Notes on Evolution, Rationality and Norms

by

KAUSHIK BASU

1. "The Doctrine of Malthus"

During the advance of economic ideas in this century, every now and then homage has been paid to evolution as a determinant of economic outcomes. But, nevertheless, evolutionary themes have never been a part of the mainstream. Economists have viewed evolution as a topic of importance to biology with peripheral implications for economics. It therefore seems ironic today that Charles DARWIN [1859] in his *The Origin of Species* introduces the idea of natural selection by invoking what he called "the doctrine of Malthus" – the view that, as population multiplied, in the ensuing struggle for survival it is the fit that prevails.

Fortunately, over the last two or three decades there has been a sharp rise in awareness among economists of the importance of evolution. Not surprisingly, this is closely tied to the increasing interest in norms and institutions. It is now more and more accepted that while a human being does choose and optimize, the feasible set from which she does so is determined not only by her budget constraint but also by social norms and custom.

The long-run economic performance of a group is bound to depend, at least partly, on its social norms. If a community subscribes to a norm that forbids the consumption of proteins, it is arguable that the community will face increased morbidity and perhaps even extinction. Hence, to understand why no group follows the norm of not eating proteins we have to invoke evolution. Such norms would not survive long enough to be seen.

Hence, whereas to understand the rise and fall of demand for guns and butter we need to study consumer theory, to understand differing work ethics among different peoples or levels of corruption it is important to understand evolution and natural selection (and, I later argue, also *group* selection).

I shall in this paper confine my attention to one kind of evolutionary economics, to wit, evolutionary game theory. And even within this I shall be particularly concerned about the origin of rational behaviour and social norms. Section 2 presents some standard concepts of evolutionary stability, and the technical tools and definitions that will be used elsewhere in the paper. Sections 3 to 5 argue that the economist, enamoured by the logical elegance of these new stability and solution concepts, have not paused to consider how the biologist's

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model needs to be modified for it to be applicable to the human context. Hence, we consider at length the appearance of *homo oeconomicus* in the Garden of Eden and how this affects the method of analysis. Finally in section 6 we consider some alternative possible formalizations of the idea of group selection, as opposed to individual or Mendelian selection.

2. *Evolutionary Games and Stability*

The pioneering work on the theory of evolutionary games is the paper by MAYNARD SMITH and PRICE [1973]. Their work was directed explicitly at *animal* behavior. It was soon evident that their solution concept, *evolutionarily stable strategy* (ESS), had interesting connections with solution concepts being used by game theorists and economists. Hence, out of this work in biology evolved a large body of work in economics (surveyed in VAN DAMME [1987] and WEIBULL [1995]).

I shall here introduce only the basics of evolutionary game theory that I will need to introduce the role of norms and group selection.

Consider a nation with a very large population. In each period the agents are randomly matched in pairs and play a two-player symmetric game, G, which is described in detail below. The idea is that the players who do badly in this game die out in the long-run, while the others multiply. Our aim is to predict what kinds of players will survive this process of *natural selection*.

In game, G, each of the two players can play any *strategy* from the *strategy set*, $S = \{1, \ldots, m\}$. If players one and two play strategies i and j, respectively, then the payoff of player one is given by $P(i, j)$. Since this is a symmetric game, player two's payoff is given by $P(j, i)$. If we write a_{ij} for $P(i, j)$, then the matrix $A \equiv [a_{ij}]$ fully describes the payoff functions.

Unless explicitly stated otherwise we shall assume that players can play mixed strategies and payoffs are then computed by taking expectations. If the two players play mixed strategies p and q, we shall abuse notation a little and denote player one's payoff by $P(p, q)$.

The players in this *evolutionary game* are not like the usual utility maximizers in von-Neumann-Morgenstern game. In particular the agents who play this do not *choose* their strategy; but instead each player *is* a strategy. This becomes clear once we remind ourselves that evolutionary games were originally written for predicting animal survival. Hence, a strategy is meant to capture a phenotype. Thus, for instance, the strategies could be levels of aggressive behavior with 1 describing maximum aggression and m the minimum. Thus a hawk may be thought of as an agent that always plays strategy 1 and a dove an agent that always plays m. From now on, unless otherwise stated, a "strategy" is used to describe a pure or a mixed strategy.

There is one more important difference between a von-Neumann-Morgenstern "game" and Maynard Smith and Price's "game." In the later the payoffs represent fitness, and is an indicator of the relative strength of survival of the agent that gets it. Fitness could also be viewed as the rate of reproduction. Hence, if agents of type p have a higher fitness than type q and the world's population is fixed, in the long-run we would expect the world to be full of type p agents. However, all this does not make the algebra any different from games that economists have talked about, where payoffs represent utility or profit. This mathematical isomorphism has allowed many economists to forget about this difference or to treat this as purely a matter of interpretation. This, I shall later argue, has often caused us to bark up the wrong tree. However for the time being, let me circumvent this problem by assuming utility and fitness to be the same.

Consider an evolutionary game in which everybody in the population is a creature programmed to play strategy p or, more simply, is strategy p. Every now and then this population is infected by small numbers of mutants who play some other strategy q. Our aim is to check if p can destroy the mutants.

We shall say that p is *immune* to q if

$$P(p, p) > P(q, p) \quad \text{or} \tag{1}$$

$$P(p, p) = P(q, p) \quad \text{and} \quad P(p, q) > P(q, q)\,. \tag{2}$$

If the last inequality were instead an equality we would describe p as *weakly immune to q*.

The idea of immunity is simple. When mutants, q, invade a large population of type p, since players play against randomly matched players, an agent p or q will most often find itself matched against p. If under such matching p does better (see condition (1) above) then p will have greater fitness than q and so in the long-run destroy q. If on the other hand, p and q are equally matched against p, we have to see how they do against q, whom they will occasionally play. If $P(p, q) > P(q, q)$ then overall, p will be more fit and destroy q. This is what (2) asserts. Hence, either of these conditions makes p immune to q. Weak immunity is a case where neither the original population nor the mutants have the ability to destroy the other.

The central contribution of Maynard Smith and Price is to define a solution concept. A strategy p is an ESS if p is immune against every strategy q (which is not p) and it is a *neutral stable strategy* (NSS) if p is either immune or weakly immune against every strategy q.

To illustrate this, consider the evolutionary game, G_1, described below.

(G_1)

$$\begin{array}{c|cc} & x & y \\ \hline x & 1 & 2 \\ y & 0 & 2 \end{array}$$

The payoff in each box shows the row player's (i.e. player one's) payoff. Thus $P(y, x) = 0$. The other player's payoff is deduced by symmetry.

This game has two Nash equilibria (x, x) and (y, y). However, a society of all type y is not ESS, nor neutral stable. To see this suppose such a population is invaded by a small number of mutants of type x. Since $P(x, y) = P(y, y) = 2$. We have to see how x and y do against x. Since $P(x, x) = 1 > P(y, x) = 0$, the mutants will destroy the original inhabitants. It is easy to check that only x is an ESS; and x is also the only NSS.

With the above definitions and concepts as a bench mark we can now explore some of the implications of evolutionary game theory for human behavior, especially that pertaining to rationality and norms.

3. *Rationality in the Garden of Eden*

It is easy to see that ESS and NSS are both Nash equilibria. Hence in the long-run equilibrium that comes to prevail through the sieve of natural selection, we would expect agents to exhibit rationality (in the sense in which rational players play Nash equilibrium strategies). It is however important to recognize that though the agents *exhibit* rationality, they *are* not rational. Players in evolutionary games are programmed phenotypes. Each player plays a particular strategy without any concern for the consequences. It is just that in the long-run all players playing non-Nash strategies perish.

Though we have approached this idea through game-theoretic models it is very close to ideas of evolutionary equilibria discussed elsewhere in the economics literature for instance, ALCHIAN [1950], and NELSON and WINTER [1982].

One reason why an evolutionary game, as described in section 2, may not be appropriate as a description of human conflict is that human beings are (at least to a limited extent) rational. They can choose among alternative strategies $S = \{1, \ldots, m\}$ and will choose to maximize their utility.

The evolutionary game model can however be used to raise an important question. Can we explain why human beings are rational? That is, can we explain the appearance of homo oeconomicus in the Garden of Eden? It turns out that evolutionary game theory does provide a framework where such questions can be raised and at least partially answered.

Note first that the fact that human beings choose and optimize is not something that they choose. They are typically (or at least largely) born with this trait. Hence, in the same way that we can check whether a phenotype will survive natural selection, we can check whether the trait to choose and optimize is likely to evolve and prevail.

This question has been investigated by BANERJEE and WEIBULL [1995]. It turns out that there is no unequivocal answer. Let me illustrate this with some examples. That there are games where a rational and fully informed phenotype will prevail in the long-run (is an ESS, that is) is easy to see. This is obvious in game G_1 and more interestingly so in a game like Rock-Scissors-Paper.

The reverse possibility however is more interesting, consider the hawk-dove game described below as G_2.

(G_2)

	H	D
H	−1	2
D	0	1

Consider first a standard evolutionary game interpretation of this where each agent plays a fixed strategy p where p is the probability of playing the hawk-strategy, H. Hence 1-p is the probability of playing dove, D. Now, in this Garden of Eden consider the entry of a new agent, a human being, R. Being rational, player R responds in the best possible way to an opponent. If R faces an R we shall suppose that they play a symmetric Nash equilibrium strategy. It is easy to see that G_2 has only one symmetric Nash equilibrium, $p^* = 1/2$. In such an equilibrium each player's payoff is 1/2.

One easy way of representing a game in which each of the two players is either a hawk or a dove or a human being who can choose to play hawk or dove, is a three strategy game in which the game G_2 is embedded and the third strategy, denoted R, is that of rational best response. I call this the hawk-dove-man game and it is represented by G_3.

(G_3)

	H	D	R
H	−1	2	2
D	0	1	0
R	0	2	1/2

If R plays against R we get the symmetric Nash equilibrium of G_2. Hence the entry 1/2. If R plays against D, it is like a rational player choosing rows in G_2 when the opponent is a phenotype that always plays D. Clearly R will then play the aggressive strategy and get a payoff of 2. That explains the entry for (R, D) in G_3 and so on.

Consider the game G_3 and a nation full of R-agents. It is evident that if some H mutants enter this society, they will have a higher fitness and so destroy R. Thus R is not ESS. In other words, rationality is not robust in the long-run. It is not immune to hawks. However, neither is hawkishness ESS in this game. As in the original hawk-dove game, $p = 1/2$ is ESS. Hence, an irrational, programmed agent has better survival chances than homo oeconomicus. It follows therefore that the robustness of rationality depends on the underlying game that is being played. In some sense this is an extension of insight that we already have from industrial organization theory and international relations, where it often pays to be irrational.

4. Fitness, Utility and Futility

Up to now I have assumed that fitness and utility are the same. In other words, rational agents maximize fitness. This is indeed the standard assumption in the economics literature that has grown out of the work of MAYNARD SMITH and PRICE [1973].[1] The assumption is explicitly made by BANERJEE and WEIBULL [1995] and BASU [1995].

How reasonable is this assumption? Looking around the world, one does not feel too reassured. After all we do not feel naturally like eating antibiotics when we have bacterial infection. Most people are inclined to eat more sweet, more fat and less fibre than is good for them. But it may nevertheless be argued that there is at least a reasonable degree of matching between utility and fitness.

Let us see if theory can help us answer this question. For reasons of consistency we should use the same theory that we used to check if a particular behavior or strategy is sustainable in the long-run to check if people maximize fitness. In other words the question I am asking is this.

Is maximizing fitness an ESS?

To answer this question consider a world of human beings (that is, agents who maximize utility). Let the human beings differ in terms of their utility functions. We want to check if human beings for whom the utility function coincides with the fitness function are evolutionarily more stable.

More precisely a game (G) is described as before as a two-player symmetric interaction between two randomly picked human beings choosing a strategy each from the set S. As before, we have a payoff function, P, which specifies the fitness index of player one. But in addition to this each agent is endowed with a utility function u, such that, for every pair of strategies (x, y), $u(x, y)$ is the utility that he gets if he plays x and the other player plays y. As before, x and y may be mixed strategies in which case $u(x, y)$ is the expected utility.

When players, represented by, respectively, u and v play game G, we shall say that the strategy pair (x, y) is a *Nash equilibrium* if $u(x, y) \geq u(z, y)$, for all z and $v(y, x) \geq v(z, x)$, for all z.

We shall say that a population consisting of individuals with utility function u is *impervious* to (mutants with) utility function v if there exists a Nash equilibrium (x, y) in the game played between types v and u, a Nash equilibrium (z, z) in the game between u and u, and a Nash equilibrium (w, w) in the game between v and v, such that

$$P(z, z) > P(x, y) \quad \text{or} \tag{3}$$

$$P(z, z) = P(x, y) \quad \text{and} \quad P(y, x) \geq P(w, w)\,. \tag{4}$$

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[1] An exception to this is the work on "learning," which is a rapidly growing area of research (see BLUME and EASLEY [1995]).

We may, for brevity, describe this as a case where utility function u is impervious to the utility function v.

We may now describe a population consisting of individuals with utility function u as an *evolutionarily stable population* (ESP) if it is impervious to every utility function v.

The question is: Is $u = P$ an ESP?

In the light of the analysis in the previous section this is easy to answer. The reason is that a mutant strategy can always be thought of as a mutant utility function, one that makes that strategy strictly dominant. It follows that if the underlying game is like hawk-dove-man game, G_3, then $u = P$ is not an ESP. On the other hand there are other games where P is an ESP. Hence, fitness maximization is not a preference that will always emerge in equilibrium. Hence, at least for the time being, the attempt to bring utility and fitness into alignment must be abandoned as futile.

In setting out to show that rational behavior is not immune to mutant invasion, BANERJEE and WEIBULL [1995, 345] assume that rational agents maximize fitness. They justify such an assumption by arguing that such an assumption tilts "the board in favour of rationality." The conclusion reached in the above paragraph however suggests that such an assumption does not amount to tilting the board in favor of rationality.

The concept of evolutionary stability, namely, ESP, developed in this section, can be very useful in studying the formation of human preferences. Are certain kinds of preferences more robust against mutant invasions than others? Why are some groups of people vegetarians? These are matters of social norms and custom and cannot be explained in terms of individual choice but as arbitrary preference patterns which survive the tussle of evolution.

I do not try to answer these questions but attempt to provide more conceptual structures for such analysis. For instance the question as to why some groups are vegetarian and others not compel us to go beyond individual selection to group selection. "Group selection" has been a topic of some importance to biologists and zoologists. I try to develop this concept for economic analysis in section 6. But before that let us look into the evolution of social norms and custom.

5. *Norms and Custom*

Taking an admittedly narrow view of the amorphous and complicated idea of a social norm, I shall here view it as a restriction on what people choose. This is the view that BOYD and RICHERSON [1994, 72] take in their anthropological study of norms: "A culture's norms determine which behaviours are permissible and which are forbidden." JONES [1995, 271] takes a similar line in describing culture, when he writes: "Most Westerners, for example, do not think of themselves as free to wear a bone through the nose, like some stereotypical cannibal."

Likewise, for most people, not picking people's pockets in buses is a norm. It is not guided by the fact that the harvest from dipping into people's pockets is usually disappointing but simply as something that is "not done." Similarly in some countries respecting a queue is a norm. You do not jump a queue not because of what others will do to you but simply because that is beyond the bounds of "acceptable" behavior. This norm may not be there in another country. International airports, where different cultures co-mingle, are a great place for doing research on cultural pluralism and conflict.

In Basu, Jones and Schlicht [1987] we had argued that social norms, customs and institutions that actually exist need not be optimal. It is, we argued, possible for all the adherents of the custom to be worse off by virtue of its existence. This is because no one chooses a custom. A custom evolves over time. Even if it arises originally for some good reason (though I do not see why that should be so either) very often it persists well after the original rationale has vanished.

It seems to me that in the light of the new advances in evolutionary economics the claims in the above paragraph needs some modification. If a norm or custom persists for a very long time it must have stood the test of natural selection. Hence, even if we reject the view that long-standing norms, customs and institutions are optimal for society, it seems reasonable to argue that they cannot be "too" sub-optimal either.

To formalize such a "minimal functionalist" view, return to the evolutionary game of section 2 and suppose that human beings do maximize fitness. However, unlike in the models of section 2 and 3, now our players are human beings endowed with norms. If S is the set of all strategies, then a social norm, T, is a subset of S. A person endowed with such a norm will not consider choosing from outside T but will freely optimize within T.

When two individuals endowed with norms T and K, play the two-person game G, effectively they play a restricted version of G where player one's strategy set is T and two's strategy set is K, and the payoffs are the same as in the original game G. Let us call this new game a restricted game. When two players play a restricted game, the players get some Nash equilibrium payoff of the restricted game. These ideas are formalized in Basu [1995].

Now we can use the tools developed in the earlier section to check the evolutionary stability of norms. Suppose we have a society where all individuals have the same norm T. Now consider the appearance of some mutant norm, K, in the society. We can use exactly the same criterion as ESS or NSS to check whether T is evolutionarily stable. The only difference is that instead of viewing a player as a phenotype programmed to play a fixed strategy, a player is now a human being who is both an optimizer and also a carrier of norms.

What is interesting and is formally demonstrated in Basu [1995] is that *norms* which are ESS can sustain cooperation and altruism. Indeed the players can earn more than Nash equilibrium payoffs in equilibrium. This seems to be a natural way to explain altruism – a phenomenon that has attracted considerable attention in recent times.

A different and plausible route for explaining altruism that has been mentioned occasionally is group selection. In economics this has remained a relatively neglected subject. The next section suggests some tentative steps for integrating this idea into evolutionary game theory.

6. Group Selection

SEN [1991, 22] has argued that "the pervasive use of self-interested behaviour in modern economics cannot be adequately defended by natural-selection arguments." This is exactly the conclusion that we reached in the last section. But reading Sen's paper carefully it is clear that his *argument* is different, for he writes (p. 21) that we must "distinguish between (1) the problem of natural selection of motivations among *different individuals* in a given society and (2) that of natural selection among different general motivations in *different* societies."

What Sen is drawing our attention to is something like the phenomenon of "stotting" among gazelles that zoologists have written about and is summed up by DAWKINS [1976, 11] thus: "This vigorous and conspicuous leaping in front of a predator [...] seems to warn companions of danger while apparently calling the predator's attention to the stotter himself." The question is: Can we explain such individual irrationality as stotting, by invoking evolution?

This line of thinking has a long tradition (see, for instance, MAYNARD SMITH [1964], [1976]) under the label of "group selection," the classic work being that of WYNNE-EDWARDS [1962]. MAYNARD SMITH [1964, 1145] observes: "If groups of relatives stay together wholly or partially isolated from other members of the species, then group selection can occur." He goes on to observe that "if all members of a group acquire some characteristic which although individually disadvantageous, increases the fitness of the group," then such groups may survive natural selection. Maynard Smith also talks of how successful groups can multiply by splitting or sending out propagules. It is not obvious whether this has a counter part in economics. If however we assume that groups form through some arbitrary process but the less fit ones perish, we could establish an argument for group selection in economics and this is easy to do using the artillery that we have already built-up.

However, there are some difficulties *en route*. As DAWKINS [1976, 8] points out, if a selfish mutant emerges within a group of altruistic agents, he may be able to destroy the group. If in one group of gazelles, a few "non-stotters" appear, their population will soon increase since they will have the protection of the stotters without being exposed to the risk themselves. In due course the group will have only non-stotters and be more vulnerable and perish.

There is however one way of getting around this problem. Whereas ESS is based on the idea of immunity against *all* mutants, this may be an excessively cautious formulation (SWINKELS [1992], Basu [1995]). Especially in human society, mutants are likely to be migrants from other groups. As DAWKINS [1976, 80] says, "... it is very difficult to see what is to stop selfish individuals migrating in from neighbouring groups ..." The clue to explaining group selection may be in the possibility that there may not exist any evolutionarily stable purely-selfish groups. Hence, we need not worry about mutants (or migrants) who fit this description.

To formalize this, return to the model of section 4. Suppose the game that is played pairwise is G, in which the set of strategies is, as before, $S = \{1, \dots, m\}$. A social norm, T, is a subset of S.

Now think of a world with n groups of human beings. Each group i is characterized by a norm T_i. That is, all individuals in group i adhere to norm T_i. We shall assume that human beings interact mainly within each group with occasional migrants. In other words, in each period individuals are randomly matched with others within each group and play the game G. Only occasionally an individual from one group may stray into another group and from then on get matched with players in this new group.

We could think of this as a model in which the groups are castes, where individuals typically interact with people in their own caste group, or as a model of an economy with college loyalties so that Oxonians typically prefer to network with other Oxonians, likewise for Princetonians, and so on. It is a tale nearly as woeful as caste. Or this could even be a description of different nations.

Now consider a *collection* of n groups with norms $(T_1, \dots, T_n)$ where $n \geq 2$. We shall say that this is an *evolutionarily stable collection of groups* (ESC) if for every group i, members of i are impervious (see section 4 for definition) to mutants from any group $j \in \{1, \dots, n\}$.

This is not an exact group analogue of individual selection because groups do not split or give birth to other groups and so we can have different groups with different fitness levels surviving. But it is a coherent idea of stability against the invasion of mutants; and captures the idea of evolutionary survival of groups. It fits closely MAYNARD SMITH's [1964, 1145] description: "What is required for group selection is that the species should be divided into a large number of local populations, within which there is free interbreeding, but between which there is little gene flow."

ESC allows for group selection without having to worry about the destructive powers of individual selection. Consider a Prisoners' Dilemma game in which individuals have the option of cooperating, defection *and* not playing, where not-playing is better than playing with a defecting partner and worse than playing with a partner that cooperates.[2] It is easy to see that if we have

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[2] This game is described in BASU [1995]. It is possible to show that the conclave of invasion resistant sets described in that paper is closely related to ESC.

two groups, one that always cooperates and another that chooses between cooperating and not-playing (that is, its norm is never to defect) then these two groups meet the criterion of group selection. That is, they constitute an ESC.

Consider now the group that follows the norm of always cooperating. It is like a group of stotting gazelles. What about the risk of a non-stotting gazelle joining the group? If we confine attention to mutants from other groups (as Dawkins says we must do) then we do not have to worry about such spoilsport mutants because by the criterion of group selection itself there will be no group that breeds such mutants.

Hence, we not only have a consistent definition of group selection but one that can explain altruism.

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Professor Kaushik Basu
Department of Economics
Cornell University
Uris Hall
Ithaca, NY 14853-7601
U.S.A.