a illustrates the famous game of Chicken. The two players drive toward one another at full

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[1]Since there is only a single "income" commodity, no reversal paradox can arise.

[2]If the proportion were exactly p = 2/7 the two strategies would yield equal returns, so that neither would tend to drive out the other. But this is an unstable situation; any small accidental shift of p in one direction or the other would be self-reinforcing.

speed, the one who turns aside (Coward) becoming an object of contempt.
If it turns out that each plays Hero, the result is death (-100 for each).
Or, both might be Cowards (0 return for each). The really desirable situa-
tion, of course, is for the other to be a Coward (-10) and you a Hero
(+20).

The Nash equilibrium (NE) is double here again, but occurs at the two
off-diagonal outcomes. That is, from an initial position at either off-
diagonal cell, it does not pay either party to change his strategy. The
numbers in matrix 2 are such that the off-diagonal outcomes are also jointly
"efficient" (maximum sum of returns), though in this case neither NE is strictly
Pareto-preferred in comparison with all the other possibilities. However,
the essential features of Chicken would persist even if the sum of incomes
in the off-diagonal cells were not maximal. For example, if the (+20,-10)
cells were changed to (+5,-10) the off-diagonal outcomes would remain the
Nash equilibria (NE's). But, whether or not the off-diagonal outcomes are
"efficient," these solutions are not available as evolutionary equilibria
(EE's) in a homogeneous population! The reason is that they require comple-
mentary pairing of strategy choices, which is not possible in random
encounters within a homogenous population.

Let us now find the evolutionary equilibrium for Chicken. We can do so
by calculating the average returns to each of the strategies as a function
of the population fraction p choosing strategy #1 (Coward). In Matrix 2
the evolutionary equilibrium occurs at p = 9/11. The population being
homogeneous, the interpretation is that each player chooses the Coward
strategy 9/11 of the time and the Hero strategy 2/11 of the time. (This
is known as a "mixed" as opposed to a "pure" strategy choice.) The average

return will then be -20/11 to each player.[1] Even if the off-diagonal outcomes cannot be attained, there evidently remains a potential cooperative gain from both being Cowards (each receiving 0 rather than a negative amount). But this cooperative outcome is not an evolutionary equilibrium; if Cowards became too numerous, they would lose out on average to those making choices closer to the EE mixed strategy.

My picturesque description may perhaps suggest that the game of Chicken is a somewhat pathological class of social interaction. Such an inference would be quite false. The pattern of Chicken, in the more interesting version characterized by positive efficiency gains if the off-diagonal outcomes can be achieved, fits the _very_ common situation of two parties in a position of potential conflict over a prize. Using a different ornithological metaphor, Maynard Smith calls what is essentially the same game "Hawk-Dove." In Matrix 2b a Hawk player encountering a Dove player wins a prize of 10, Dove receiving nothing. But Hawk-Hawk encounters involve a big loss (-5) to each. Dove-Dove encounters yield a modest gain (2) to each; the two do not suffer injury, but some potential gain (e.g., nutrition) is lost from lack of aggressivity. The EE here has the proportion $p = 5/13$ playing the Dove strategy. (Rather than assuming that every individual follows a mixed strategy, we can equally well interpret the EE as a population balance of individuals each of whom separately has a fixed Hawk or Dove nature.)

There are of course many examples in Nature of organisms faced with Hawk-Dove choices (whether to fight or retreat). Nor is it at all hard to imagine human analogs in the realms of warfare, politics, business, or

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[1]Since the zero-point is arbitrary, the negativity of average achieved returns need cause no concern.

or anywhere that jockeying for position is important.[1] The essential feature is that each player must balance "cowardly" loss of the prize against the even greater loss should potential conflict become actual.

In Tender Trap, putting together a critical mass provided a way of escaping the inferior of the two solutions. In Chicken or Hawk-Dove (I will more usually employ the latter metaphor from now on), the trap takes the form of the EE mixed strategy with some positive probability of inefficient mutual losses due to Hawk-Hawk interactions. Critical mass does not provide any route out of Hawk-Dove. Instead, the obvious mode of excape is to somehow arrange that at each meeting one party will take the role of Hawk and the other the role of Dove. Any means of doing this would be PPP-efficient, but for the method to be viable each organism would have to be able to play each role about half the time. In effect, a convention is needed to assure that when two parties meet their behavior will be non-parallel, in contrast with the parallelism convention needed under Tender Trap.

If the two parties can be regarded as arriving randomly (as in search or exploration situations) at the location of the prize, "first come first served" would provide such a convention. Each organism would be first about half the time. Remarkably, Nature has evolved this precursor of ownership or property rights in a number of ecological circumstances.[2] Mathematically,

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[1]Cornell and Roll [1979] suggest a number of examples in economic affairs, including seniority ladders and stock market analysis.

[2]Maynard Smith [1976] cites several instances: for example, male hadmadryas baboons recognize conventional prior "ownership" of females by other males. For a more general discussion of the emergence of property rights among animals, see Fredlund [1976].

the convention "last come first served" would do as well, but I know of no
examples of this in Nature (and few in human affairs).[1]

"First come first served" as the basis for conventional avoidance of
conflict is an example of what Maynard Smith [1978] calls an _uncorrelated_
asymmetry. Another example might be sex (e.g., males defer to females).
At least as important are _correlated asymmetries_[2] -- for example, differences
in the parties' adeptness at Hawking or Doving behaviors, or differences in
their valuations of the prize. Perhaps the most obvious such convention would
be "weaker defers to stronger." In Nature it is very commonly observed that
after only a test of strength (taking the form of _limited combat_, in which
the parties do not use their most lethal weapons or tactics) the weaker party
does give way.[3]

Now for the Prisoners' Dilemma (Matrix 3). The tale is probably familiar. Two
prisoners, held incommunicado, can be convicted only of a misdemeanor and
suffer mild punishment (-1) if they both refuse to confess; they can be
convicted of a felony and will suffer heavier punishment (-10) if they both
confess. But if one confesses and the other does not, the authorities will
release the first (0 penalty) and throw the book at the second (-20). Here
mutual choice of the omertà strategy #1 provides a large efficiency gain.

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[1] A possible explanation is that "last come first served" conflicts with
the adaptive incentive to search diligently for resources. A large fraction
of the time, diligent searchers can expect to find and consume the prize
before any competitors even put in an appearance. (For a different
explanation see Cornell and Roll [1979], p. 14.)

[2] For an economic discussion of uncorrelated versus correlated asym-
metries, see Cornell and Roll, [1979].

[3] Lorenz [1966], Maynard Smith [1978].

Yet, it is in each party's selfish interest to choose the fink strategy #2 --
regardless of what the other does! (That is, strategy #2 "dominates" #1.)
The fink-fink outcome is the sole Nash equilibrium (NE) and the sole evolu-
tionary equilibrium (EE). It might be regarded as a tough trap, in con-
trast with the tender trap of Matrix 1.

The Prisoners' Dilemma model has a wide range of applicability. The
typical economic "externality" or "commons" problem falls into this pattern.
If all nations were to cut back whaling activities, there would be a collect-
ive benefit (efficiency gain) to be shared from preservation of this valuable
resource. Yet, it pays each alone to engage in whaling without regard to long-
run considerations. Note that this is not a merely "defensive" policy made
necessary by others' greed; even if other nations practiced restraint, each
separate nation is motivated to engage in unrestrained whaling. (Indeed,
it may often be the case -- though not for the particular numbers shown
in our Matrix 3 -- that restraint on the part of others increases the
gains of the selfish or fink strategy.) On the other hand, Prisoners'
Dilemma need not be socially disfunctional in the larger sense; the coopera-
tion it subverts may be a conspiracy against the public.[1] This is presumably
the case for the two prisoners of the initial example. And similarly for
cartel agreements to restrict production.

Before turning to the large question of possible escapes from the
Prisoners' Dilemma trap, it will be very useful to note that all three
classes of mixed-motive games considered to this point can be put in general

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[1]Recall the argument in the Section above about the relativity of the
efficiency criterion with regard to the boundaries of the group.

format of Matrix 4. A generalized Tender Trap is represented by x,y<0.
(In this generalized form, Tender Trap will not be a pure game of coordina-
tion; there is some conflict of interest whenever x≠y.) Hawk-Dove has x>1,
y>0 (with x+y>2 in the more interesting case for which the off-diagonal
cells are "efficient" outcomes). And Prisoners' Dilemma has x>1, y<0. I
do not mean to suggest that all 2-person symmetrical games with mixed con-
flict/cooperation incentives can be put in this format; Matrix 5, known as
"Battle of the Sexes,"[1] represents a mixed-incentive game characterized by a
somewhat different kind of symmetry. But I will consider only the generalized
Matrix 4 pattern here, in order to explore a little more rigorously the
nature and determinants of evolutionary equilibrium.

The evolutionary equilibrium (EE) strategy is one that, broadly speaking,
will drive others out of existence by "defeating" them in binary encounters.
If the population can be regarded as of infinite size, the average return
α to the first strategy in Matrix 4, where p is the population fraction adopt-
ing that strategy, is:[2]

$$\alpha = (p)1 + (1-p)y \tag{1}$$

Similarly, the average return β to the second strategy is:

$$\beta = (p)x + (1-p)0 \tag{2}$$

The first strategy will on average defeat the second, and therefore drive
it out, whenever $\alpha-\beta$ exceeds zero, where:

$$\alpha - \beta \equiv p(1-x) + (1-p)y \tag{3}$$

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[1]See Luce and Raiffa [1957], Ch. 5.

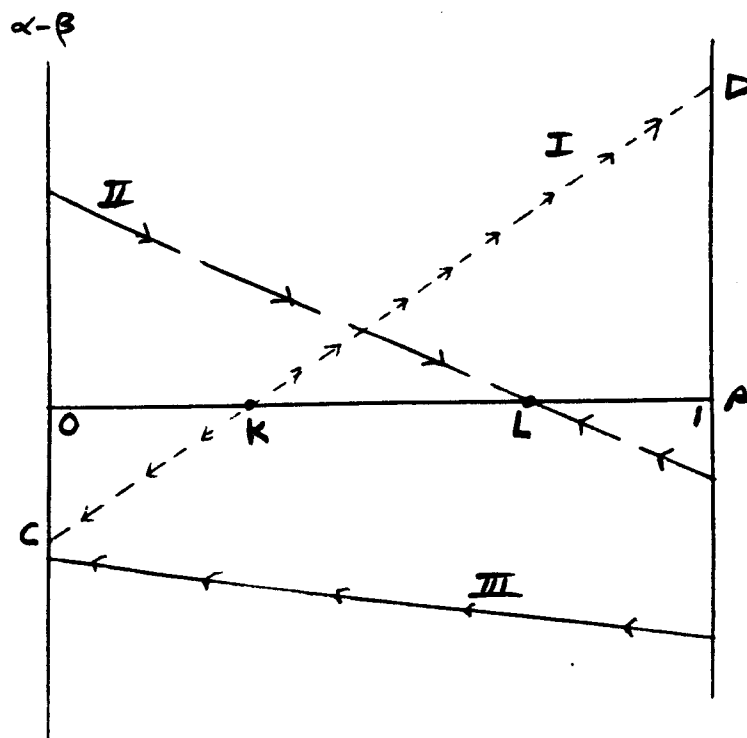[2]The analysis that follows derives in part from Hirshleifer and
Riley [1978].

Figure 1

Three Classes of Cooperation Failures

There are three qualitatively different types of situations, as illustrated by the three lines in Figure 1. The dotted line I corresponds to the generalized Tender Trap (x,y<0). As can be seen, for p sufficiently large $\alpha-\beta$ is positive, and so the proportion adopting the first strategy tends to grow. But for p sufficiently low, $\alpha-\beta$ is negative and the dynamic trend goes the other way. Thus, the two evolutionary equilibria are the extreme final situations C(where p=0) and D(where p=1); which one is attained depends upon the starting-point. (At point K the two strategies are in balance, but K represents an unstable equilibrium.) The dashed line II corresponds to Chicken or Hawk-Dove (x>1,y>0). Here the _less_ prevalent strategy has the advantage, the result being a mixed or interior solution at point L. Finally, line III represents Prisoners' Dilemma (x>1,y<0) for which the first (cooperative) strategy never has the advantage.[1]

I would have liked to claim that these simple curves represent _the_ three ways in which potential cooperation may fail: (I) where lack of a critical mass traps the population at an inferior corner solution; (II) where inability of a homogeneous population to arrive at a complementary pairing convention leads to an inferior mixed solution;[2] (III) where the "selfish"

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[1] An important complication arises, however, where the populations are taken as of finite rather than of infinite size (Riley [1979]). Once only a single member of the population is following a given strategy, it can no longer encounter any other playing the same strategy. For small populations (by no means uncommon in Nature, or in human affairs) this effect can be significant. In Figure 1, the cross-over cases I and II are affected. What can happen, essentially, is that the cross-over point can come so close to either end of the p scale that one strategy _is_ driven out even though the infinite-population model calls for a mixed solution (line II) or for a possible Tender-Trap EE at that strategy (line I).

[2] Recall that the interesting case is where x+y>2. In such a situation the mixed solution is more "efficient" (in the PPP sense) than either of the diagonal outcomes, but still falls short of what could be achieved by complementary pairing.

strategy is strictly dominant in terms of private calculations, despite the potential gain from mutual adoption of the cooperative strategy. While these three patterns do cover a surprising amount of territory,[1] it would be absurd to claim full generality. The underlying model remains excessively restrictive, in <u>at least</u> the following respects:

1. Not all symmetric patterns of mixed cooperation-conflict incentives have been covered (see, for example, Matrix 5).

2. The symmetry restriction (equivalent to assuming a homogeneous population) is very severely limiting. More generally, at any moment of time a population would be characterized by a probability distribution along many relevant dimensions. For example, as already mentioned in connection with the Hawk-Dove game, some individuals may be better fighters than others, or may need the food more, etc.

3. Equally severe, perhaps, is the limitation to <u>dyadic</u> interactions. This is particularly relevant for us here, since the law is (at least in part) a way of converting dyadic into <u>triadic</u> social interactions. (There are the two contending agents, plus a third "uncommitted" party to decide between them.)

4. We have considered only binary-strategy situations (2x2 game matrices).

5. Finally, we have implicitly been ruling out any structuring of the interactions among individuals that might make possible binding agreements to cooperate, as by exchange. The difficulty is that contractual agreement does in general require some kind of outside (third-party)

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[1]For example, a large fraction of the problems analyzed in Schelling's fascinating <u>Micromotives and Macrobehavior</u> [1978] can be fitted under these headings.

enforcement, for example, law. What I am trying to do here, in effect, is to get a better focus upon the need for law by exploring the obstacles that cooperation encounters without it.

It follows that there are more complex forms of mixed-incentive cooperation/conflict interactions than we have yet gone into. Indeed, the number of qualitatively different mixed-incentive cases increases at a frightening rate when we depart from the simplifying assumptions of this Section, which is undoubtedly why the problem of cooperation versus conflict remains so baffling. In the next Section I shall mainly pursue one part-icular line of inquiry, into the possible modes of escape from the Prisoners' Dilemma -- the "tough trap" for potential cooperators. These escape routes typically involve relaxing one or the other of the restrictive conditions mentioned above. Yet, as we shall see, a plausible escape route often leads toward other, more intricate traps that subvert cooperation in subtler ways.

V. ESCAPES, MAINLY FROM THE PRISONERS' DILEMMA

The Prisoners' Dilemma has been by far the most studied pattern of cooperation failure -- failure to achieve a potential mutual benefit in the strict Pareto sense, or possibly even an aggregate "efficiency" gain in the potentially Pareto-preferred (PPP) sense. Also, as we have seen, the Prisoners' Dilemma does represent the "toughest" trap, mainly due to the fact that the non-cooperator strategy is actually <u>dominant</u> (preferred whatever the choice of the other participant).

However, it will be of interest here first to show more rigorously how the "ownership" (first come first served) convention mentioned in the preceding Section can actually provide an escape route from cooperation failures of the Chicken or Hawk-Dove type. Following Maynard Smith,[1] we can suppose that the Hawk-Dove game (Matrix 2b) is expanded by the addition of a third "Bourgeois" strategy (Matrix 6). The Bourgeois rule is: When you are the first-comer in possession of the resource, play like a Hawk; when the late-comer, play like a Dove. That is, when an "owner" fight to defend your property; when an interloper, defer to others' owner-ship.

The elements of the R_3, C_1 interaction (Bourgeois encountering Dove) in the lower-left cell of Matrix 6 are derived as follows. On average, half the time Bourgeois will be in an ownership situation against Dove, thus reaping the 10 units of income that Hawk would obtain against Dove; the other half of the time, Bourgeois as non-owner would receive only the 2 units of income that Dove would obtain against Dove. Averaging the two,

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[1]Maynard Smith [1978].

Matrix 6
Hawk-Dove-Bourgeois

		C_1 (Dove)	C_2 (Hawk)	C_3 (Bourgeois)
(Dove)	R_1	2,2	0,10	1,6
(Hawk)	R_2	10,0	−5,−5	+2 1/2,−2 1/2
(Bourgeois)	R_3	6,1	−2 1/2,+2 1/2	5,5

Matrix 7
Prisoners' Dilemma
(Cost-Benefit Format, b>c)

		C_1 (Helper)	C_2 (Nonhelper)
(Helper)	R_1	−c+b,−c+b	−c,b
(Nonhelper)	R_2	b,−c	0,0

Matrix 8
Prisoners' Dilemma with Retaliators

		C_1 Helper	C_2 Nonhelper	C_3 Retaliator
Helper	R_1	−c+b,−c+b	−c,b	−c+b,−c+b
Nonhelper	R_2	b,−c	0,0	0,0
Retaliator	R_3	−c+b,−c+b	0,0	−c+b,−c+b

the return to Bourgeois against Dove is 6. By analogous reasoning, the
second element of the lower-left cell (the return to Dove against Bourgeois)
is 1. The elements in the other new cells can be derived in the same way.

How about efficiency? Note that the maximum aggregate income of 10
units is attained at the old off-diagonal outcomes (R_1, C_2 and R_2, C_1) as
well as at the Bourgeois-Bourgeois (R_3, C_3) outcome. All three solutions
are therefore equally efficient in the PPP sense. Furthermore, each is a
Nash equilibrium (NE).

But it still has to be shown which, if any, is an _evolutionary_ equilibrium
EE. The first step is to calculate the expected returns α, β, and γ to the
three strategies Hawk, Dove, and Bourgeois respectively -- as functions of
the corresponding population proportions p,q,r (where of course r=1-p-q).
Then we have to find the ranges of values for p,q,r in which each strategy
defeats the others, and the implied dynamic directions of change in those
proportions. The algebra is rather tedious, but the result can be shown in
Fig. 2 (which is a kind of generalization of Fig. 1). As the arrows indicate,
there is a dynamic convergence toward the origin -- that is, toward p=q=0,
which implies r=1. In other words, only the Bourgeois strategy survives
in the evolutionary equilibrium. (In Fig. 2, at point A the gains from the
three strategies are in balance, but this is a dynamically _unstable_
equilibrium like point K in Fig. 1.)

There is a fly in the ointment, however. Ability to play a Bourgeois
strategy would seem to require a more complex mentality, or at least bio-
chemistry: the Bourgeois strategist must be able to distinguish between
owner and interloper situations, and must be able to execute the appropriate
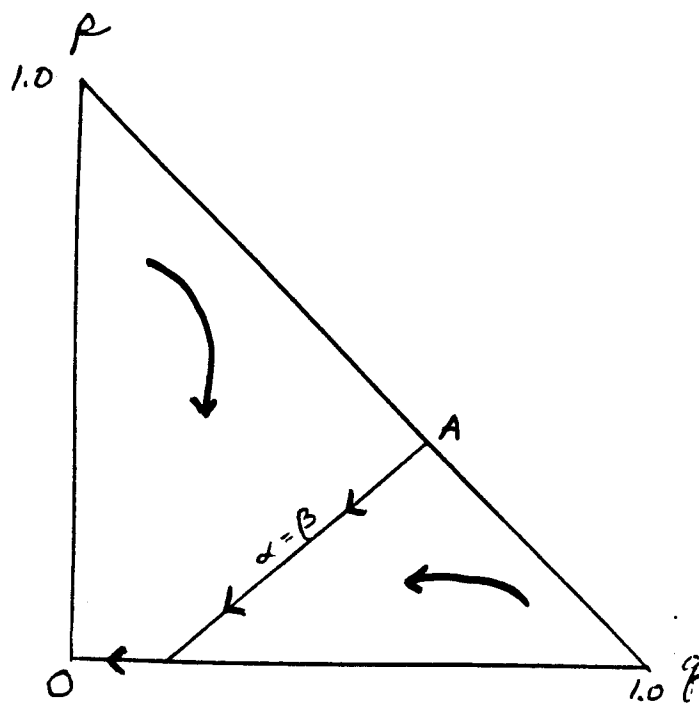
Figure 2

Convergence to "Bourgeois" EE

(Hawk-Dove-Bourgeois Game)

behavioral maneuvers of both Hawk and Dove. It seems reasonable to suppose that these capacities impose a certain burden; if so, the elements of the R_3,C_3 cell might become (for example) 4,4 rather than 5,5. This would mean, first, that a population of Bourgeois players is definitely a less efficient solution than complementary pairings of Hawk and Dove. In Fig. 2, it also suggests that point A would become a stable rather than unstable equilibrium. Thus, making due allowance for the costs of a more elaborate behavioral repertory, the overall result might be an analog of Tender Trap -- the population might tend toward either an evolutionary equilibrium at pure-Bourgeois, or a stable Hawk-Dove mixture, depending upon the starting point. This theoretical result need not surprise us. Since it seems plausible that not every population in a Hawk-Dove environment has succeeded in finding the Bourgeois way out of the trap, we would have proved too much in demonstrating that pure-Bourgeois is the only evolutionary equilibrium.

Nevertheless, there are many fascinating examples of respect for "ownership" in Nature. Robert Ardrey, in a well-known popular work,[1] attributed this to a somewhat mystic force which serves the good of the species by minimizing the scope of inefficient combat. The Maynard Smith development, in contrast, shows that respect for ownership is a possible evolutionary emergence that need not call upon any force other than private advantage. What is required (apart from the critical mass problem just alluded to) is only that the environment provide the particular patterns of mixed individual incentives for cooperation versus conflict represented by the underlying Hawk-Dove game. On the human level, a corresponding

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[1] Ardrey [1966].

environmental situation might be expected to lead to a "social ethic" supporting a system of property rights.[1] (For our purposes, it is not essential whether this ethic is a genetically implanted or a culturally learned pattern.)

We can now turn to the tougher cooperation trap represented by the Prisoners' Dilemma (PD). In this Section it will be convenient to set up the PD matrix in a "cost-benefit" format (Matrix 7). Each act of "helping" costs the donor organism c, and benefits the recipient organism by the amount b -- where b>c. Mutual helping is evidently efficient, but the parties are trapped at the Nonhelping (0,0) equilibrium. Critical mass provides no escape route here; even if 99% of the other organisms one is likely to encounter are behaving as Helpers, it still pays to play Nonhelper.[2] Nor is there a possible gain from any kind of "ownership" convention -- Nonhelping remains dominant no matter what the other player does.

There is, of course, the valid escape route through reciprocation or contractual exchange: each party promises to act cooperatively, provided the other does. "Smith's Theorem" is potentially at work in Prisoners' Dilemma as it is in all mixed cooperation-conflict situations.

In what follows, a number of excape routes not requiring third-party intervention or support will be discussed in turn. There is a certain sense in the sequence of topics, though no attempt will be made at a taxonomy of

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[1]Hirshleifer [1980].

[2]Schelling [1978], Ch. 7, is perhaps misleading on this score. He shows that with a sufficient proportion p of Helpers in the population there may be an absolute expected gain to playing Helper -- that is, for large p it may be that $p(-c+b) + (1-p)c \equiv -c + pb > 0$. Nevertheless, the absolute gain from playing Nonhelper is even greater (it is in fact pb), and so the Helper strategy remains non-viable in the evolutionary sense.

escape modes -- apart from a major division between symmetrical and asymmetrical strategy games.

A. Symmetric Strategies

1. The Silver Rule

Determined uncontingent Helpers are following the Golden Rule of social interaction, selfish Nonhelpers the Brass Rule. How about the Silver Rule -- responding to help with help, to nonhelp with nonhelp? Matrix 8 represents an expansion of Matrix 7 by addition of such a "Retaliator" strategy. This game has two symmetrical Nash equilibria -- Nonhelper-Nonhelper and Retaliator-Retaliator. The latter, if it can be attained, would be just as efficient as the ideal Helper-Helper outcome. Both these NE's are "weak," in that there is in each case a second equally attractive strategy available for either player. Consequently, in an evolutionary model we might expect some random "drift" away from each of the NE's. The dynamic calculations to obtain the evolutionary equilibria (EE's) are rather troublesome but the results are pictured in Fig. 3. Here α, β, γ represent the expected returns to Helper, Nonhelper, and Retaliator respectively. In Zone I (above the line where $\beta = \gamma$), there is strong convergence toward point K (q=1, or an all-Nonhelper population). But point K, while a stable equilibrium with respect to Zone I, is unstable with respect to Zone II. So drift into Zone II, and consequent convergence toward the origin O (r=1-p-q=1, or an all-Retaliator population) then occurs. However, O is only neutrally stable along the dotted range of the vertical axis (up to point L where p=1-c/b). If a sufficiently large fraction of the population consists of Retaliators, any individual organism can do as well being a pure Helper. (But if the
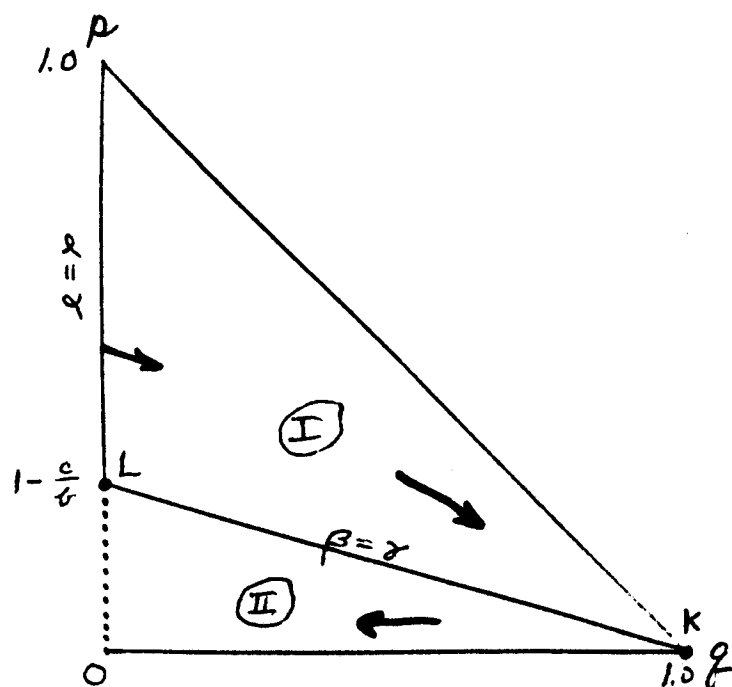
Figure 3

Neutral EE Range

(Prisoners' Dilemma With Retaliator Strategy)

proportion of Helpers ever exceeded 1-c/b, we are in Zone II where it becomes profitable for Nonhelpers to enter.) At point L itself all three strategies yield equal returns, and so this end-point of the dotted range is unstable. Subject to a fuller study of the dynamics, it seems reasonable to conclude that after a possible initial transient the population proportions would, almost all the time, lie somewhere on the dotted interval in Fig. 3. That is, the population would be a mixture of Retaliators and pure Helpers.

So far, so good, but this otherwise attractive escape from the Prisoners' Dilemma has a flaw analogous to that discussed in connection with the Bourgeois strategy. The Retaliator must be able to recognize Helpers and Nonhelpers, and must also possess both helping and nonhelping in its repertory of feasible actions. These capacities again probably impose a certain cost upon being a Retaliator rather than pure Helper. Then, in an all-Retaliator population (r=1), it would be strictly more profitable (rather than only equally profitable) to be a pure Helper instead. Thus the all-Retaliator population is not an equilibrium, and in fact the final outcome will be an all-Nonhelper population. We are back in the Prisoners' Dilemma. Note that the "cost of complexity" difficulty subverts the Bourgeois strategy in a Hawk-Dove environment situation only to the extent of requiring a critical mass before Bourgeois can become an EE -- whereas it entirely destroys any hope of a Retaliator EE in a Prisoners' Dilemma environment.

Another type of Silver-Rule strategy has received somewhat more discussion in the literature: actual or potential retaliatory behavior in repeated plays of the Prisoners' Dilemma game. The idea here is that to escape the trap, parties tend to pair up in a long-term pattern of

business association. Given the mutual gain from continuance of the association, Nonhelper behavior is to be checked by the retaliatory response of the other party breaking off a mutually advantageous relationship.[1]

But again a paradox is encountered. No matter how many times the PD game is repeated, on the _very last_ play it remains dominant strategy to act as a Nonhelper. Knowing that his partner-opponent will rationally behave in this way, each player will then have no incentive to act cooperatively on the _next-to-last_ play. Following this logic the entire game unravels, and Nonhelper remains the dominant strategy throughout.[2]

2. Nepotism and other discrimination techniques

Under the heading of "altruism," biologists have devoted a great deal of attention to cooperation among living forms, as seeming exceptions to the rule of reproductive competition in Nature. The psychological or ethical term "altruism" is, however, an unfortunate terminological choice for what is better described in operational terms simply as _helping_. The clearest instances of helping behavior are associated with kinship ("nepotism"). That parents care for offspring, that blood is thicker than water, is of course commonly though by no means universally observed in Nature or in human affairs. To some extent at least, relatedness seems to provide a way out of the Prisoners' Dilemma. My purpose here is to explore how this mechanism works, and more generally to understand how analogous mechanisms can apply to other forms of mutual aid.

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[1]The saliency of this threat in actual modern business practice has been discussed by Macaulay [1963].

[2]This paradox can be overcome if there is no "last play." For example, if the game is to be played an infinite number of times. Or, more realistically, if at each play there is a certain constant probability of the game continuing further. See Luce and Raiffa [1957], p. 102 and Telser [1980].

We can think of a population in which a "gene for helping H is in competition with a "gene for nonhelping" N. It might be thought that Nonhelpers will always be free-riders upon Helpers, so that the H gene could never be viable.[1] But, as we shall see, helping can be viable despite free-riding if the ecological circumstances provide for a sufficient degree of _discrimination_ in which aid is preferentially directed toward fellow-Helpers. Kinship is one mechanism that provides the basis for such discrimination.[2]

The basic kin-selection model is due to Hamilton, but a more tractable version has been put forward by Charnov.[3] Quite generally, before bringing in nepotism, we can ask under what conditions W_H will exceed W_N -- the "fitness" or viability of the helping gene H will exceed that of the non-helping gene N. Let b and c be the benefit conferred and cost incurred of each helping act, let p be the proportion of the population bearing the helping gene, and finally let m be the discrimination factor -- the fraction of helping acts received by fellow-Helpers. Then, the viability condition $W_H > W_N$ can be expressed as:

$$-c + bm > b(1-m) \frac{p}{1-p} \tag{4}$$

On the left-hand side, the first term -c is the cost incurred by the Helper (measured in fitness units, and normalized so that there is one helping

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[1] See Tullock [1978], and the countering arguments of Frech [1978], Hirshleifer [1978], and Samuelson [1980].

[2] In the previous discussion, the presence of Retaliators provided in effect a degree of discrimination in the population as a whole.

[3] Hamilton [1964]; Charnov [1977]. I will be using the latter's simplest "sexual haploid" model.

act per time-period). The second term, bm, represents the average per-Helper benefit of helping acts (per time-period) that are directed at _fellow-Helpers_. The right-hand side, analogously, shows the average per-Nonhelper (free-rider) benefit of helping acts per time-period. Inequality (4) reduces to:

$$\frac{c}{b} < \frac{m-p}{1-p} \qquad\qquad (5)$$

Thus we see that for helping to be competitively superior to nonhelping, a _necessary_ (though not sufficient) condition is m>p -- helping acts must be disproportionately directed to fellow-Helpers.

All that has been said so far is perfectly general; kinship has not entered specifically at all. Still deferring the specifics of kinship, we can use Matrix 9 to gain a better understanding of the role played by the discrimination factor m. Matrix 9 is in the standard form of Matrix 7 except for the introduction of new "recognition coefficients" v_H and $\bar{v}_N$. The first of these, v_H, is the conditional probability that an encountered Helper will be recognized as such by a fellow-Helper and therefore will be "correctly" granted aid (in the form of the benefit b). The conditional probability that an encountered Nonhelper will be helped (because of being _incorrectly_ recognized as a fellow-Helper) is denoted $\bar{v}_N$. These two coefficients are in principle independent; for example, an organism might never fail to recognize a fellow-Helper yet often treat Nonhelpers as Helpers. The discrimination factor m will generally be functionally related to v_H and $\bar{v}_N$, as well as to p. More specifically, m/(1-m) -- the ratio of correctly to incorrectly directed helping acts -- can be expressed as:

Matrix 9
Prisoners' Dilemma
With Recognition

		C_1 Helper	C_2 Nonhelper
Helper	R_1	$v_H(b-c), v_H(b-c)$	$\bar{v}_N(-c), \bar{v}_N b$
Nonhelper	R_2	$\bar{v}_N b, \bar{v}_N(-c)$	$0,0$

Matrix 10
Prisoners' Dilemma
With Asymmetrical Commitment

		C_1 (Helper)	C_2 (Nonhelper)
Helper	R_1	$-c+b,-c+b$	$-c,b$
Nonhelper	R_2	$b,-c$	$0,0$
Committer	R_3	$-c+b,-c+b$	$0,0$

$$\frac{m}{1-m} = \frac{p \ v_H}{(1-p)\bar{v}_N} \tag{6}$$

Or,

$$m = \frac{pv_H}{pv_H + (1-p)\bar{v}_N} \tag{7}$$

EXAMPLE: If $v_H = .8$, $\bar{v}_N = .4$, and $p = .25$, then $m = .4$. Evidently, m will rise as v_H increases, and fall as $\bar{v}_N$ increases.

We now want to compare the expected returns α and β to the Helper and Nonhelper strategies, respectively:[1]

$$\alpha = pv_H(b-c) - (1-p)\bar{v}_N c = pv_H b - c[pv_H+(1-p)\bar{v}_N] \tag{8}$$

$$\beta = p\bar{v}_N b \tag{9}$$

The condition for α to exceed β is then:

$$p > \frac{\bar{v}_N c}{(b-c)(v_H-\bar{v}_N)} \tag{10}$$

We see therefore that the ratio on the right-hand-side is a kind of critical mass. Should p ever exceed it, Helping will grow until the population consists exclusive of Helpers. The critical mass will of course be more

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[1]To reconcile these expected returns in (8) and (9) with condition (4), note that in (4) one helping act was supposed to occur per time-period. To re-normalize α and β in this way, divide both α and β by the bracketed expression at the right of equation (8). From (7), this expression equals pv_H/m. The results are the "fitnesses" compared in inequality (4):

$$\alpha\frac{m}{pv_H} = W_H = -c + bm$$

$$\beta\frac{m}{pv_H} = W_N = b\frac{p\bar{v}_N}{pv_H+(1-p)\bar{v}_N} = b \ \frac{p(1-m)}{1-p}$$

difficult of attainment the higher are c and $\bar{v}_N$, and the lower are b and v_H.

The incorporation of constant recognition factors thus converts the Prisoners' Dilemma into a "Tender Trap" situation, as discussed in Section IV above, for which the stability considerations are as pictured by the line labelled I in Figure 1. But, unfortunately, if the population is initially in a Nonhelping mode, putting together the critical mass needed to escape the trap will not be easy.

> EXAMPLE: Using our previous numbers $v_H = .8$; $\bar{v}_N = .4$, and supposing that b=10 and c=5, the critical value for p is 1! Thus, if the population were already all Helpers, they might remain so -- but any smaller initial proportion of Helpers would spiral downward to the pure Nonhelper situation p=0. And this despite a favorable 2:1 benefit-cost ratio b/c, and a similarly favorable recognition ratio $v_H/\bar{v}_N$.

While constant recognition coefficients v_H and $\bar{v}_N$ lead to a "Tender Trap" type of situation as in line I in Figure 1, a constant discrimination factor m would lead to a "Hawk-Dove" class of solution with a stable interior equilibrium as in line II of Figure 1.[1] That is, in equilibrium a certain proportion p* of the population would be Helpers and the remainder Nonhelpers. A stable m implies of course varying v_H and $\bar{v}_N$. In particular, for m to be actually or nearly constant, it must be that as p rises either v_H falls or $\bar{v}_N$ rises (or both). This might characterize a "mimicry" situation, in which Nonhelpers try to cheat by disguising their identities.

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[1]If m is constant, the left-hand-side in (4) is a constant. But the right-hand-side will be an increasing function of p. So W_H-W_N is a _decreasing_ function of p, from which $\alpha-\beta$ must behave similarly --- leading to a picture like that of line II in Figure 1. (But in this case $\alpha-\beta$ will be a negatively sloped curve rather than a line.)

Then, it seems reasonable to believe, as the proportion of true Helpers

rises it is easier for the few cheaters to successfully disguise themselves.

Now we can turn to <u>kinship</u> as a means of escape from the Prisoners'

Dilemma trap. We may note from equation (7) that, for any <u>constant</u> recogni-

tion coefficients (however favorable) the discrimination factor m approaches

zero as p goes to zero. This is what makes it hard for a critical mass of Helpers

to evolve. But, for kinship helping, there is a considerably better lower

bound on m. Suppose we are talking of siblings, for whom genetic relatedness

is $r = 1/2$. (The probability of two siblings having received the same gene

at any given haploid locus -- that is, of both having inherited the mother's

gene or both the father's gene -- equals 50%.) What happens when p approaches

zero? We can imagine that the helping gene arose as a single new mutation

in one parent. Then, if a given offspring of that parent is a Helper, there is

a 50% chance that its sibling is a fellow-Helper. Thus, at the limit,

$m = r = 1/2$. And in fact, for sibling helping the relation between m and p

is:

$$m = \frac{1+p}{2} \tag{11}$$

Even when p approaches zero, the proportion of helping acts directed at

fellow-Helpers never goes below 50%, and m rises toward unity as p increases.[1]

It follows immediately that the population will evolve toward cooperation

(p=1) of the Help-your-sibling variety if and only if:

$$c/b < 1/2 \tag{12}$$

Or, more generally for any degree of relatedness r, if and only if:

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[1]In terms of the underlying recognition coefficients, if $m = \frac{1+p}{2}$

then it follows from (6) that $\frac{1+p}{p} = \frac{v_H}{v_N}$. So the ratio v_H/v_N falls as p rises, but never goes below 2.

$$c/b < r \qquad (13)$$

Thus, helping relatives will be more viable in evolutionary terms than nonhelping whenever the cost-benefit ratio of the helping act is less than the degree of relatedness. For efficiency in the PPP sense, however, the rule "should" be to help whenever $c/b < 1$. Thus, even within the kinship group, the kin-selection process provides only a partial escape from the Prisoners' Dilemma.

3. Group selection

A topic much debated among biologists is the degree to which evolution of cooperative behavior may be due to group selection. Under kin selection, the favorable discrimination factor m needed to make helping viable is achieved because helping one's relatives is likely to mean helping fellow-carriers of one's own helping gene H. In the genetic sense, a relative is partially one's self. Under group selection, the discrimination needed for viability of H is supposed to be achieved simply by propinquity, combined with improved survival of groups containing helpers.

In anthropological terms, it seems reasonable to infer that the shift from small kinship-based bands to large nations has been associated with a corresponding shift from kin selection to group selection as the major winnowing process in human evolution. Kin selection still, it is evident, retains importance today for eliciting helping actions within the family. But we are much more interested in the viability of cooperative behaviors among unrelated individuals in the group structures of modern life.

Kin selection and group selection are often hard to distinguish in practice. Neighbors are more likely than random members of a population to share common ancestry. To illustrate the power and limitations of group

selection, we will analyze a simple model containing no element of kinship.

Suppose an entire population swarms together at mating time, but otherwise divides itself quite randomly into propinquity subgroups. Then, by sheer chance, certain subgroups will be characterized by higher-than-average fractions of help-your-neighbor H genes -- even though members of a given subgroup are not otherwise any more closely related than average. The mechanism of group selection postulates that the viability of subgroups will be strongly correlated with the proportions of helpers they contain. Differential subgroup survival will then tend to raise the overall fraction of H genes in the population. The problem, however, is that within each subgroup containing Helpers, it pays Nonhelpers to free-ride upon them. It has been shown that it is nevertheless mathematically possible for the proportion p of Helpers in the population to increase; the inter-group gain from helping may overcome the intra-group loss. But the dominant opinion among biologists is that the conditions for this to occur are so special that, factually speaking, group selection essentially never operates[1] in Nature -- at least, below the level of Homo sapiens.

Analysis in terms of the discrimination factor m sheds some additional light upon the difficulty with group selection. If in fact a population broke up merely randomly into binomially distributed samples of unrelated carriers of H and N genes, then propinquity alone would dictate that m --

[1]See Williams [1966], Maynard Smith [1964]. The major instance of group selection commonly cited is the tendency toward reduced virulence of disease germs (Barash [1977] Ch. 4). But even this is not a pure group-selection case, as there is a kin-selection element involved (Alexander and Borgia [1978]).

the overall proportion of helping acts directed at fellow-Helpers -- would just
equal p! Condition (5) could not be met, and helping would not be viable.
To make it viable, some other conditions would have to be modified. For
example, it might be that the per-act benefit b is not a constant but
increases with the number of Helpers per group, thanks to some kind of
increasing returns. Alternatively, it might be that grouping causes the
recognition coefficients v_H and $\bar{v}_N$ to take on more favorable values.

Whatever the mechanism may be, it can only work through differential
survival of Helper and Nonhelper genes as a function of the number of
cooperative individuals falling into any given subgroup. To take the simplest
case, suppose that after the initial mating swarm the population divides
into subgroups of exactly two members each. With random segregation, if
the proportion of H genes in the population is p then the proportion of
groups containing two Helpers will be p^2, the proportion containing just one
Helper will be 2pq (where q = 1-p), and the proportion containing zero
Helpers will be q^2.

Let s_{2H} be the per-capita survival probability of Helper individuals
in groups of two H's, let s_{ON} be the per-capita survival probability of
Nonhelper individuals in groups of two N's, and let s_{1H} and s_{1N} be the
respective survival chances of each type of individual in mixed groups. We
would expect the survival probabilities to rank as follows: $s_{1N}, s_{2H} > s_{1H}, s_{ON}$.
That is, the more profitable situations are (1) to be a free-rider upon a
Helper partner (s_{1N}), or (2) to be one of the two Helpers in an all-H
group (s_{2H}). The less profitable situations are (3) to be a Helper with a
Nonhelper partner (s_{1H}), or else to be one of two Nonhelpers (s_{ON}). (The
proper rankings within the upper and the lower pairs will be left open for
the moment.)

After the differential selection of H and N genes[1] represented by these survival probabilities takes place, in the next mating swarm the new Helper/Nonhelper ratio $(p/q)'$ in the overall population will be:

$$(p/q)' = \frac{p^2 s_{2H} + pq s_{1H}}{q^2 s_{ON} + pq s_{1N}} \tag{14}$$

At equilibrium, $(p/q)'$ would have to equal p/q, so:

$$1 = \frac{p s_{2H} + q s_{1H}}{q s_{ON} + p s_{1N}}$$

Or,

$$\frac{p}{q} = \frac{s_{1H} - s_{ON}}{s_{1N} - s_{2H}} \tag{15}$$

It may be verified that this is a stable interior solution if both numerator and denominator on the right-hand-side of (15) are positive. The H gene will remain present in the population at large if $s_{1H} > s_{ON}$, and the N gene if $s_{1N} > s_{2H}$. When these conditions are met, within each subgroup we have a Hawk-Dove type of game (as described in Section IV). If we had instead a true within-subgroup Prisoners' Dilemma, so that it always paid to be a Nonhelper whatever the other party played, the survival probabilities would show $s_{1N} < s_{ON}$ as well as $s_{2H} < s_{1N}$ — the H gene would not be

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[1] The standard biological literature on this subject (see for example E.O. Wilson [1975], Ch. 5; Barash [1977], Ch. 4) places undue emphasis upon differential group extinction as the critical factor in group selection. This is somewhat misleading. Differential rates of group extinction play an important role, but are by no means a sufficient statistic for determining the proportions of H and N genes in the next generation; it is also necessary to take account of differential H and N survival within groups, both those going extinct and those not doing so. In the biological literature, the model here is generally consistent with that of D.S. Wilson [1975] and (I believe) with the views of Hamilton [1975].

viable at all in the population. Put another way, for the H gene to survive in this model despite the advantage of being a free-rider when one's partner is a Helper (i.e., where the denominator in (15) is positive), it must be that when one's partner is a Nonhelper it is selfishly advantageous to be a Helper (i.e., the numerator must be positive). This seems rather implausible; we would probably expect the numerator in (15) to be negative. But there is another route to viability of helping -- the denominator might be negative. If only the denominator were negative, q would go to zero and all the population would be Helpers in equilibrium. In what is probably the most interesting case, where both numerator and denominator are negative, the interior equality will be unstable -- the population will go to all-H or all-N depending upon the initial situation. Then, a critical mass would be necessary for viability of helping behavior. (Compare the Tender Trap game in Section IV.)[1]

If we think in terms of selection operating among (and within) human groups, the increasing-returns factor mentioned earlier tends to make s_{2H} very big, thus contributing to a negative denominator in (15). One arena where increasing returns to within-group cooperation are particularly effective is warfare,[2] and warfare among humans has been a potent selective force.[3] Suppose it is the case that $s_{2H} > s_{1N}$. That means your survival chances, if your partner is a Hero, are better fighting alongside him than running away. If in addition $s_{1H} > s_{ON}$ (even if your partner runs away, it is still better to fight on), the numerator in (15) is positive and the

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[1] More complicated models, involving groups larger than two, or partial in-group mating rather than simple swarming, will of course have more complex stability conditions. But the simple model here lays bare the key issues.

[2] "God is on the side of the bigger battalions" -- Voltaire.

[3] Alexander [1979], Ch. 4.

Nonhelper gene will be driven out. This does seem implausible. But even if the latter condition fails, there will still be a critical mass for p beyond which only helping behavior is viable so long as s_{2H} exceeds s_{1N}. And the critical mass is the more easily achieved, the greater is this difference.

The other force tending to raise the discrimination factor m is improved recognition within groups, which allows carriers of the H gene to modify their behavior so as to reward fellow-H's and punish N's. This seems a likely result of human intelligence. In particular, suppose it really does not make sense to fight on if one's partner runs away $(s_{1H} < s_{ON})$. Then, a smart Hero will act accordingly -- i.e., will run away himself. If his recognition coefficient for Nonhelper partners were perfect $(\bar{v}_N = 0)$, his recognition-adjusted survival probability would then be $s'_{1H} = s_{ON}$ rather than $s_{1H} < s_{ON}$. Even short of this, any improved s'_{1H} relative to s_{ON} would reduce the negative balance in the numerator of (15) and thus tend to make Helping more viable.

B. Nonsymmetric Strategies

We have already seen how a kind of asymmetry may lead to complementary strategic choices in the Hawk-Dove game -- converting the solution from an interior mixture of Hawks and Doves to fully efficient Hawk-Dove pairing. We are here considering possibly asymmetries in the Prisoners' Dilemma context. There are of course many possible dimensions along which some degree of asymmetry may obtain: the payoffs might diverge from the fully symmetrical form of Matrix 7, or there might be differential knowledge of these elements, or differential communication capacities, or the players might vary in their ability to recognize fellow-Helpers, etc. In this section I will mainly

consider, however, an asymmetry in ability to employ threat or promise strategies.

A more general statement is in order first. We have so far been considering only interactions within homogeneous populations, encounters where the player choosing Row comes from the same population as the player choosing Column. In all such cases Nonhelpers are free-riders on Helpers. A bird that endangered itself by calling out to others when a predator appears would be subject to free-riding on the part of those who never call warnings. In Matrix 7, this feature is represented by the advantage of Nonhelpers over Helpers in the off-diagonal cells. But when the interacting players come from different populations, free-riding disappears. A bee following a "Nonhelper" strategy of refusing to pick up pollen from a flower does not gain thereby; the flower loses, but so does the bee. Evidently, there is no Prisoners' Dilemma trap here at all; if a mutual benefit exists, the "Helper" strategy is dominant for both players. It is quite generally easier, therefore, to convert potential into actual cooperation when the players come from different populations, or are otherwise in less direct competition with one another. One advantage of sexual over asexual reproduction, perhaps, is that sex divides the population into largely non-competing halves. Males compete with males, and females with females, but the male-female interaction is complementary.[1]

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[1] This is not entirely true, of course. For one thing, at the genetic level a "gene for having male offspring" can be regarded as in competition with a "gene for having female offspring." But given that the population is sexually divided, intra-sex competition is much more intense than inter-sex competition.

Turning back to the Prisoners' Dilemma, I will be considering here a particular form of nonsymmetrical strategy -- commitment to a threat or a promise. Commitment is very much like the Retaliator strategy represented in the symmetric Matrix 8: the player cooperates with Helpers, but not with Nonhelpers. But here we allow only one of the players to adopt such a strategy, as shown in Matrix 10.

Commitment as a type of strategy has many interesting features.[1] First, its essence is restriction of one's own freedom of action. It is an engagement to do something one would otherwise not do, in order to influence the behavior of the other party. Second, the difference between commitment to a threat versus a promise is not fundamental. Threat, strictly speaking, would involve Committer in a self-damaging "punishment" response to Nonhelper behavior; promise, in a self-damaging "reward" respond for Helper behavior.[2] Third, threats or promises involve communication as well as commitment. If the other party does not know of the commitment, or does not believe it, his behavior will not be affected. But only one-way communication is required, and indeed threats and promises may typically be more effective if only one-way communication is possible.

Incorporation of a Commitment strategy into the options of one player allows achievement of the efficient outcome. In Matrix 10, upon Row's commitment to R_3 and communication of that commitment, Column player will choose the Helper strategy C_1 so long as $b > c$ -- that is, whenever mutual helping

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[1] For a fuller discussion, see Schelling [1960], Ch. 2, 5.

[2] In these terms, R_3 in Matrix 10 represents a promise rather than a threat. (Row promises not to play his more advantageous R_2 if Column plays C_1.)

satisfies the criterion of efficiency.

To achieve this result in pairwise interactions, the players would have to combine into subordinate-superordinate teams. For larger groupings, this form of teaming generalizes to a hierarchical ranking system in which each player makes a commitment-plus-communication move in relation to those below him.[1] One further implication may be of interest for our purposes. It was suggested above that law could be thought of as an institutionalized "impartial" third party whose function is to enforce agreements between members of potentially cooperating dyads. This left open the question of who is to play that role, and what incentive there is for him to do so. The present discussion illustrates another institutional model of law: hierarchy. Here the suggestion is that one possible basis of law is the threat (or promise) on the part of superordinate parties to mete out punishment should subordinates engage in non-cooperative behavior (or to grant rewards for cooperative behavior). As an interesting point, it is not logically necessary that the superordinate player actually ends up any better off than do the subordinates! And, in fact, in our otherwise symmetrical Matrix 10 the two players do equally well. (In such a situation there might be unanimous agreement on the principle of hierarchy, even if the actual ranks were to be randomly chosen.) However, as a practical matter it seems likely that only an initial asymmetry of power will lead to this form of solution to the Prisoners' Dilemma, and consequently that the superordinate player will set up the terms of the association (the elements of the payoff matrix) so as to reap the superior outcome.[2]

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[1]This situation is analyzed in detail in Thompson and Faith [1976, 1979].

[2]See Section VII.B below.

The Committer in Matrix 10 is promising to reward the other player by not playing his Nonhelper strategy R_2 if the latter plays the cooperative strategy C_1 -- but the other player knows that if he should play C_1, the Committer would be better off reneging (choosing R_2 any-way). How can threats (or promises) be made credible? As a means of providing the needed guarantee, Nature has evolved "uncontrollable" emotions -- of loving gratitude or vengeful rage as the case may be. Put another way, it sometimes pays off to be irrational, to lose the capacity for optimizing choice. Even on the human level, emotions limit the possible scope of rational behavior -- not always to our disadvantage.[1]

One interesting example of these ideas is the "Rotten-kid" model.[2] A selfish individual (the Rotten Kid) can be induced to engage in cooperative behavior by an appropriate promise of reward. One way of guaranteeing such reward is for the other member of the dyad (Big Daddy) to evolve a sufficient degree of benevolence for Rotten Kid. The strategic situation must be asymmetrical, in that Big Daddy must be able to <u>commit</u> himself to rewarding cooperation by distributing enough of the gain back to Rotten Kid. (And of course he must be able to communicate the fact of that

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[1] The difficulty of guaranteeing to behave in a way that is ex-post irrational is exemplified by the "Mutual Assured Destruction" (MAD) problem in nuclear deterrent strategy. The underlying theory is that a potential attacker will be deterred if the target nation can retain enough strength to impose sufficient retaliatory damage. Yet, having suffered the attack, the victim's "rational" incentive to retaliate is not very strong. One's own losses are no longer remediable, and it seems pointless to engage in mass murder of the other population. A semi-whimsical solution for the problem is the "Doomsday Machine," which would make retaliation automatic rather than subject to human control or recall.

[2] Becker [1976]. Becker's discussion is in the context of the family, so there is some danger of confounding this route to cooperation with mutual aid due to relatedness (kin selection). The mechanisms are entirely separate, and relatedness plays no role in the present analysis.

commitment.) The emotion of love provides the needed guarantee. The crucial point is that <u>Big Daddy himself also ends up better off</u>. And better off not merely in terms of emotional satisfactions, but in terms of the actual material gains needed to make the commitment-to-benevolence strategy a viable one.

In Figure 4, on axes representing Daddy's income I_D versus Kid's income I_K, Rotten Kid simply wants to attain a position highest up in the I_K direction. (In effect, Kid's indifference curves are horizontal.) Daddy's degree of love and concern for Kid is illustrated by his normal-looking indifference curve U_D. We now must suppose that Kid makes the first move, and Daddy the second: Kid proposes, but Daddy disposes.[1] If Kid were short-sighted as well as selfish, he would choose point R*. But, knowing Daddy's emotion-based commitment, Kid in his long-run self-interest should choose position J* -- which is jointly optimum ("efficient") in the sense of achieving the highest sum $I_K + I_D$. From J*, Daddy makes a love-induced transfer along the 135° line SS to his indifference-curve tangency optimum A*. Kid's "pragmatic" cooperation has been repaid, since A* is higher up (involves larger I_K) than R*. But, what is more remarkable, Daddy's "Hard-core" cooperation[2] has also paid off in material terms: I_D too is higher at J* than at R*. And in fact, if Big Daddy were somewhat less loving as represented by his alternative indifference curve U_D', he would only react to Kid's cooperative move by more limited income transfers to point B*, which

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[1] The necessity for this "hierarchical" asymmetry is emphasized in Hirshleifer [1977].

[2] For further discussion of pragmatic versus hard-core cooperation, see E.O. Wilson [1977].

Kid's
consumption

135° transfer line

U_D

U'_D

A

R^*

P

Joint production-
income
opportunities

B

j^*

O

S

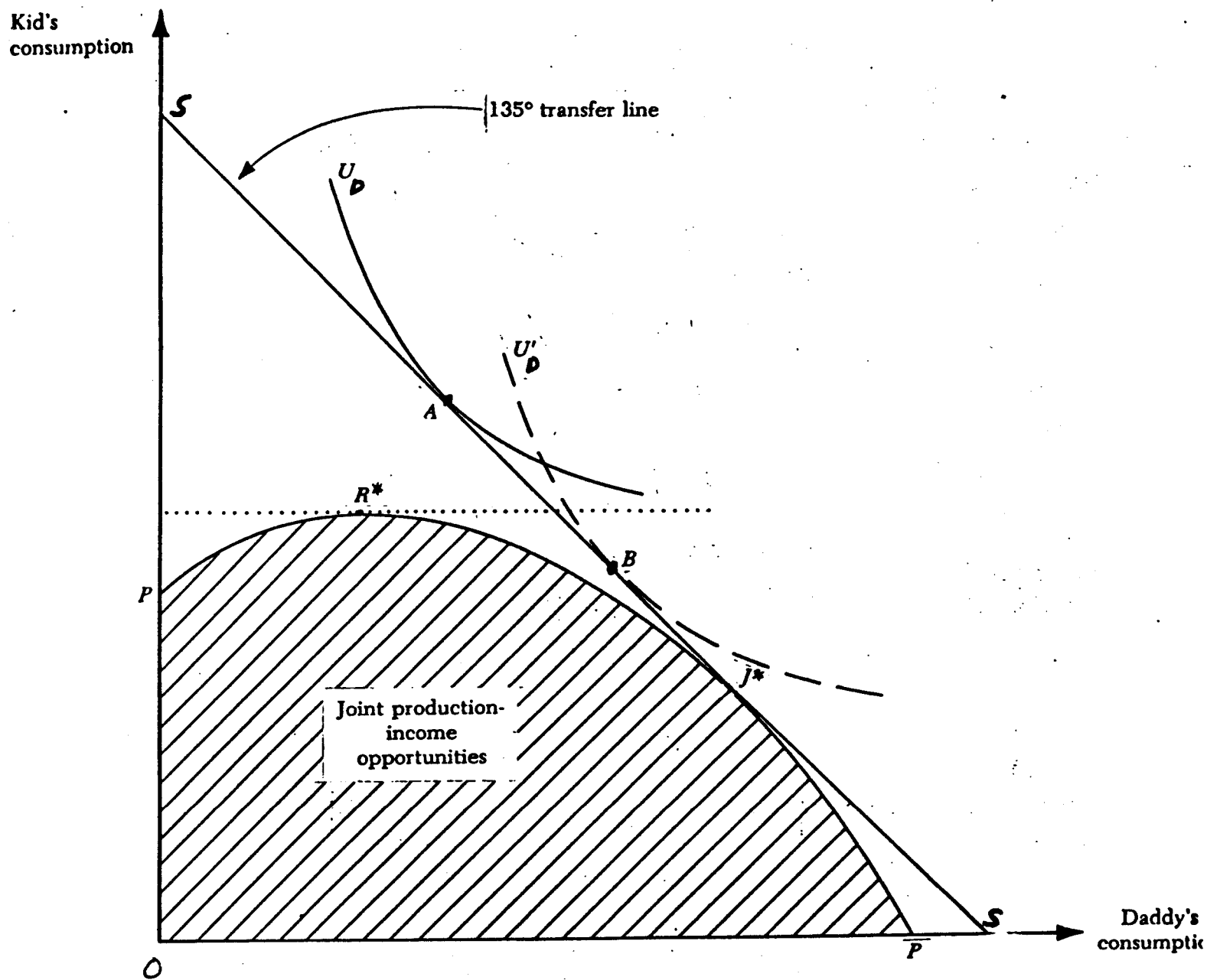$\overline{P}$

S

Daddy's
consumption

Figure 4

Rotten Kid and Big Daddy

would be insufficient to motivate Kid to cooperate in the first place.

As one further implication of this analysis, benevolence or love on the one hand -- and rage or jealousy on the other -- are the sort of preferences or "tastes" that the economist is likely to regard as arbitrary brute facts. The evolutionary approach, in contrast, suggests that at least some aspects of preferences are not accidental, but have evolved as ways of restraining freedom of choice where such restraint can conduce to advantageous coopera-tion. More broadly speaking, it suggests (as will be brought out later) that social ethics -- such as ingrained respect for property rights, or obedience to constituted leaders, etc. -- may also have evolved to aid group efficiency by allowing the Prisoners' Dilemma to be overcome.

A number of econo-legal scholars have suggested that "altruism" is a partial substitute for law in eliciting cooperative behavior.[1] The thrust of our theoretical development in Sections IV and V has been to the effect that the situation is far, far more complex than that. The likelihood that cooperative behavior will be viable depends on the details of the ecological situation (summarized, in our simple models, by the game matrices). Further-more, helping can emerge among organisms evidently incapable of "altruism" in any ethical or psychological sense of the word. Among more advanced animals including man, on the other hand, emotions like benevolence and love can indeed serve to promote helping interactions -- but it may well be that emotions like hate and rage are at least equally important (to induce, for example, "irrational" efforts to punish non-cooperators).

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[1]See, for example, Kurz [1977], Landes and Posner [1978].

Sections IV and V of this paper explored a number of alternative routes along which cooperation might evolve. In a binary-strategy world of random dyadic encounters between members of a homogeneous population, the possible payoff patterns (environmental situations) fall into a limited set of classes. In Tender Trap all the motivation is to cooperate, yet the population might (depending upon the initial situation and the required critical mass) not end up in the best cooperative solution. In Hawk-Dove there are mixed motives. The cooperative strategy (Dove) can be the more advantageous, up to a point, but not to the extent of driving out Hawk. (That is, each strategy is the more profitable once sufficiently rare in the population.) Thus, the result tends to be a mixed population (or a homogeneous population playing a mixture of strategies). What was rather significant is that some structuring of the possible encounters in Hawk-Dove may allow fully complementary efficient pairing. In particular, the evolutionary equilibrium achievable under the rule "first come first served" is a possible precursor of territoriality and property rights. This solution is associated with a "Bourgeois" strategy: playing Hawk against intruders, but Dove against possessors.

But if the environmental circumstances correspond to the game of Prisoners' Dilemma, where the cooperative strategy is always dominated by the non-cooperative, evolution of mutual-aid interactions will be much more difficult. A Retaliator strategy would be the analog to Bourgeois in the Hawk-Dove game. Like Bourgeois, Retaliator represents self-enforcement of cooperation: Retaliator reacts favorably to good behavior, while punishing bad behavior committed against himself. But Retaliator seems not be be viable under Prisoners' Dilemma. Various other routes to cooperation do promise a

degree of success. Nepotism (aiding only one's kin) facilitates cooperative
interactions, but not so far as to achieve full efficiency even within the
kinship group. Much the same can be said for other "discrimination" techniques,
as in group selection, which focus aid upon individuals more likely to be
fellow-helpers. Ability to interact repeatedly with the same partner may
also provide a partial escape. More interesting for our purposes here
is the asymmetrical or hierarchical route out of the Prisoners' Dilemma.
A player in a superordinate role can make a pattern of cooperation effective
by becoming committed to a threat of punishment for bad behavior (or, what
is essentially equivalent, a promise of reward for good behavior).

VI. COMPETITION AND EFFICIENCY

For eco-biologists in the Malthus-Darwin tradition, competition -- in the ruthless sense of the struggle for existence -- is the fundamental principle of Nature's economy. The source of competition is the limited resource base of the globe in the face of the universal tendency of populations to multiply. By natural selection the biosphere has come to teem with life forms successful at pressing upon one another to obtain the nutrients needed to sustain life.

Biologists have found it useful to distinguish three main classes of competitive strategies: <u>scramble</u>, <u>interference</u>, and <u>predation</u>.[1] Scramble competitors interact only through depletion of resources. The winning organisms are those most effective at extracting energy and other needed inputs from the external environment. <u>Interference</u> competitors, in contrast, gain and maintain control over resources by attacking (or otherwise reducing the efficiency of) other contenders -- mainly, though not exclusively, of their conspecifics. (Members of the same species, having a higher overlap zone of resource needs, are typically closer rivals than members of different species.) <u>Predation</u>, finally, is mainly interspecific[2] -- the competitor organisms have been made part of the resource field.[3]

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[1] This classification represents only one of the dimensions along which distinctions might be made. One might distinguish also strategies of competing by high survival versus high fertility, by adventurous versus risk-avoiding behavior, by specializing versus generalizing in use of resources, by adaptation to mountain or desert or polar conditions, etc. Another strategic dimension which is very crucial for our purposes is competition via isolated versus group struggle.

[2] Cannibalism occurs widely in Nature, but is still far less common than eating other species. Conceivably, this is the result of group selection.

[3] The predator-prey interaction has a cooperative aspect, though a one-sided one. A rational predator would be concerned to promote the survival of its prey species, but generally speaking the prey would do better without the predator.

Competition in Nature, in all these forms, tends to be both anti-social
and wasteful of resources. And yet the economist views market competition
as a harmonizing force, one that leads to productive efficiency. What are
the special features of market competition making this possible? First, under
idealized institutions of political economy only the more innocuous form
of "scramble" competition is permitted in the market. When one businessman
finds a customer for his output or a supplier for needed input, he does indeed
deplete the resource field for other businessmen. But he is not permitted
to blow up his rival's shop (interference), or to stock his own store by
raiding the other's inventory (predation). Second, again under idealized
conditions, the adverse externalities that the businessman imposes on his
competitors are only "pecuniary" -- as discussed in Section II above. A
less successful business competitor may have to lower his product price quota-
tion to customers, or raise his hire-price offer to input suppliers, but in
"efficiency" terms the effects of such price adjustments cancel out. Another
way of looking at this is to note that market competition for the economist
is not a two-sided but a three-sided interaction. The market competitor
vies not just _against_ a rival, but _for_ the opportunity to engage in mutually
advantageous exchanges with other parties. The gain to third parties in this
"vying-competition" counterbalances any loss suffered by competitors. In
simple two-sided "taking-competition," in contrast, there is no such off-
setting gain. The really useful distinction (so far as efficiency is con-
cerned) is therefore not along the scramble-interference-predation dimension
but rather is the dichotomy of competitive _vying versus taking_.

While the more downright _taking_ form of competition is far more common
in Nature, important instances of vying-competition have evolved as well.

In sexual competition there are two main modes of resolving rivalry for females:[1] (1) male combat and (2) female choice.[2] The latter comes close to what the economist would regard as mutually advantageous exchange. Where female choice obtains, males defer to the female's "property right" in her own reproductive capacity, which she will dispose of at her option to the most desired partner.

On the human level, taking in its extreme "interference" version is clearly the mode of competition in duels for survival such as Rome versus Carthage, or Ike Clanton versus Wyatt Earp. Such competition obviously tends to adopt inefficient or even violent methods. Turning back to male combat as an example of taking-competition in Nature, the wasteful results include not only the direct damage which one or both combatants may suffer, but the consequent misdirected evolutionary trends -- such as sexual dimorphism (the development of excessive male size, or weapons like horns and claws, that serve only for fighting other males). The consequences of human "interference" competition are entirely parallel, whether we speak in terms of genetic or cultural evolution.[3] But even the "scramble" form of taking-competition is inefficient in the absence of property rights. An organism chancing upon a food source will consume it until the marginal

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[1] Males are essentially always in severer competition for females than females for males. The female's more costly investment in facilities for reproduction is the scarce resource sought after by males. (On the other hand, females may compete for higher-quality males, especially where monogamy governs.)

[2] In Darwin's words, males strive "to conquer other males in battle" or alternatively "to charm the females."

[3] Culturally, humans learn that a degree of willingness to fight for resources does pay off in this world. Whether this message has become genetically implanted in the human species may be left an open question for the moment. As to sexual competition, male superiority in size and strength suggests that the principle of male combat may have governed even in human evolution. (On sexual competiton as a cause of possible masculine intellectual as well as physical superiority, see The Descent of Man, Ch. 19.)

benefit to itself falls to zero, even though stopping earlier might be more efficient for the species or other larger group -- i.e., might provide greater nourishment for the next searcher.

What has come to be known as <u>rent seeking</u> is a less violent, "scramble" form of competition in human affairs.[1] Where an asset exists that has not been reduced to recognized property, an inefficient struggle for the resource (or for the fruits thereof) tends to take place. This struggle takes two main forms. If the asset can be sequestered (e.g., if it can become legally protected property), its value will thereafter be maintained even though valuable goods or services may have been initially wasted in the two-sided competition for it. An example would be a political struggle for a television channel or an airline route. Where the asset cannot be or is not sequestered at all, as in the case of common-property resources like hunting grounds or underground aquifers, unlimited taking-competition tends to sharply reduce the net social yield.

To achieve an ideal state of efficiency, property rights in all resources would have to be pre-assigned and perfectly respected. Absent these conditions there will be "excessive" efforts to acquire assets (if they can be sequestered) or to seize their fruits (if they cannot be sequestered). Such efforts include unlawful activities like theft (but recall that defending against theft is also inefficient).[2] Resource-taking may also occur because there is no relevant law, as when nations contend for power or territory. Or, finally,

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[1] See Kreuger [1974], Tullock [1967], Posner [1975]. The term "rent-seeking" is another unfortunate terminological choice. All economic agents are seeking "rents" -- i.e., returns to resources under their control. The loss of efficiency is not due to <u>rent-seeking</u>, but to effort expended in <u>resource-taking</u>.

[2] At least in the short-run, and if the thief is regarded as a member of the group within which efficiency is calculated -- see Section II.

taking-competition may take place even under law (which may or may not

be regarded as an "imperfection" of the legal order). One example is the

search for undiscovered resources like petroleum, fish, or ideas (whether

patentable or not). Such search is, evidently, not totally wasteful. The

increments to the community's stock of resources are socially useful, but

it remains true that the degree of effort devoted to searching tends to

be excessive.[1] The costly contests that take the form of redistributive

politics, on the other hand, are unqualifiably inefficient.[2]

We are not surprised that male combat for females, or struggles for ter-

ritory or pecking-order dominance (and their human analogs), represent

wasteful forms of competition. Much more puzzling is that highly

inefficient competition has evolved in Nature even in cases where the equi-

valent of preassigned and respected "property rights" does exist -- specifically,

in male competition for mates even where female choice governs. The peacocks

with their burdensome tails are an obvious instance. Another case is that of

the bower-bird males, who toil at constructing attractive (rather than merely

utilitarian) domiciles for prospective spouses. Two explanations have been

offered. First, that the evolution of attractive sexual characters is a

self-sustaining pattern, rather on the order of a chain letter or a speculative

bubble.[3] It pays a peahen in the current generation to choose the cock with

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[1] For the fishery case, see Gordon [1954]. On the possibility of "exces-
sive" searching for ideas, see Cheung [1979] and Hirshleifer [1971].

[2] Again, only if both gainers and losers are considered part of the group
within which efficiency is calculated. From the point of view of the gainers alone,
the losers may merely constitute a resource field -- like a prey species.

[3] See R.A. Fisher [1958], p. 152, Dawkins [1976], p. 170.

the largest tail, because her male offspring will then also tend to have big tails, thus attracting the next generation's peahens, who will prefer big-tailed cocks so that their sons will have big tails, and so on indefinitely. Alternatively, it has been suggested[1] that we have here what the economist would call a "signalling equilibrium."[2] The big tail is a kind of advertisement. It does not contribute to the male cock's quality as a mate, but it signals quality -- since only a very strong bird can successfully carry a big tail.[3] Note that this explanation also has a rather fragile or unstable "self-sustaining" element; it pays for hens of this generation to respond to this signal only to the extent that future hens will read the signal the same way.

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[1]See Zahavi [1975].

[2]See Spence [1974, Riley [1975].

[3]For an analogous theory of advertising, see Nelson [1970, 1974].

VII.   EVOLUTION AND LAW

A.   Forms of Association, and Precursors of Law

Man's laws are subject to the deeper rules of Nature. The first of
these rules is that all living forms are in reproductive (Malthusian)
competition with one another. However, and here we come to what might be
called Nature's second rule, it is often more effective for separate organisms to
come together and engage in cooperative association. But such alliances
are merely secondary and contingent, in at least two respects: (1) In-
group cooperation is only a means for more effectively and ruthlessly compet-
ing against outsiders; and (2) There is never perfect parallelism of
interest among the members of a group, hence cooperation must generally be
supported by sanctions to punish "anti-social" behavior. Indeed, one of
the greatest obstacles to cooperation is the fact that those individuals having
the best opportunities to engage in mutual aid -- because they are nearest
in terms of propinquity or similarity or relatedness -- are commonly the most
closely competitive in their needs for resources.

Forms of association vary widely in degree of cooperativeness. What
seems to be a social unit may be only a "selfish herd":[1] the term refers
to animals who seek protection against predators by moving toward the center
of the crowd, thus placing others at risk on the periphery. Here the element
of cooperation is entirely lacking. Then there are cases of merely parallel
mutual interests, as when birds return annually to a mating area where they
can expect to find other birds. In patterns of association like territoria-
lity or dominance hierarchies there is at least a negative cooperative

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[1]Hamilton [1971].

element, a tendency to avoid strife. And, finally, there are true communities --
most notably, families -- characterized by more or less intense positive
helping.

The theoretical analysis in Sections IV and V suggested two possible
situations serving as precursors of law, interpreted as a system of retaliation
that deters noncooperative behavior: (1) Bourgeois strategies under Hawk-
Dove, and (2) Hierarchy under Prisoners' Dilemma. In the relatively benign
environment corresponding to the conditions of the Hawk-Dove game, the
regulation of behavior is egalitarian and decentralized. In the severer
environment corresponding to Prisoners' Dilemma, it is hierarchical and
centralized. In each case a "social ethic" is also involved, in the sense
that one or more of the parties is required to engage in behavior that is
not in its private interest in terms of the immediate situation. In Matrix
6, playing Bourgeois (R_3) means foregoing the more profitable Hawk strategy
(R_2) upon encountering a Dove (C_1), as well as the more profitable Dove
strategy (R_1) upon encountering a Hawk (C_2). And in Matrix 10 the super-
ordinate Committer strategist (R_3) foregoes the more profitable Nonhelper
choice (R_2) against Helper (C_1) -- that is, he rewards cooperative behavior.
(Compare also "Big Daddy" in Fig. 4.)

The Bourgeois solution under Hawk-Dove can be generalized to a population
of any size, in which everyone possesses some property or territory which
he is prepared to defend. The Committer solution under Prisoners' Dilemma
also extends to a group of any size, each member being ranked relative to
all others. Nevertheless, the limitation of the analysis in Sections IV
and V to binary-strategy dyadic encounters in a homogeneous population
remains very restrictive, and I do not mean to imply that there are not

other archetypes or primitive forms of law that arise out of more complex

interactions. And in particular, I believe that another source of law

arises out of the balance-of-power or coalitional considerations that emerge

when more than two parties interact.

More specifically, this other source corresponds to what biologists

have called <u>moralistic aggression</u>:[1] intervention of "uninvolved" third

parties on the side of the victim of hostile or uncooperative behavior.[2]

I am not prepared to provide a formal analysis, but I conjecture that

moralistic aggression will be a viable strategy -- at least, as part of a

mixed solution -- in multi-party Prisoners' Dilemma interactions. If moralistic

aggression is operative, coalitional power in an egalitarian social structure

serves essentially the same role as the dominant power of a superordinate

player in a hierarchical structure. Like the other sources of law, moralistic

aggression also involves a social ethic; the intervenor foregoes the short-

run advantage of shirking the third-party enforcer role.

Finally, we should keep in mind that forces promoting cooperation may

amplify and support one another. Kin selection and group selection are each

perhaps weak forces regarded separately, but they tend to be mutually

reinforcing since members of propinquity groupings are almost always more

closely related than average in the population. Parent-child nepotism

may also support a cooperative superordinate-subordinate commitment interaction

(Big Daddy in our example above). And similarly, parents might be more

inclined than mere outsiders to play the "moralistic aggressor" role so as

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[1]Trivers [1971].

[2]On this, see also Hamilton [1975], Aubert [1963].

to enforce mutual helping among their offspring.

B. <u>On the Historical Evolution of Law</u>

A number of legal historians and philosophers have viewed the law
as following an evolutionary course of change. Before commenting on these
interpretations, it is elementary though perhaps still useful to notice
that the evolution of law must be considered in conjunction with the evolu-
tion of societal forms. Very primitive men lived in small bands based
primarily upon a hunting economy. Later on pastoralism and agriculture
emerged, followed ultimately by industry. To bring out a slightly less
familiar point, at least one other economic way of life has been important
probably in all historical periods: predation upon other human groups.
In response to accumulated technological advances and other forces (climatic
change, population growth, pressure of nonhuman and human predators), the
typical <u>scale</u> of human association has gradually increased over time --
culminating eventually in the large modern nation-state based upon div-
ersified economic activity and the division of labor.

It goes without saying that the characteristic laws of an era when
most of the world's population lived in sparsely-distributed hunting bands
must have diverged from the types of law in force now, when most people
live in urban environments within huge national states. There is a question
of cause versus effect here. I am suggesting that the law responds to
larger social changes governing forms of economy and state. But, to some
extent at least, legal systems tend to bring about these larger changes.
For example, Marxist communism as a system of law has not proved to be
very conducive to economic advance -- but its effectiveness in organizing
and using military strength against internal and external enemies has led

to its enormous extension over the face of the globe.

Returning to the traditional legal historians,[1] they have -- not surprisingly, in the light of the foregoing -- tended to agree that the dominant evolutionary trend is from laws suitable for an intimate face-to-face community to a legal system capable of governing impersonal public life among strangers (from _Gemeinschaft_ to _Gessellschaft_).[2] More specifically, Sir Henry Maine contended that the directions of historical change were from family responsibility to individual obligation, and from legal relations based on family status to those based upon contract. Max Weber emphasized progress toward abstract rationality, decisions being made in accord with logic and principle rather than personality, magic, or emotion. A somewhat similar position was taken by Roscoe Pound, who tended to emphasize moral as well as procedural improvements in this unfolding development. Somewhat more specifically, primitive law was said to be characterized by strict liability, self-help, and collective responsibility; modern law by liability only for moral fault, recourse via impartial public law rather then self-help, and individual rather than collective responsibility for behavior.[3]

There is considerable disagreement among scholars on both the broad sweep and the finer details of these trends. For instance, important elements of strict liability remain in modern American law, and their scope may even be expanding (as in workmen's compensation). But, far more importantly, the drastic events suffered by humanity in the twentieth century cast a

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[1]For citations and discussion, see Friedman [1975], Moore [1978].

[2]Ferdinand Tonnies, cited in Friedman [1975], p. 282.

[3]For a general discussion see Moore [1978], especially Ch. 3.

dubious light upon the generally optimistic tone of this entire line of thinking, and especially upon the implied trend toward ethical as well as procedural progress in systems of law governing the majority of men.

Thrasymachus in Plato's Republic says that "Justice is the interest of the stronger." If we interpret this as a positive statement (rather than as a principle of normative ethics), it is difficult not to concede a degree of validity to the Sophist's contention.[1] A revisionist interpretation of past legal trends might seek to explain why the more powerful groups have been led to favor collective responsibility in some areas and times, individual responsibility in others, and so forth. Or perhaps more correctly, why the balances of power among groups of varying strength brought about such developments.

C. Social Ethics and Systems of Law

While I will not be able to tie things all together in a very neat package, I will try to make a start at connecting up the theoretical development in Sections IV and V above with actual legal trends.

First, consider the hierarchical Committer solution to the Prisoners' Dilemma. This has of course a rather close correspondence to the power structures sometimes observed among animals and men. I have called it elsewhere[2] the "Iron Rule" of social order.[3] One curious point in the previous analysis (see Matrix 10) was that the superordinate or dominant

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[1] That law is whatever serves the interest of the Soviet state is (I believe) openly professed as the main principle of Soviet justice.

[2] Hirshleifer [1980].

[3] For an analysis of dominance patterns among humans and other primate species, see Willhoite [1976].

individual did not end up any better off than the subordinate. And
curiously enough, something like this does occasionally occur among animals,
where it is found that the dominant male in the band does not always father
the most offspring. Nevertheless, we would be quite surprised if this were
the case normally. Equality of result despite inequality of role is, I
want to suggest, a special case due mainly to the assumption of a homogeneous
population in the theoretical analysis. When there are strong asymmetries
of power in the population, even before the form of association is fixed,
it is more than likely that the stronger will be able to set up a hier-
archical system in which he reaps most of the mutual gain -- as Thrasymachus
suggested. (On the other hand, since individuals striving for dominance
may not achieve it, and may suffer damage in the process, the average
payoff of a "seek power" strategy may be no greater than that of an "accept
inferiority" strategy.)

There is a social ethic associated even with the Iron
Rule of dominance. In our simple Matrix 10, we saw that good behavior by
the subordinate must be rewarded -- even though it is against the Committer's
immediate interest to do so. In more general contexts (where injury
strategies are allowed in the contest for the top position), it has been
observed also that animals typically fight by conventional means, often
not using their most lethal weapons.[1] The defeated animal does not fight
to the death, and his submission is accepted.

Let us now consider the more egalitarian precursors of law mentioned
earlier. If the environment corresponds to the conditions of the Hawk-Dove

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[1]Lorenz [1966], Tinbergen [1968].

game, we saw that a "Bourgeois" strategy (under our assumed conditions)
was an evolutionary equilibrium. The strategy of fighting to defend your
own "property," but deferring to the corresponding rights of others, was
superior to always seeking short-run gain (Hawk) or always deferring (Dove).
The territoriality observed in Nature is such a social structure.
Members of many animal species, humans among them, have either a fixed or
a mobile bubble of personal space, invasion of which will be resisted.
The supporting social ethic here involves both willingness to defend and
reluctance to intrude -- each action being (at least under the assumed
conditions of Matrix 6) against the immediate interest of the territory-
holder. This is indeed what occurs. "Irrational" fury on the part of
property-owners and corresponding fearfulness or timidity on the part of
intruders lead to the defeat of most incursions.[1]

However, while the bourgeois ethic undoubtedly plays a role even
on the human level, it does not conduce to more affirmative forms of group
cooperation. Egalitarian coalitions, we suggested above, enforce good behavior
through the social ethic of "moralistic aggression." Again, emotions like
indignation[2] may have evolved to overcome the short-run disadvantage of
becoming involved in third-party punishment of offenders. Moralistic
aggression is open-ended in its scope of application; it can be used to
support a variety of different social norms. Among the many possibilities
observed among mankind are sharing, reciprocation, and heroism. Human
beings seem able to learn alternative "ideologies," but once learned the

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[1]See especially Ardrey [1966].

[2]See Trivers [1971], Willhoite [1979].

support for any particular idiology stems probably at least in part from an
innate pattern of behavior.

The social behavior of human beings is of course subject to many other
influences, some mentioned in the preceding analytical discussions. In
particular, kinship as a source of cooperative or even self-sacrificial
behavior has always been of great historical importance; as a biologically-
determined universal, it is unlikely ever to lose its sway. Early human
societies were very largely made up of close kin (though exogamy provided
a counterbalancing force setting some bound upon xenophobia).[1] Associa-
tions broader than family groupings, it is interesting to note, tend to be
supported by ideologies simulating family relationships. The dominant
individual in a hierarchical society became "the father of his country";
in an egalitarian society, participants became "brothers." Culture, it
seems, permits humans to learn to fool themselves -- in ways that are often,
though by no means always, socially productive.

D. Does the Law Evolve Toward Efficiency?

It follows from Coase's Theorem that, given any initial assignment of
property rights, there will be a trend toward efficient use of resources.
All possibilities for mutually advantageous exchanges will gradually be
discovered and consummated, except as prevented by the barrier of transac-
tion costs.

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[1]The origin of exogamy is subject to some question. Close inbreeding
leads to expression of more genetic defencts, but on the other hand a more
closely related group will tend to be more cooperative and thus more
effective. It has been suggested that exogamy is of "political" advantage
in enabling groups to form alliances with others.

As indicated in Section II, however, it is not in general true that
trade makes _all_ affected parties better off; the result of exchange is only
potentially rather than _strictly_ Pareto-preferred to the pre-exchange situation.
Still, the net balance of such losses must be less than the gain to the contract-
ing parties. (Since otherwise, the Coasian argument goes, these third
parties would enter the transaction and induce a change in its terms).

Recent thinking has suggested that the process by which the law itself changes,
so as to _redistribute_ established property rights, is not essentially different
from the Coasian process of _exchange_ of rights that is conditional upon an
initial structure of property entitlements. This is clear enough when a change
in the law is unanimously approved, either because it benefits everyone directly
or because appropriate compensations are paid. A possible instance is the priva-
tization of hunting rights for fur-bearing animals that took place among certain
Indian tribes in North America. This change came about after the arrival
of European traders opened up a larger market for furs, thus increasing
the social gains achievable by shifting away from the previous inefficient
regime of common-property rights.[1]

The more difficult case, which is (with only rare exceptions) the one
of practical concern, is when the law changes in ways that clearly help
some individuals while injuring others. Traditional "welfare economics"
implicitly viewed this process as a benign one in which a paternalistic
government apparatus balances considerations of equity against
efficiency in the light of changing external circumstances. A degree of
optimism seemed warranted, since ongoing improvement in analytical under-

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[1]See Demsetz [1967]. For a somewhat analogous treatment of the
enclosure movement in England, see Dahlman [1976].

standing could be expected to aid performance in this regard, with the added nice feature of suggesting that lots of economists should be hired at all levels of government.

The "new political economy"[1] literature, in contrast, is much more pessimistic. It regards all the actors on the political scene -- voters, legislators, bureaucrats, and even judges -- as each making choices so as to maximize personal utility subject to the constraints imposed by laws and institutions (and the behavior of other actors). While it might theoretically be possible to redesign the constraints of duties and rights, so as to lead to more efficient outcomes, there seemed to be no particular reason to suppose that any such improvements are likely to come about.

One of the most exciting new ideas in recent years has been the proposition that the law does after all tend to evolve in the direction of efficiency. (This is the positive, rather than normative, version of "Posner's Theorem" as described in Section I above.) It supposedly does so evolve not because of the wise benevolence of lawmakers, but as an inevitable result of the conflictual process of litigation.[2] The basic idea is quite simple. Suppose we are dealing with a situation where mutually advantageous exchanges of entitlements are partially or wholly unfeasible, so that the initial assignment of property rights may make a real efficiency difference. An inefficient assignment leaves more scope for improvement; that is, the net balance of gains and losses will be greater in shifting from an inefficient to an .

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[1] I will cite only the major seminal work of Downs [1957].

[2] Rubin [1977], and see also Gould [1972], Priest [1977].

efficient set of rights than for the reverse change.[1] It follows that, other

things equal, those individuals and groups whose interests will be served

by legal changes in the direction of efficiency will be motivated to bring

more pressure and strength to bear than will their opponents in the contest

for judicial determination of rights.[2]

Different models have been proposed for the actual mechanism of this process.

In the original version of Rubin the emphasis is upon re-litigation. If pre-

cedents are not absolutely binding, attempts will be made repeatedly to over-

turn an inefficient one. Even if judges never become any more enlightened,

intellectually speaking, so long as there is a random element in their

decisions the efficient outcome will eventually be hit upon so as to become

the new precedent.[3] In an alternative version, those standing to benefit

from the efficient precedent can afford to make the greater investment (e.g.,

hire more able lawyers) so as to influence the outcome of the action.[4]

Finally, what is very important, the thrust of this efficiency-through-

strength argument is by no means limited to the arena of common-law litiga-

tion. With minimal modifications the same logic can be applied also to

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[1] Note that the "reversal paradox" problem discussed in Sec. II above
is being ignored.

[2] Perhaps this is the prophetic meaning of the otherwise mysterious
riddle of Samson: "Out of the eater came forth meat, and out of the strong
came forth sweetness." (Judges; xiv, 14).

[3] Rubin [1977]. Similarly motivated attempts to overturn even efficient
precedents will also probably take place. In consequence, we would expect
to observe both the more and less efficient precedents, each governing with
a certain fractional probability or a corresponding fraction of the time --
see Cooter and Kornhauser [1979]. However, the more efficient rule will
tend to prevail more frequently, increasingly so the larger the efficiency
improvement it represents.

[4] Goodman [1978].

the forces determining statute law and constitutional interpretation.[1]
For that matter, since the process is essentially one of "trial by combat,"
why not apply it also to civil wars and international conflicts? Dr.
Pangloss, it seems, may have been right after all!

To refute the idea that strife and contention lead to efficiency in any
all-encompassing sense we need only look about us. Still, it is important to
appreciate how and to what degree the argument goes wrong, at least in its
application to the evolution of law. I see three major flaws, which I will
try to explain in order of increasing importance.

First, while I would support the contention that judicial or political
results are ultimately determined by <u>strength</u> (by pressures brought to bear
upon decision-makers), the link is weak between result-relevant strength and
the underlying costs and benefits imposed upon individuals. Rubin mentions
that there is a "public good" situation here; others who may gain from
overturning the precedent are free-riding upon the actual litigant. Put
more generally, each side has the problem of <u>mobilizing</u> its strength. Among
the forces favoring the ability of one side or the other to mobilize so
as to bring potential strength to bear are such familiar considerations as
compactness (small numbers, geographical concentration), perceived unity
of interest, cheapness of communications, and perhaps a group-centered
social ethic. In this model, it is interesting to note, litigation emerged
in the first place because of negotiation breakdowns[2] between the interests
on each side. And yet, negotiations <u>within</u> each side aiming at mobilizing

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[1]As already suggested by Rubin [1977] and Priest [1977].

[2]As emphasized by Cooter and Kornhauser [1979].

forces so as to present a common front are quite essential for winning
the contest. The overall conclusion, then, is that there are at least two
sets of forces at work in this conflictual process: on the one hand the
balance of efficiency considerations, but on the other hand comparative
effectiveness at mobilization.

Second, and in part a related consideration, once the outcome is seen
to depend in part upon ability to mobilize we would expect to observe a
kind of "arms race" between the contenders. Each would be motivated to
trade off some of the potential efficiency gain in order to increase the
chance of defeating the other. In the animal world, we have seen, male
combat for females leads to the diversion of resources to the development
of otherwise unproductive weapons of contest. The same effect is of course
very visible in the sphere of internation conflict. Thus, any trend toward
efficiency gains from improved precedents (or, more generally, from realloca-
tion of resources in accordance with the outcome of contests) must be
weighed against losses due to the pressure to "meet the competition" by
adding to combative capacity. Increased armaments, furthermore, may raise
the costs of the process of coming to a decision (determining who wins and
who loses). In warfare among nations, the costs of producing armaments
are generally minor in comparison with the direct damage should war actually
come about.

Third, and most important, is the question of <u>whose</u> efficiency? That
is, what are the boundaries of the relevant group? Even if economic bene-
fits and costs translate directly into combat strength, even if no resources
are wasted in arms races or direct damage, the loss to the defeated can be
said to be outweighed by the gains to the victors only if the transaction

changing the structure of rights is internal to the group -- which thereby
gains collective power for the purpose of competing against others. An
example might be military conscription of a particular age-cohort. If an
external enemy presented a sufficiently urgent threat, many of us might
think that such a drastic revision of rights was nevertheless warranted
in the interests of national survival. But suppose it were a question of
one nation enslaving another. Even if the enslavers were willing and
able to "bid higher" than their victims in a military contest, we would
be disinclined to regard the transaction as improving efficiency in any
meaningful way.[1] (Conceivably, this process of "efficient enslavement"
might aid the entire human species in its competition for survival against
other species, but such competition is not sufficiently urgent at this
time to be a major consideration.)

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[1]A somewhat similar argument is put forward by Rothbard [1979],
though I am sure he would reject my suggest that military conscription
might (even hypothetically) be said to be efficient.

VIII. CONCLUSIONS

I will not attempt any general summary of the paper but instead will try to set down here a number of the more interesting or noteworthy implications of the evolutionary approach, as it applies to conflict versus cooperation strategies in human affairs.

1. The central tradition of economic reasoning emphasizes the harmony of interests among men. Under the guidance of the Invisible Hand, even entirely self-interested individuals are led to cooperate so as to achieve the mutual gains of trade. Economists have paid much less attention to conflict and aggression, to attempts to reap one-sided gains at the expense of others, although this aspect of behavior is also entirely amenable to economic analysis.

2. Recent economic approaches to the study of political interactions reflect a similar harmonistic tilt, in viewing the political problem as one of "collective choice" rather than as fundamentally a contest for power and domination. And analogously in the legal sphere, recent economic approaches have viewed the main function of law as that of facilitating (and possibly supplementing) the process of market exchange in its triumphant progress toward economic "efficiency." The alternative view which has some claim to our attention is that law is a system of coercion imposed on the weaker by the stronger party, or at least that it represents a balance of pressures among parties each contending to achieve or resist such domination.

3. The evolutionary approach suggests that this darker picture is the true one. As a generalization holding over the entire realm of living forms, reproductive competition is the first imperative of Nature. Furthermore, in the last analysis no holds are barred -- all means of struggle

will be employed in this competition, so long as one contender or another finds it advantageous to do so.

4. Nevertheless, it is true that in a multitude of ways and on all levels of life organisms have found it profitable to come together in patterns of cooperative association. But such cooperation is always secondary and contingent, in at least two respects: (1) In-group cooperation is only a means for more effectively and ruthlessly competing against outsiders, and (2) Even within the group there will not be perfect parallelism of interests, hence cooperation must generally be supported by sanctions.

5. From this point of view, the ultimate test of any group's constitutive law is whether it makes the group a more effective collective competitor. A very major concern of law must always be to prevent internal subversion of the collective effort by members pursuing their private interests.

6. Efficiency, on this interpretation, is meaningful only as a measure of group strength or advantage relative to competing groups in the struggle for life and resources. Forming a cartel may be an efficient course of action for a group of firms, even if the net balance is adverse when the interests of consumers are also counted in. Outcomes efficient for our nation may be inimical to the well-being of other peoples; gains for the entire human species may be achieved at the expense of other forms of life. A totally universalistic measure of efficiency is pointless; we must draw the line somewhere, at the boundary of "us" versus "them."

7. Whether in fact cooperative or helping behavior will be elicited from individuals with mixed motivations depends ultimately upon the ecological situation (the payoffs from hostile versus friendly interactions). This paper provided a systematic analysis for the simplest case: random

dyadic encounters in a homogeneous population, individuals having only a binary choice between a more and a less cooperative strategy. Three qualitatively different sets of environmental circumstances (payoff matrices) each led to a characteristic result: (A) In the "Tender Trap" class of interaction, the gain from choosing either strategy _increases_ with the proportion of the population adopting it. The more cooperative (more mutually advantageous) strategy will then be unanimously adopted if the proportion following it comes to exceed a critical mass in the population; otherwise, the result goes the other way. (B) In the "Chicken" or "Hawk-Dove" class of interaction, the gain from either strategy _decreases_ with the proportion adopting it. The characteristic result is then a mixed equilibrium, with the more and the less cooperative option each being pursued a given fraction of the time (or by a given percent of the population). In both Tender Trap and Hawk-Dove, typically the potential efficiency gain from cooperation is only partially realized. (C) In the "Prisoners' Dilemma" class of interaction the selfish strategy _always_ dominates, and cooperation will not be viable at all despite the potential mutual gain.

8. In extending the analysis beyond this very simple case, innumerable analytical variations become possible. Among the cases of greatest interest for our purposes are the following: (i) Generalization of the Hawk-Dove game to allow a "Bourgeois" strategy -- defense of one's own established control over resources, while deferring to the corresponding priority of others -- can lead to an equilibrium characterized by a high degree of cooperation. This suggests how a sense of _property_, one of the possible preconditions supporting a system of law, might have evolved. (ii) With regard to the Prisoners' Dilemma, biologists have been much concerned

with evolutionary solutions that turn upon ability to direct helping acts
preferentially toward fellow-cooperators. Aiding only one's relatives
(kin selection) or only members of one's own propinquity group (group
selection) may, under certain conditions, provide partial ways out of the
trap -- that is, some but typically not all of the efficiency gains can be
thus achieved. This analysis again is suggestive of major features of
human cooperative association, to wit, that observed helping largely takes
place within kinship or other closely-knit groups. (iii) If an asymmetrical
environmental situation permits one player to commit himself to a threat-
promise strategy relative to the other, full cooperation can in principle
be induced even in the Prisoners' Dilemma context. Curiously, it does not
necessarily follow that the individual in the superordinate hierarchical
role reaps more gain than the other from the interaction. Nevertheless,
in practice the circumstances making an asymmetrical strategy choice possible
are likely to coincide with an inequality of power and thus of realized
gain. This analytical model can therefore be regarded as patterning the
Sophist view of law as the imposed will of the stronger. (iv) In a more
egalitarian environmental context, coalitional power of the majority can
serve a function analogous to that of the dominant individual in an unequal
situation. Cooperative behavior is enforced by "moralistic aggression"
on the part of third parties against malefactors. This interaction mode
therefore provides the elementary pattern for a democratic structure of
law.

9. To the extent that these systems of eliciting cooperation or punishing
subversion require organisms to act in ways opposed to their immediate
interests (for example, when a superordinate player has to carry out a

threat or deliver on a promise), a "social ethic" in the form of ingrained
emotional drives may provide the over-riding motivation. Rage on the part
of the victim and/or indignation on the part of third parties, for example,
each "irrational" in terms of the direct interest of the party affected, may
serve to raise the costs of cheating or other group-subversive activities.
Or, equally "irrational" love and gratitude may lead to enough unenforced
reciprocation to make mutual helping viable. Different social ethics are
required according as the structure is hierarchical or egalitarian. Among
more advanced animals, and humans in particular, typically each individual
will have a mixture of ingrained "hard-core" cooperativeness (appropriate
for the social context in which he is placed) as well as merely prudential
"pragmatic" cooperativeness based upon immediate considerations of cost
and benefit.

10. Turning specifically to economics, the following are among the
suggestive implications:

(a) The image of "economic man" has been much denounced, but the evolutionary
approach suggests that self-interest is indeed ultimately the prime
motivator of human as of all life. This is however subject to several
qualifications, among them that one's kin are in the genetic sense
partly one's own self. Also, as just indicated, even economic man's
behavior is constrained by inbuilt emotions and tastes. While
these no doubt contain merely accidental elements, they are not
completely arbitrary. What tastes sweet to us is mainly what serves
our own interest, and even our "irrational" or "unselfish" drives have
largely met the evolutionary test of enabling us the better to compete
via group membership.

(b) "Economic imperialism," the use of economic analytical models to study all forms of social relations rather than only the market interactions of "rational" decision-makers -- is similarly entirely consonant with the evolutionary approach. All aspects of life are ultimately governed by scarcity of resources. But our use of the powerful tools of economic analysis must not lead us to unconsciously carry over harmonistic preconceptions, valid for the domain of mutually advantageous market exchanges, to the sphere of struggles for power and dominance. It is with that sphere that politics and law are mainly concerned.

(c) I find this thought somewhat disconcerting, but the evolutionary approach also suggests that, after all, the mercantilists were really not so wrong! Failing to appreciate the significance of the mutual advantage of exchange, they viewed trade essentially as an instrument in the international struggle for power. Well, mutual advantage is very nice, but trade still must be looked at with suspicion if it strengthens a potential enemy in war. This point is not without topical interest, for example when we consider the sale of industrial technology to the Soviet Union.

11. And now turning to law:

(a) In the great debate between natural-law and social-contract philosophies -- that is, between those who view association under law as fundamental and intrinsic in man as against those who regard it as merely a contingent and pragmatic option -- the evolutionary approach suggests an intermediate position. Human social behavior is enormously variable. That man is a social animal, often capable of great heroism and self-

sacrifice, is true for some and perhaps true in part of all men. It
is also true of other men, or perhaps the same men at other times,
that they will help others only to the extent that they thereby serve
themselves. And indeed the latter is the deeper truth, since ingrained
social ethics are themselves viable only if ultimately of selfish
advantage.

(b) The analysis here suggests that law, in the sense of coercive social
control of group-subversive behavior, has two elementary forms, each
of which corresponds to an associated social structure. The first form
is hierarchical, control being achieved by the superordinate player's
commitment to a threat-promise strategy. The second is egalitarian,
with control effected by third-party moralistic aggression. Of course,
these elements are interweaved in highly complex ways in any actual
society. The circumstances making one or other form more effective in
the competition among groups remain to be explored.

(c) As to the historical evolution of law itself, such alleged trends as
the movement from status to contract or the shift from strict liability
to moral fault do not seem valid except over limited segments of human
history. The only really clear unidirectional trends are the fairly
obvious developments associated with the greatly increased scale of
human societies over historical time. The law necessarily became
more impersonal, systematic, predictable, and professionalized as bands
and tribes gradually gave way to huge industrial nations.

(d) The adversarial processes of law themselves engender a certain tendency
toward efficient solutions, since supporters of the more productive
legal rule can "bid higher" in the struggle to establish precedents.

But too much ought not be claimed. For one thing, the struggle itself
is likely to lead to a wasteful "arms race" as each side attempts to
mobilize its strength. Even more fundamental is the question of whose
efficiency is being achieved: is it really meaningful to balance off
the loss of some parties against the gains to others? Are these
redistributions only internal to some group whose competitive via-
bility is of valid concern for the contending parties?

12. What might be called "the Smith-Coase message" tells us
that, under a system of perfectly effective law, there will be a continuing
tendency to seek out and achieve all mutually advantageous exchanges. How
generalizable is this message to transactions in a world of imperfect law,
or subject to no law at all? The harmonistic or Panglossian argument,
which economists are perhaps predisposed to favor, is that wherever mutual
advantage is present we can expect continual progress toward its achievement.
Refuting that contention has been the main concern of this paper. At every
point in time, each decision-making agent will be weighing the relative
attractiveness of cooperation and conflict strategies -- of seeking mutual
advantage on the one hand, or on the other hand unilateral advantage even
at the expense of others. And indeed, the latter is the more fundamental
evolutionary force; ultimately, cooperative association is only a means
for more effectively competing against others in the struggle for reproductive
survival.

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