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September 2004

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This Version: July 2004

Abstract

The main aim of this essay is to provide an approach to the analysis of the link between Thorstein Veblen's evolutionary approach and Evolutionary Game Theory (EGT). Analysing this connection we expect to shed some light on the potential contribution of Veblen's theory of socio-economic evolution to the discussion on the application of EGT to social environments. We also attempt to investigate to what extent elements of EGT can be used to formalise some of the basic evolutionary principles proposed by Veblen. In order to study these issues, the paper has been structured as follows: in the first section, the methodological imperatives laid down by Veblen, defining an evolutionary approach, are presented. The main idea in this section is to provide an analytical framework that allows the evaluation of EGT in terms of Veblen's evolutionary approach. To better understand the main principles and rationale behind EGT and how it can be applied as a tool for analysing issues on the diversity, interaction, and evolution of social systems, the second section presents a discussion of this non-traditional approach and its basic concepts. Finally, in the third section the main characteristics of EGT previously discussed are contrasted with Veblen's principles outlined in the first part of the paper.

JEL Classification: B15, B52, C72, D62,
Keywords: Evolutionary Game Theory, Institutional and Evolutionary Economics and Thorstein B. Veblen.

1. Introduction

One of the main criticisms of the “old” school of institutional economics is its lack of formality and of an operational approach that allows the replication of the institutional type of analysis by the academic economic community at large. Clearly this has been one of the reasons behind the seemingly little attention that this non-traditional approach to economics has received from a mainstream with an ever increasing emphasis on mathematical models (see Rutherford (1994)). Recently, however, some distinguished economists, recognising the importance of the institutional context in economic analysis, have started to incorporate topics usually associated with old institutionalism in the debate of the mainstream of economic thought. This has given rise to the development of what is now known as “new” institutional economics, typically associated with the names of Ronald Coase, Douglas North, Mancur Olson, Richard Posner, Oliver Williamson and others[1]. The main aim of this school has been to provide a formal approach to institutional analysis based mainly on neo-classical and utilitarian foundations (see, for instance, Hodgson, 1993), thus leaving out of the study many of the basic principles behind the original tradition of institutional economics which push these foundations forward. Indeed, little has been done so far to formalise some of the main tenets and ideas of the “old” institutional-economics approach as proposed by their main exponents, namely Thorstein B. Veblen, John R. Commons and Wesley C. Mitchell. It is precisely in this context that this paper attempts to make a contribution. In particular, we attempt to link the work of Thorstein Veblen on evolutionary economics with the recently developed approach of biological game theory, or evolutionary game theory (EGT) as it is best known within economics. EGT is a formal, mathematical, approach within evolutionary economics, which thus far has been mainly applied to economics as a refinement of the Nash equilibrium concept.

Considering that the main developments in EGT have occurred in the field of theoretical biology, it is not surprising that until now no clear link between EGT and any of the economic approaches identified with the label ‘evolutionary economics’ has been established. Indeed, EGT has so far been developed completely independently from evolutionary economics (Weibull, 1998: 2). Nevertheless, whenever a methodological link has been suggested, EGT has been principally connected with the work of economists like Joseph Schumpeter, David Hume, Karl Marx and Friedrich Hayek[2]. However, so far in the discussion one economist has been “conspicuous” by his absence, Thorstein Veblen. To the knowledge of the authors, no specific work analyses Veblen’s contribution to the development of a theory of socio-economic evolution in relation to the potential application of EGT to the social context. This is quite extraordinary considering the rather Darwinian nature of EGT, and the fact that Veblen was one the first economists to make a direct appeal to biological science for inspiration and certainly the first economist to propose explicitly an approach to economics based on Darwinian lines, or as he put it a ‘post-

[1] For reviews of the new institutional-economics paradigm, see inter alia: Andersen and Bregn (1992), Hodgson (1989; 1993; 1998) and Rutherford (1989; 1994).
[2] See, for instance, Sugden (1986; 1989), Hargreaves Heap and Varoufakis (1995) and Vromen (1994) respectively.

Darwinian' economics. This is even more striking considering that some authors have argued that Veblen was relatively successful in establishing the basis of a Darwinian economics (Hodgson, 1992; 1993; 1999).

Analysing the connection between Veblen's evolutionary approach and that of EGT we expect to shed some light on the potential contribution of Veblen's theory of socio-economic evolution to the discussion of the application of EGT to social environments. Similarly, we also investigate to what extent elements of EGT can be used to formalise some of the basic evolutionary principles proposed by Veblen. The paper has been structured as follows. The first section presents the methodological imperatives laid down by Veblen, defining an evolutionary approach. In particular, we outline here the main characteristics of an evolutionary science as understood by Veblen, and the reasons of why he thought that the economics of his time was not one. In addition, some key characteristics of a Veblenian evolutionary-economics approach are put forward. The main idea in this section is to provide an analytical framework that allows the evaluation of EGT in terms of Veblen's evolutionary approach. To better understand the main principles and rationale behind EGT and how it can be applied as a tool for analysing issues on the diversity, interaction, and evolution of social systems (as opposed to biological evolution for which EGT was originally developed), the second section presents a discussion of this non-traditional approach and its basic concepts. In particular, we present and discuss the concepts of Evolutionary Stable Strategy (ESS) and Replicator Dynamics (RD), providing some simple economic examples. In the third section, we contrast the main characteristics of EGT with Veblen's principles outlined in the first part of the paper. In particular, we examine EGT on two accounts: is EGT consistent with Veblen's notion of an evolutionary science? and can Veblen's main evolutionary tenets be useful in the discussion on EGT? and vice versa. Finally, some concluding remarks are offered.

2. Veblen's Evolutionary Economics

The analysis of Veblen's evolutionary economics is centred here principally on methodological work presented in his seminal 1898 article in the *Quarterly Journal of Economics* (QJE) on "Why is economics not an evolutionary science?". Although, much of Veblen's theoretical work on evolutionary economics was developed later in his first three books, "The Theory of the Leisure Class" (1899), "The Theory of Business Enterprise" (1904), and "The Instinct of Workmanship" (1914), it was in this essay where he formulated the methodological basis that guided his research work over the subsequent 25 years (Rutherford, 1998: 464).

The work presented by Veblen in this article was essentially a manifesto for an evolutionary economics, a methodological outline, which according to some authors can be considered not only as one of the key founding works of institutional and evolutionary economics, but also as the beginning of a major paradigm shift in economic thought (Hodgson, 1998: 398; Wisman, 1989: 1). Indeed Veblen, after recognising that economics "stands in need of rehabilitation" (Veblen, 1898: 373), attempted to show the way forward in the field by proposing an alternative methodological perspective. In Veblen's opinion economics was not a "modern science" because it was not evolutionary, and proposed instead what he called a "post-Darwinian" economic science (Veblen, 1898: 374-75). Veblen accordingly claimed that economics should adopt the metaphor of evolution-and-change, rather than the static ideas of equilibrium that had been borrowed by neo-classical economists from physics (Hodgson, 1992: 286).

While reviewing Veblen's work regarding evolution in all its extension is far beyond the scope of this paper, we address here two main points. First, what were the main characteristics according to Veblen of an evolutionary science, and why he thought that economics of his time was not one. And second, Veblen's main proposals in terms of what he thought an evolutionary-economics approach should be all about.[3]

2.1 Veblen's Conception of Evolution: A Taxonomic versus an Evolutionary Science.

For Veblen while economics could be considered close to an evolutionary science in some respects, the underlying principles behind the analysis and the formulation and interpretation of the facts were somehow different to that of scientists embracing an evolutionary science. In particular, Veblen claimed that the evolutionist, or "the modern scientist" as he called it, would be unwilling to depart from the "test of causal relation or quantitative sequence" when analysing the problem at hand. According to him evolutionists would insist on an answer in terms of cause and effect, being this type of analysis their last recourse. At this point he suggested that this last recourse had been made available in his time "for the handling of schemes of development and theories of a comprehensive process by the notion of a *cumulative causation*." (Veblen, 1898: 377-378). Here Veblen went one step further and pointed out that this notion of cumulative causation implied that in order to explain any economic process the analysis should be carried out only in terms of cause and effect, and that therefore economists should leave out of the analysis any search for "higher grounds for their ultimate syntheses".

The kind of analysis proposed by Veblen, based mainly in terms of cause and effect omitted any consideration or assumption about the normal state of things or about the tendencies of events to develop in a particular way towards a predetermined end. In consequence, the scientist should not have a predetermined view about where the system goes or where it should go. Scientific inquiry, therefore, should be based on an analysis of the facts alone and the potential relationships between these facts and past situations which could cause or affect them. From this type of analysis it is clear that according to Veblen, history should matter in economics, and that the future is open and uncertain. Indeed, it can be argued that Veblen's discussion on cumulative causation involves a clear idea of path dependency[4].

The idea of the concept of cumulative causation is also a clear indication of Veblen's commitment to a Darwinian conception of economics. Indeed, Darwin's conception of

[3] For a complete analysis of these two issues see Villena and Villena (2002). This paper is available upon request.
[4] On this issue, see, for instance, Rutherford (1994: 11) and Pluta and Leathers (1978: 133).

evolution was materialist, and he explicitly recognised that evolution is not guided by a "law of necessary development" (Edgell and Tilman, 1989: 1005). Hence, it is clear that Veblen's concept of cumulative causation follows Darwin's theory of evolution in the sense that it is free of any preconception regarding inherent tendencies or controlling principles which underlie the laws of motion. From this standpoint, dynamic analysis in a truly evolutionary, Darwinian, theory is characterised by "non-spiritual" sequences and "dispassionate cumulative causation" (Argyrous and Sethi, 1996: 476).

For Veblen this was the main difference between economics and evolutionary sciences, while for evolutionists the system is unbound to follow any particular direction, for economists in general the system tends to move towards an equilibrium point. In this way, economists typically think that the economic system behaves according to a specific pattern, some sort of "natural law", which makes the system evolve towards a point which is the normal state of affairs. In this framework any event or situation that makes the system move away from this state should be considered as a "disturbing factor", something external to the system. Veblen called this perspective, which he associated with the classical economists, the "standpoint of ceremonial adequacy".

According to Veblen, following this "standpoint of ceremonial adequacy", economists working within this framework analyse any economic problem considering the conditions under which this "putative" equilibrium supervenes. Paraphrasing Veblen, these conditions are reduced to a normalised scheme of relations which "spiritually" bind on the behaviour of the problem studied. Using this normalised scheme as a guide, the economist can then develop a "ceremonially consistent formula" applying the deductive method. Finally, the formula can be tested by comparison with observed permutations, using the "normal case"; the results arrived at are thus authenticated by induction. The events that do not conform to the relation stated by the formula are considered abnormal cases produced by disturbing causes (Veblen, 1898: 383-384).

Hence Veblen claimed that: "In all this the agencies or forces causally at work in the economic life process are neatly avoided. The outcome of the method, at its best, is a body of logically consistent propositions concerning the normal relations of things -- *a system of economic taxonomy*. At its worst, it is a body of maxims for the conduct of business and a polemical discussion of disputed points of policy." (Veblen, 1898: 384; Emphasis added). This "system of economic taxonomy" can therefore be seen as the result of an economic science formulated in terms of teleology. It is noteworthy that a taxonomic science does not imply the presence of teleology, but the presence of teleology implies that a science is taxonomic (Wesson, 1999: 3-4). In this respect, and following Veblen's work Joseph P. Wesson points out that on these terms reality can be described without assuming that it is purposeful. By contrast if reality is assumed to be purposeful outside of subjective human desires, then all that is left for the scientist to do is to describe the process by which the purpose is played out. For if reality is purposeful in the teleological sense, then there is no room for explanation, the teleology is the explanation (Wesson, 1999: 3-4).

In summary, according to Veblen's analysis the main difference between economics and evolutionary sciences can be expressed in terms of a teleological versus an evolutionary mode of scientific thought, which in turn implies a theory drawn in causal terms rather than in terms of teleology. In others words, Veblen rejected the notion of equilibrium and advocated an evolutionary science where the evolution of events is unbounded, and where the system, can therefore end up in a state which is not necessarily good or bad in terms of society's welfare. In these terms, the behaviour of the system does not respond to any "natural law", and therefore it can not be successfully studied in those terms. Figure 1 below summarises our brief review of Veblen's distinction between an economic and an evolutionary science.

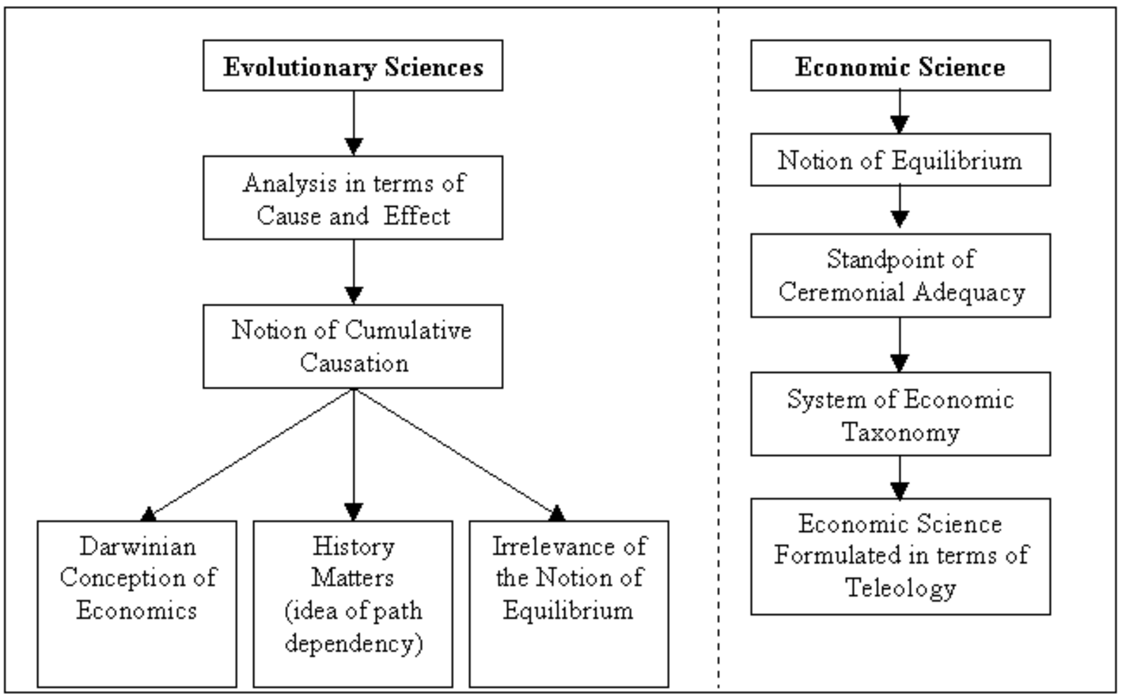

Figure 1: Veblen's distinction between Economics and an Evolutionary Science.

From Figure 1, we can mention the following characteristics that Veblen associated with an economic evolutionary science:

i. A Darwinian conception of economics
ii. The idea that history matters in economic analysis, and
iii. The irrelevance of the notion of equilibrium.

2.2 Some Key Characteristics of Veblen's Evolutionary Economics

In addition to Veblen's conception of an evolutionary science, discussed above, we can also point out some key characteristics present in Veblen's evolutionary approach.

i. *Institutions as the Basic Unit of Analysis*: Economists should study "the dynamic side of the economic process" namely the human factor through its "prevalent habits of thought"[5]. In other words, economics should consider in its analysis the idea of social institutions which involves not only economic factors in the analysis but also social and cultural factors which can importantly influence the individual's behaviour.
ii. *Institutional Context*: Consequently, economists should not be only concerned with the "economic sphere" narrowly defined, but with all the spheres that compose the cultural environment of the agent. This implies that institutional factors should be also considered in the analysis.
iii. *Not Optimising Behaviour*: An evolutionary economics should also allow for the study of not optimising behaviour from the part of the individual, since this type of analysis necessarily points to the characterisation of static equilibria.
iv. *Institutional Inertia and Conflict*: The durable character of social institutions implies that there can be some conflict between newly adopted institutions and previously adopted ones, and that certain social institutions can also produce socially inefficient outcomes.
v. *Evolution of Institutions*: More importantly, in this context, given the durable character of social institutions, they can be considered as an equivalent to the gene in the socio-economic world.

Having briefly reviewed Veblen's work on evolutionary economics and spelt out some of its most important principles, let us turn to the analysis of the Evolutionary Game Theoretic Approach.

3. The Evolutionary Game Theoretic Approach

In the past few years, and mostly since the publication of biologist John Maynard Smith's book on "Evolution and the Theory of Games", evolutionary game theory (EGT) has started to attract the attention of many economists who question the idea of perfect rational agents as the only valid assumption in the study of human economic behaviour. Since John F. Nash's seminal work on Non-Co-operative Games was published in 1951, many refinements to his equilibrium concept have been proposed. These attempts, which aim at capturing the behaviour of perfectly rational players as opposed to providing a widely accepted notion of rationality in economics, have given rise to many criticisms. These criticisms question the very existence of a single notion of "perfect rationality" and point to the idea that the study of perfect rationality alone would not lead to an understanding of human behaviour (Matsui, 1996: 263). Hence, EGT as an approach that does not necessarily require agents to be "rational" – introducing the more modest assumption that people adjust their behaviour on a trial and error basis towards the action which yields the highest pay-off – has attracted the attention of many economists and game theorists who, in

[5] The "habits of thought" concept is recurrent in Veblen's work and gave rise to his concept of "institution". For an analysis of the concept of "institution" in the context of the "old" school of institutional economics see, *inter alia*, Hodgson (1988: 117-140), and Neale (1994: 402-406).

turn, have started to direct their attention away from their elaborate definitions of rationality (Binmore, 1996: x). Since then, new EGT models have been developed by economists and many of the results from the biology literature have been adapted and generalised to the context of social evolution. At present, EGT forms part of the economics literature with a large number of journal articles and some monographs and textbooks .

The EGT approach can be explained in simple terms by comparing it with non-co-operative game theory. According to George J. Mailath, non-co-operative game theory is built on two basic assumptions: “Maximisation, every economic agent is a rational decision maker with a clear understanding of the world; and consistency, the agent's understanding – expectations in particular – of other agent's behaviour is correct, (i.e. the overall pattern of individual optimising behaviour forms a Nash equilibrium)” (Mailath, 1998: 1347). Consequently, non-co-operative game theory typically assumes that in each position of the game a rational agent plays the game against another rational player exactly once. On the other hand, EGT does not assume common knowledge rationality; in fact players are boundedly rational, having little or no information about the game. The game in question is being played not once but many times by agents who are randomly drawn from large populations (Weibull, 1998: 1). In other words, EGT does not necessarily require agents to be “rational”, placing more importance on what has been established in a society. Although EGT is still at the stage of theoretical development, without many applications to economic contexts, some researchers have already noticed its potential usefulness for the study of several economic problems because of its key characteristics (Matsui, 1996: 263).

3.1 Evolutionary Stability Criteria

Evolutionary stable strategy (ESS) is one of the central concepts in evolutionary game theory (Maynard Smith and Price, 1973; Maynard Smith, 1974, 1982). In general, a strategy (phenotype) that is evolutionarily stable is said to be robust to evolutionary-selection pressures in an exact sense. The typical framework in which this concept is applied is one where individuals are repeatedly drawn at random from a large population to play a symmetric two-person game. At first, all individuals are genetically or otherwise "programmed" to play a particular pure or mixed strategy of the game. Then, at some point, it is assumed that a small proportion of the population adopts a different pure or mixed strategy and that those individuals are also programmed to play only that strategy. In this context, the incumbent strategy is said to be evolutionarily stable if there exists a positive invasion barrier, in terms of population size, that makes each such mutant strategy not perform as well as the incumbent strategy in terms of payoffs. In other words, if a mutant strategy is played by a proportion of the population which falls below the invasion barrier, then the incumbent strategy earns a higher payoff than the mutant strategy, and therefore cannot be invaded by it (Weibull, 1996: 33-34). As Vega-Redondo (1996: 13-14) put it :"A strategy is said to be an ESS if, once adopted by the whole population, no mutation adopted by an arbitrarily small fraction of individuals can 'invade' (i.e. enter and survive) by obtaining at least a comparable payoff." An ESS is thus intended to reflect a stationary situation in the evolutionary process in which the pattern of behaviour prevailing in the species cannot be invaded by any mutation which is a better fit.

While the criterion of evolutionary stability is based on ideas from biology, it can be argued that it also provides a relevant robustness criterion for human behaviours in a broad variety of situations including many interactions in economic contexts. In such a context, evolutionary stability may be thought of as a norm or institution (Weibull, 1996: 33-34). In general, the EGT approach presents some clear differences when applied to economics. As typically presented in biology the ESS concept is associated with the notion that higher success reflects an advantage in reproducing; this being comparable to monetary payoffs in the socio-economic context. Thus, the social mechanisms of learning and imitation in EGT are more important than the genetic mechanism when applied to the socio-economic context, implying that emulation of successful behavioural attitudes (phenotypes) leads to evolutionary selection. Individual traits that produce lower payoffs will thus be driven out by more successful traits. Consequently, imitation may induce a process that resembles natural selection or the 'survival of the fittest'[6] (Bester and Güth, 1998: 201).

3.1.1 Conditions for Evolutionary Stability[7].

Consider a large population of players. In each period, agents are randomly matched to play a symmetric (and finite) 2x2-person game. Suppose that initially all members play a certain pure or mixed strategy s^* from a set *S*. Now allow a small population share of individuals to enter who all play some other pure or mixed strategy *s* $(\in S)$. We say that the monomorphic population in which all individuals play s^* is stable, i.e. resistant against mutations, if each mutant *s* that enters the population with small frequency is selected against. In other words, playing strategy *s* always yields a lower payoff than strategy s^*. To state this formally, let us assume that whenever an individual playing strategy s^* meets another adopting strategy *s*, the payoff (number of offspring) to s^* is $\pi(s^*, s)$, where $\pi : SxS \rightarrow R_+$ is a given fitness function. Thus, we can define an ESS as follows.

Definition 1: *A strategy s^* is said to be an evolutionarily stable strategy (ESS) if these conditions hold. (Maynard Smith and Price, 1973; Maynard Smith, 1982).*

(2) $\pi(s, s^*) \leq \pi(s^*, s^*) \quad (all\ s),$

(3) $if\ \pi(s, s^*) = \pi(s^*, s^*) \ then \quad \pi(s^*, s) > \pi(s, s) \quad (all\ s \neq s^*)$

Condition (2) is the basic equilibrium requirement, which ensures that s^* is at least as good a reply to itself as any other strategy. Condition (3) guarantees that s^* can not be invaded by any mutant strategy. We can see this by assuming that (2) holds as an equality. If this occurs a population playing s^* might be invaded by an agent adopting strategy *s*, since an *s-player* would do no worse than the s^*-players in this setting. Consequently, in order to

[6] See, for instance, Mailath (1992) and Selten (1991) for a discussion. Björnerstedt and Weibull (1996) show that population dynamics based in imitation may be closely related to biological dynamics.
[7] See Van Damme (1994: 848-849) and Weibull (1998: 4-45).

avoid a successful invasion of s-players, we have two options: either s^* must be strictly better than s when playing against s^* or, whenever this does not hold, s^* must be better when playing an s than s is when playing itself (Hargreaves Heap and Varoufakis, 1995: 198). In other words, condition (2) shows that (s^*, s^*) is a Nash equilibrium if s^* is an ESS and because of (3) not every symmetric Nash equilibrium corresponds to an ESS. In fact, every ESS induces a proper – hence perfect – equilibrium (Van Damme, 1987).

To better understand the concept of evolutionary stability let us conclude this section with a simple numerical example.

Example 1.

Let us consider a doubly symmetric 2-player game with two pure strategies and payoff matrix:

(4) $$A = \begin{array}{c} \\ C \\ NC \end{array}\begin{array}{c} \begin{array}{cc} C & NC \end{array} \\ \begin{pmatrix} 6 & 0 \\ 4 & 3 \end{pmatrix} \end{array}$$

Since *C-C* > *NC-C* and *NC-NC* > *C-NC*, we have that this game is a co-ordination game. We can think of this game for example as a two-person common property resource game in which, the common resource is an inshore fishery exploited by two fishermen, and that each agent can exploit the fishery choosing between two different levels of effort, e.g., fishing effort might be measured by the number of standardised vessels operating in a fishery during a particular day. In particular, here we consider a low fishing effort, *C*, which we call co-operative, and a high fishing effort, *NC*, which we call non-co-operative. From the payoff matrix it can be inferred that if both players choose the co-operative fishing effort, they will be better off than if both players use the non-co-operative fishing effort, i.e. a payoff of 6 against one of 3. This could be the case if both players adopt the large fishing effort, the stock could be harvested to a level where extraction gets more difficult and therefore not as profitable as in that case where both fishermen use the low fishing effort giving thus more time to the stock to recover. Playing in a co-operative manner is not without its risks, since if one plays co-operatively and the other non-co-operatively the player can end up receiving nothing while his/her opponent gets a payoff of 4. In terms of our example this makes sense, since, as we have assumed here, co-operation means using a lower effort to exploit the resource, which, depending on the relation between efforts, can imply that the other individual using a larger effort can be able to harvest the stock down to a level where it is not more profitable for individual 1 to continue in business or even can harvest the entire stock and there will then be nothing left for individual 1. In any case the co-operative individual will lose revenue by using a lower effort than the other individual who uses a larger effort. Finally, if considering the risk of playing co-operative both players decide to use the non-co-operative fishing effort then they get a return of 3, which is lower than that obtained if both players decide to play co-operative, getting a return of 6.

Consequently, according to the basic principles of traditional game theory, it is evident that here both players (strictly) prefer the strategy profile *C-C*, which gives payoff 6 to each player. Indeed, *C-C* is a strict Nash equilibrium. However, the pure strategy profile *NC-NC* is also a strict Nash equilibrium, resulting in payoff 3 to each player. If one player expects the other to play strategy *NC* with sufficiently high probability, then her unique optimal action is to play strategy *NC* as well. The game has a third Nash equilibrium, which is mixed. This corresponds to the symmetric pair (x, x) where $x = \left(\frac{3}{5}, \frac{2}{5}\right)$, the payoff to each player in this equilibrium being $\frac{18}{5}$. All Nash equilibria are clearly perfect: Two are strict, and one is interior.

It can be shown that each of the two pure strategies in this co-ordination game is an ESS, since each of these is the unique best reply to itself. Let us first consider that playing strategy *C* is the norm in the population, i.e. there is a co-operative institution in place, and that *NC* corresponds to a mutant strategy, i.e. in terms of equations (2) and (3), $C = s^*$ and $NC = s$. In this context, first, we have to check whether or not the inequality given in (2) is satisfied. In this case from (4) the first condition of stability, i.e. $u(NC, C^*) \leq u(C^*, C^*)$ is clearly satisfied since: 4 ≤ 6. The second condition is also satisfied since $u(NC, C^*) < u(C^*, C^*)$. Consequently, to play the co-operative strategy *C* is an ESS in the population. Similarly, for the case where strategy *NC* is the norm in the population, i.e. there is a non-co-operative institution in place, and *C* corresponds to a mutant strategy, i.e. $NC = s^*$ and $C = s$, we have that the first and second conditions of stability are satisfied since: 0 ≤ 3, i.e. $u(C, NC^*) < u(NC^*, NC^*)$. Therefore, playing non-co-operative strategy *NC* is also an ESS. It can also be easily checked that the mixed strategy $p = \frac{3}{5}$, is not an ESS.■

3.2 Evolutionary Dynamics

The criterion of evolutionary stability emphasises the role of mutations in an evolutionary process – a *mutation mechanism*. However, a *selection mechanism* is also required that favours some varieties over others. This is precisely the role of replicator dynamics, which does not embrace any mutation mechanism at all. Robustness against mutations is indirectly taken care of by dynamic stability criteria (Weibull, 1996: 69).

Despite being a static concept, ESS does relate to some basic dynamic process. In fact, a strategy profile must be an asymptotically stable point of a simple dynamic in a monomorphic population in order to be an ESS. Nevertheless, a dynamic process based on a monomorphic population clearly fails to capture the real dynamic process in its whole dimension. This is due to the assumption that each agent in a monomorphic population adopts a common strategy that may be pure or mixed, whereas in the real world a population typically consists of a variety of agents, each taking a pure strategy (Matsui, 1996: 270-271). Consequently, the replicator permits the analysis of a genuinely diverse range of behaviour (that is, a *polymorphic* profile of strategies (Vega-Redondo, 1996:43-44)) as opposed to the concept of ESS, which makes good theoretical sense only when it represents a monomorphic situation.

As typically formalised in the literature, the replicator is formally presented here as an ordinary differential equation.

3.2.1 The Replicator Equation[8]

Let us consider a game with *n* pure strategies. If an agent playing strategy *i* meets an agent adopting strategy *j,* the payoff to *i* is π_{ij}. Assuming that $p = (p_1, ..., p_n)$ is the probability of meeting each type in the population, the expected payoff to an *i*-player is then $\pi_i(p) = \sum_{j=1}^{n} p_j \pi_{ij}$. Hence, the average payoff in the game becomes $\bar{\pi}(p) = \sum_{i=1}^{n} p_j \pi_i(p)$ (Gintis, 2000: 201). In this setting the replicator dynamics can be defined as follows.

Definition 2: *The dynamic in a polymorphic population is called the replicator dynamic and is given by:*

$$(5) \qquad \frac{dp_i}{dt} = p_i\left(\pi_i(p) - \bar{\pi}(p)\right) \quad (all\ i),$$

where $\bar{\pi}(p)$ *denotes the average fitness of the population. Equation (5) is called the replicator equation.*

From equation (5) it transpires that according to the replicator equation, the strategies that grow are those that perform better than average, and that generally the best performing strategies grow the fastest. In this framework, a Nash equilibrium is a stationary point of the dynamic system. On the other hand, each stable stationary point is a Nash equilibrium and an asymptotically stable fixed point is a perfect equilibrium (Bomze, 1986). Moreover, evolutionary stability becomes a sufficient (but not necessary) condition for asymptotic stability if only pure strategies can be inherited (Taylor and Jonker, 1978).

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[8] The mathematical formulation of the replicator dynamics is due to Taylor and Jonker (1978).

Example 2.

Let us obtain the replicator dynamics for the same doubly symmetric 2-player game with two pure strategies and payoff matrix given by (4) of example 1. Here we suppose that within the population there is a proportion of players using the co-operative strategy *C*, and other of players adopting the non-co-operative strategy *NC* which we denote p_1 and p_2 respectively. We also have the identity $p_1 + p_2 = 1$. Thus, we get the following replicator equation:

(6) $$\dot{p}_1 = p_1(1 - p_1)(5p_1 - 3).$$

In order to see how solutions of (6) change over time, let us draw the associated phase portrait. Defining $\dot{p}_1 = f(p_1)$, we have that the steady states or stationary solutions of the differential equation (6), i.e. the zeros of $f(p_1)$, are: $p_1 = 0$, $p_1 = 1$ and $p_1 = \frac{3}{5}$. The derivative of $f(p_1)$ is as follows:

(7) $$f'(p_1) = 5p_1(1 - p_1) + (5p_1 - 3)(1 - 2p_1).$$

Evaluating $f'(p_1)$ at the rest points, we have that: (i) if $p_1 = 0$ then $f'(p_1) = -3$, (ii) if $p_1 = 1$ then $f'(p_1) = -2$, and (iii) if $p_1 = \frac{3}{5}$ then $f'(p_1) = \frac{6}{5}$. Accordingly, since $0 < \frac{3}{5} < 1$, we have the following: (i) if $p_1 > 0$ then $f(p_1)$ is negative; (ii) if $\frac{3}{5} < p_1 < 1$ then $f(p_1)$ is positive; (iii) if $0 < p_1 < \frac{3}{5}$ then $f(p_1)$ is negative; and (iv) if $0 < p_1$ then $f(p_1)$ is positive. With this information we can draw the phase portrait of (6), see figure 2 below.

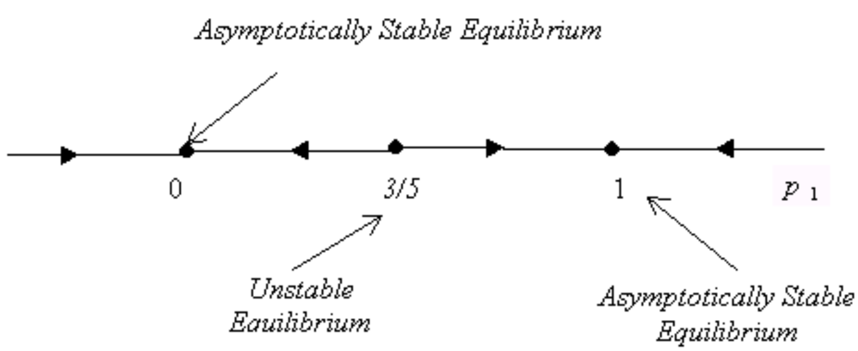

Figure 2: ***Phase Portrait of Equation (6).***

From figure 2, it is clear that the steady states $p_1 = 0$, and $p_1 = 1$ are asymptotically stable, while $p_1 = \frac{3}{5}$ is unstable. In other words, if one starts to the left of *3/5*, that is where the population playing *C*, co-operative, is a rather small proportion of the total population, the system tends to the steady state $p_1 = 0$, i.e. the co-operative population is wiped out. If one starts anywhere to the right of *3/5*, the system tends to the steady state $p_1 = 1$, i.e. the population adopting the non-co-operative strategy is wiped out. The unstable equilibrium at $p_1 = \frac{3}{5}$ is the boundary, or *separatrix*, between the region of attraction of $p_1 = 0$ and that of $p_1 = 1$.■

4. Is Evolutionary Game Theory Veblenian?

Having presented the main concepts and rationale behind evolutionary game theory, in this section we attempt to evaluate this approach in terms of Veblen's evolutionary framework. Basically we will examine EGT on two accounts. First, is EGT consistent with Veblen's notion of an evolutionary science? And second, can Veblen's main evolutionary tenets be useful in the discussion on EGT? and vice versa.

4.1 Veblen's Notion of An Evolutionary Science and Evolutionary Game Theory

4.1.1 A Darwinian Approach to Economics

From the review on Veblen's evolutionary tenets and the brief description of evolutionary game theory's main features and concepts, a first point of comparison that can be made between these approaches is the Darwinian character of both of them. Indeed, as argued above, Veblen explicitly attempted to develop his economic approach based on Darwin's theory of evolution, what he called a "post-Darwinian" economics science (Veblen, 1898: 374-75). Veblen's commitment towards an evolutionary, Darwinian, science is reflected in his emphasis on a non-teleological type of analysis based on cumulative causation, i.e. an analysis in terms of cause effect. In the same way, EGT is also based on evolutionary ideas taken from biology. In fact the two basic concepts in EGT, namely evolutionary stability and replicator dynamics, attempt to highlight the role of mutations, and the role of selection respectively, which represent the basis of any biological evolutionary process (Weibull, 1995: 69). In this context, the Darwinian nature of EGT is evident since the concept of evolutionary stability can be said to generalise "Darwin's notion of survival of the fittest from an exogenous environment to a strategic environment where the fitness of a given behavior (strategy) depends on the behaviors (strategies) of others"(Weibull, 1996: 33-34) and the concept of the replicator dynamics can be interpreted as "a stylised formalisation of Darwinian natural selection which follows directly from an identification of pay-off and 'fitness', i.e. reproductive success" (Vega-Redondo, 1996: 4). Consequently, the Darwinian character of these two approaches provides solid grounds to link Veblen's methodological proposals with EGT, which main developments have thus far occurred not in economics but in the field of theoretical biology. Indeed, in this respect Veblen's work seems closer than other methodological schools within evolutionary economics to provide EGT with the necessary economic rationale to apply EGT's tools to the socio-economic context. [9]

4.1.2 The Importance of History in Economic Analysis

From our review on Veblen's evolutionary principles we also saw that the concept of cumulative causation put forward by Veblen implies that history is significant in economics analysis (see figure 1). In the Veblenian framework, the emphasis on an analysis based on terms of cause and effect points toward the notion that the current state of affairs must be necessarily analysed considering related events occurred during the past, which somehow determine the present situation. In particular, within this framework initial conditions are crucial in this scheme and even small differences may imply widely differing outcomes. This obviously points toward the openness of the evolution of the socio-economic system.

We can argue that this idea on the importance of history in economic analysis is in a sense consistent with the evolutionary game theoretic approach to the social context. Indeed, the basic concepts of evolutionary game theory, namely evolutionary stability and replicator dynamics, which as we saw in section three relate to the evolution of groups within populations, pay special attention to the relationship between past and current events. We can see this in the context of the replicator dynamics by reviewing the exercise presented in example 2. In that example we used the concept of the replicator dynamics to analyse the evolution of a population where there is a proportion of players using the co-operative strategy *C*, and other of players adopting the non-co-operative strategy *NC*. We can interpret these two strategies as two different institutions (or conventions or norms), one co-operative and the other non-co-operative. The result given in example 2 clearly shows that in this particular example the emergence of one institution as the dominant one depends on the initial number of people who subscribe to each institution. In particular, if, initially, less than 60% of the total population adheres to the co-operative institution, then the non-co-operative one will become the dominant in the long run and people adopting the co-operative strategy will be wiped out. Otherwise, the co-operative institution will become the dominant and the population adopting the non-co-operative strategy will be wiped out. This clearly points to the importance of initial conditions which somehow determine future developments and to the relevance of studying the historical context in evolutionary game theory. While at present this is not common practice in EGT, some economists, like Ken Binmore, have already started to recognise this important issue in the literature on game theory (see Binmore, 1996: x-xi).

A related point here is that, as recognised by Rutherford (1994: 11), in the Veblenian framework there is place for formal theory, as that that could be provided by evolutionary

[9] For example EGT has been connected with the works of Joseph Schumpeter, David Hume, Karl Marx and Friedrich Hayek (see, for instance, Weibull (1998), Sugden (1986; 1989), Hargreaves Heap and Varoufakis (1995) and Vromen (1994) respectively). Nevertheless, Veblen's evolutionary economics seems to be the only one consistent with the Darwinian nature of EGT (for details see Villena and Villena (2002)).

game theory, but that the analysis of the historical context should not be limited to highly abstract formal models. This idea implies that while EGT can be useful to formalise Veblen's notion of cumulative causation and thus the importance of history in economic analysis, this formalistic type of analysis should also be complemented by a more descriptive review of the historical context which allows us to fully capture the historical details of the specific situation in analysis. In terms of example 2, we could study, for instance, the historical facts behind a large initial population adhering to the co-operative institution. An analysis of this type would be clearly specific to the case study being examined, involving a study of the historical accidents which could have initiated the "cumulative effect" leading to the population composition of the present.

4.1.3 Irrelevance of the Notion of Equilibrium

As we saw in section 2.1, key to Veblen's approach is the idea that the notion of equilibrium is meaningless within an evolutionary framework. This basically means that we can not discard any possible outcome as the result of evolution, and that therefore we may in some cases arrive to a stationary state in the long run, but in others we may not. If one analyses the two basic concepts of EGT as presented in this paper we can conclude that the concept of evolutionary stability as well as the replicator dynamics do somehow support this basic idea about the openness of evolution. Indeed, while both of these concepts can in some cases provide support to the notion of Nash equilibrium and the assumptions of rationality of traditional game theory, it is also true that in some cases both concepts are undetermined. In other words there are many situations where the result of evolution as represented by these concepts does not end up in a stationary state.

In particular, in terms of the concept of evolutionary stability, we have that by condition (2) every ESS is a Nash equilibrium and because of (3) not every symmetric Nash equilibrium corresponds to an ESS. In addition, many games have no evolutionarily stable strategies at all. For example, if we go beyond the basic model which only deals with two-person, symmetric, static interactions, and consider an asymmetric context with different populations where players can take different roles (such as buyers and sellers), the existence of ESSs is not ensured. Indeed, as showed by Selten (1980), in the asymmetric case, the conditions analogous to (2) and (3) can be satisfied only at a strict Nash equilibrium (if there would be an alternative best reply to the equilibrium, a mutant playing this best reply could invade since it would never meet itself). Many games do not admit such equilibria, hence, they fail to have ESS (Van Damme, 1994: 851). Non-existence is even more common in extensive form games due to in this context an ESS has to reach all information sets in order to exclude alternative best responses (Selten, 1983). The non-existence of the static concept of equilibrium, ESS, in some contexts gives some room for linking Veblen's idea about the openness of evolution with evolutionary game theory. Indeed, if sometimes there exist an equilibrium point and sometimes does not, then evolutionary modelling within this framework can not be based on the notion of equilibrium. Nevertheless, instead of following Veblen's views on the irrelevance equilibrium in an evolutionary approach, game theorists have started to look to alternative equilibrium concepts in evolutionary game theory. As Eric Van Damme put it: "[t]heorists have been reluctant to give up the idea of equilibrium and they have come up with concepts with somewhat better existence properties" (Van Damme, 1994: 851). Among these attempts we can mention some weakening and set-valued versions of evolutionary stability proposed by Maynard Smith (1982), Thomas (1985) and Swinkels (1992).

Similarly, the concept of the replicator dynamics as defined here in its basic formulation (see Taylor and Jonker (1978)) is not without its problems when talking about the idea of equilibrium, as understood in conventional game theory. Indeed, sometimes the solution trajectory of the replicator dynamics does not converge, implying that in some cases there is no possible equilibrium in an evolutionary dynamical game. This, in turn, relates to the notion of rationality in evolutionary game theory. As Jörgen W. Weibull explains: "If an interior solution to a weakly payoff-positive selection dynamics converges over time, then we have seen that the surviving strategies are rational in the sense of being best replies to the resulting mixed-strategy profile. The question hence is what happens if the solution trajectory *does not* converge. When there is no hope of equilibrium play in the long run we are lead to the question whether play is *rational*" (Weibull, 1998: 11).

A basic rationality postulate in non-co-operative game theory is that players never use pure strategies that are strictly dominated. This postulate requires no knowledge of other players preferences or behaviour (Weibull, 1998: 11). Nevertheless, the population share of individuals programmed to a certain pure strategy grows in the replicator dynamics (5) if and only if the strategy earns a payoff above the current population average, and since even a strictly dominated strategy may earn more than average, it is not clear a priori whether such strategies necessarily get wiped out in the replicator dynamics. This is confirmed by Dekel and Scotchmer (1992) who provide a game in which a strategy for this reason does not become extinct in a discrete-time version of the replicator dynamics (Weibull, 1996: 79). Consequently, the concept of the replicator dynamics does not provide a total support neither for the notion of equilibrium nor the rationality postulate.

Nevertheless, despite all these problems to justify the use of Nash equilibrium and the notion of rationality using elements of EGT, game theorists still seem reluctant to discuss whether or not the idea of equilibrium is really needed or even compatible with an evolutionary economic approach. In this context, it becomes clear the potential contribution of Veblen's insights on the subject to this discussion. This obviously remains a topic for further research.

4.2 Veblen's Evolutionary Approach to Economics and Evolutionary Game Theory

4.2.1 Institutions as the Basic Unit of Analysis

A vital point in Veblen's approach is his focus on the dynamic side of the economic process, what he called "prevalent habits of thought" and gave rise to his concept of institutions. In particular, Veblen argued that institutions should be the basic unit of analysis in economics science. This point is also relevant when comparing Veblen's approach with EGT. Indeed, as briefly discussed above, it can be noted that when the concepts of evolutionary stability and replicator dynamics, which have thus far been mainly applied in biology to analyse animal behaviour, are applied to the socio-economic context they are typically used to study the development of institutions (or conventions or norms as they are sometimes called in the modern economic literature) in society[10].

This emphasis on an institutional type of analysis provides another key link between Veblen's evolutionary economics and EGT. While Veblen's institutional approach is frequently associated with a descriptive type of institutional analysis, the EGT approach to social institutions is more formal, mathematical, in character, being currently carried out mainly by mathematical economists. These differences in emphasis could be seen as an opportunity to complement both approaches in the future. If one thinks that probably the main criticism (or one of the main) to Veblen's approach, and to the old school of institutional economics in general, is its lack of formal theory and of an operational "toolkit" that allows the replication of institutional analysis by the academic economics community at large, it becomes evident that the more formal nature of EGT could provide the necessary theoretical concepts to formalise some of the institutional theory proposed by Veblen and his followers and to apply the institutional analysis to specific economic problems. In the same way, in terms of EGT, it can be argued that a clear connection between the literature on evolutionary economics and the economic rationale of EGT's concepts has not been thus far developed (Weibull, 1995, 1998). In this context Veblen's contributions could be valuable by providing the basis for a justification of the application of EGT elements in economics, and insights into the development of a Darwinian, evolutionary, economics based on EGT. Thus, it can be argued that this relationship can supply an interesting new avenue for future research aimed at complementing both research projects.

4.2.2 Institutional Context

While in the traditional approach to economics typically so called 'economic factors' are considered in the analysis, Veblen argued that all institutions "may be said to be in some measure economic institutions". The approach he proposes is thus more inclusive, considering the cultural and institutional context as key to economic analysis. This point is also related to the importance of history in economics discussed above, which Veblen repeatedly emphasised in his works on evolutionary economics (see section 2 and figure 1). This stress on the importance of the context in economic analysis contrasts sharply with the currently dominant paradigm in economics, where models are typically thought to be applicable to different situations, unchanged, regardless of the institutional, cultural, and historical context. This is specially thus in the traditional approach to game theory where

[10] As Mailath (1998: 1348) explains: "Since evolutionary game theory studies populations playing games, it is also useful for studying social norms and conventions. Indeed, many of the motivating ideas are the same". Se also Weibull (1996: 34).

the same game is applied to similar strategic environments without considering the distinctive characteristics and setting of the players involved.

Nevertheless, on this point it can be argued that EGT when applied to the socio-economic context is also consistent with Veblen's approach. In fact, from many economic applications it becomes evident that some of the results of EGT depend on the details of the selection and mutations processes involved (Weibull, 1998: 20). Consequently, in terms of EGT this dependency on context implies that predictions in some games depend on the context in which the game is played. This point has been made several times by the distinguished game theorist Ken Binmore (see, for instance, Binmore (1996: x-xi)).

While the dependency on context of EGT's results can be seen as a natural coincidence with Veblen's work and therefore with a truly evolutionary approach to economics, this characteristic of EGT is not without its critics. In fact, for some practitioners, who consider that a model, or a game in this case, should be a complete description of the problem or situation being analysed, context dependency represents a major shortcoming of EGT. It is in this context that Veblen's perspective can be useful to enrich the debate on this issue in evolutionary game theory and economics in general, by providing the rationale behind the need for incorporating an historical and institutional analysis in an evolutionary approach to economics. Thus far though in the economic literature on EGT, some game theorists have started to recognise that to incorporate the study of the context far from being a drawback represents a necessary step within the EGT approach to the socio-economic environment.

4.2.3 Optimising Behaviour

Another important parallel that can be established between Veblen's work and EGT is the fact that both approaches allow for the study of non-optimising behaviour. Indeed, for Veblen a hedonistic conception was a clear impediment for developing an evolutionary economic science. In general an 'hedonistic conception' of man implies an analysis based on the profit maximisation hypothesis. This, in turn, involves theory mainly aimed at the characterisation of equilibrium, which according to Veblen is not compatible with an evolutionary view where the notion of equilibrium is meaningless. Besides, given Veblen's conception of human nature, for him the notion of maximisation as a motive of economic behaviour has only a very limited meaning (Eaton, 1984: 869). This view is compatible with the economic approach of EGT, which assumes boundedly rational players who have little or no information about the game. This is a key characteristic of EGT because it distinguishes it from the rationalistic approach to game theory which assumes one perfectly rational player for each position in the game. This feature of EGT has also implied that an important part of the economic research conducted on EGT has been on the evolution of rational behaviour, the basic question being: does evolution wipe out irrational behaviour? Typically, this type of analysis attempts to investigate whether or not sub-optimal behaviours will be selected against in the long run by a trial-and-error process, the more specific issue being whether or not market forces will select against firms and firm practices that perform poorly (see, for instance, the reviews of EGT by Van Damme (1994) and Weibull (1998)).

This topic on the evolution of rationality can also be connected with the evolution of social norms. In particular, some studies have contrasted norm-guided behaviour, which is associated with not-optimising, non-rational, behaviour, with optimising, rational, behaviour. This is, for example, the case of Banerjee and Weibull's (1994) work which in their words: "attempt[s] to look at the old question of survival of nonrational agents in a strategic environment represented as a symmetric two-player game" (Banerjee and Weibull, 1994: 343). In their model they consider that non-rational agents act exactly like the agents in standard evolutionary game theory, i.e. they always play a fixed pure strategy, irrespective of any information they might have about their opponent or the current distribution of strategies in the population (from which the opponent is randomly drawn). Banerjee and Weibull call these agents "programmed" and characterised them as follows: "[P]rogrammed agents do not always play 'irrationally' in the sense of using (strongly or weakly) dominated strategies; they may indeed (at least occasionally) play a best reply to the strategy used by their opponent. In a sufficiently varied environment, though, they will end up playing nonoptimally against many of their opponents" (Banerjee and Weibull, 1994: 343-344). On the other hand, they define "rational" agents as those that always play optimally given their information and call them optimising. Specifically, they use the concept of the replicator dynamics to analyse the evolution of rational and non-rational behaviour, studying how the population shares of not optimising and optimising groups in this generalised evolutionary game theory setting develop over time, examining the attractors of this dynamic process. In this context, the principle of the replicator dynamics is based on the postulate that the relative shares of the various strategies present in a heterogeneous population will evolve under pressure of differential payoffs in such a manner as to cause strategies earning higher payoffs to proliferate relative to those earning lower payoffs. The basic result of Banerjee and Weibull's work is that under certain conditions a population of optimisers would not be stable against invasion by non-rational players who stubbornly adhere to a given strategy regardless of its material merits. In some cases extinction of optimisers occurs, in other cases co-existence with non-optimisers prevails.

As Banerjee and Weibull rightly suggest: "nonoptimizing behavior here acts as a form of commitment" (1994: 344), it becomes evident that from this type of analysis non-rational behaviour can be associated with the adoption of specific social norms by part or the whole population. Hence, this result can be considered as crucial to provide an economic theory of the evolution of social norms based on evolutionary game theory. Obviously, this could not be possible working under the typical economic approach, i.e. non-co-operative game theory, which does not allow non-rational behaviour. This fact has also been recognised by Argyrous and Sethi (1996: 480-481) who in this context point out: "In certain contexts the 'non-rational' behaviour can be interpreted as an adherence to social norms, so that the survival of such behaviour under pressure of differential payoffs can help to provide a theory of social norms. This line of thinking, which Axelrod (1986) has explored by means of computer simulations, has been developed analytically in recent work by Binmore and Samuelson (1994) and Sethi (1996)".

4.2.4 Institutional Conflict and Social Inefficient Outcomes

From Veblen's work it can be inferred that there can be some conflicts between institutions and that institutions are not always positive in terms of society's welfare. While these ideas may seem to some extent intuitive, Veblen's somehow descriptive type of approach does not provide the necessary elements to formalise these ideas in terms of formal theory. It is in this context that EGT can be useful to model some of Veblen's institutional theory.

A simple exercise using elements of EGT that shows the potential conflict between institutions, as suggested by Veblen, is provided by examples 1 and 2, where two competing institutions, one co-operative and one non-co-operative, are modelled. From these exercises, it transpires that any of the two conflicting conventions may emerge as the dominant one and that the evolutionary success of either of these institutions crucially depends on the initial number of people who subscribe to each of them (see also Hargreaves Heap and Varoufakis (1995: 208)). The rationale behind this result is simple. A social norm indicates the best course of action whenever you meet an individual who also adheres to your convention. Conversely, the same social norm will guide you to an inferior result whenever you meet an individual who subscribes to a different convention pointing to an alternative course of action. In this setting, it is clear that as the number of individuals using your convention increases so it becomes more likely that it will lead you to the best action. Moreover, since individuals change over conventions based on expected returns (see equation (5)), in the long run one institution will emerge as the dominant one.

In terms of the potential social benefits of institutions, as Veblen pointed out, there are some situations where some institutions are clearly not efficient in terms of society's welfare. This can also be shown using elements of EGT. Looking at example 1, it can be noted, for instance, that evolutionary stability does not reject the socially inefficient profile *NC-NC*, i.e. where both players use the non-co-operative fishing effort. In this sense a socially inefficient institution, e.g., always use strategy *NC* when meeting, may be evolutionarily stable. Similarly, as shown in example 2, the concept of the replicator dynamics also allows for socially inefficient institutions. In that case depending on the initial population adhering to the co-operative institution, the non-co-operative institution can become the dominant in the long run and people adopting the co-operative strategy will be wiped out. In this context, it can be argued that EGT is also consistent with the Veblenian idea that social institutions can produce socially inefficient outcomes and can therefore be used to pursue this type of institutional analysis studying conflicting institutions in society.

4.2.5 Evolution of Institutions

Finally, in terms of the Darwinian character of Veblen's approach, as pointed out above Veblen not only suggested that economic analysis should consider institutions as the main unit of study, but also that the development of the economic process can be investigated through the study of the evolution of the "prevalent habits of thought" present in society. In other words, according to Veblen the durable character of institutions makes possible to consider them as equivalent to the gene in the socio-economic world. Thus institutions evolve through time, changing as individuals and the environment embracing them changes, being selected according to their capacity to succeed in that environment. As Veblen succinctly put it: "The evolution of social structure has been a process of natural selection of institutions." (Veblen, 1899: 188). This fits precisely with the approach of evolutionary game theoretic to the socio-economic context. What one typically studies using the concepts of evolutionary stability and/or replicator dynamics is what "strategy" within a population survives in the long run. Here the concept of strategy is associated with a particular type of behaviour, which is followed by a fraction or the whole population in a particular moment in time. In the particular case of the notion of evolutionary stability one assumes a monomorphic population in which all individuals follow a particular sort of behaviour, i.e. strategy, and evaluates whether or not this type of behaviour can last in time, resisting thus the 'invasion' of alternative mutant strategies. In other words, one evaluates whether the incumbent strategy does better in terms of evolutionary success than the mutant strategy or not. Evidently, this type of analysis can be used to study the evolution of norms, conventions, or institutions as we called here, which in an economic context can be selected in terms of the material payoff they produce. This analysis can be further enriched by using the dynamic concept of replicator dynamics, which allows for the study of a genuinely diverse range of behaviour, by considering a polymorphic profile of strategies.

5. Final Discussion

As a result of reviewing EGT with each of the key features of Veblen's evolutionary framework., we conclude that EGT is indeed consistent with Veblen's proposals, and thus may be considered to be a Veblenian evolutionary approach.

However, EGT is not without its problems and limitations. Some researchers have put forward a number of criticisms of EGT which must be taken into account if this tool is to be successfully applied in economics. For example, applying EGT to social environments requires a clearer interpretation of "fitness". While "fitness" in economics is typically associated with monetary payoffs, it is sometimes not so clear that profit represents the best basis for an evolutionary analysis. For instance, differential growth rates or bankruptcy considerations may better represent "fitness" in the context of industrial competition (Vega-Redondo, 1996: 2). Moreover, some authors claim that a more flexible framework is needed to formulate a true theory of social or cultural evolution; the usual linear (or strictly increasing) function related to individual fitness has been criticised as being too restrictive. Similarly, since the utility theory used in conventional game theory assumes highly rational individuals, this approach to individual fitness should not be carried over to EGT which seeks to describe the behaviour of "boundedly rational" individuals (McKenzie, 2002). While all these concerns appear to be legitimate, some economists have already realised that, as in biology, the correct interpretation of “fitness” must be resolved empirically and therefore through a case-by-case type of analysis (Vega-Redondo, 1996: 2).

Another point of criticism is related to the level of explanation provided by EGT. Reviewing the basic EGT concepts, the notion of ESS clearly does not explain how a population selects a strategy; its main concern is whether a strategy is robust to evolutionary pressures once it is reached (Weibull, 1996: 33). Similarly, the replicator dynamics tell us what strategy played by a proportion of the population will become the “social norm” (the one adopted by the majority), but does not tell us anything about how those strategies were adopted by players in the population in the first place. Accordingly, some authors argue that EGT models do not explain the *etiology* of a social phenomenon, but only the persistence of it. J. McKenzie (2002) claims that EGT may be irrelevant since: ”...we rarely need an evolutionary game theoretic model to identify a particular social phenomenon as stable or persistent as that can be done by observation of present conditions and examination of the historical records …”; This criticism is also applicable to game theory in general, since the Nash Equilibrium concept does not explain the arrival at such particular points, either. Nevertheless, while acknowledging the validity of McKenzie’s point, it can be argued that reality is never so simple that one can always easily observe the stability or persistence of complex social phenomena and hence conclude what the relevant variables involved are. In addition to clarifying some of these not so obvious points, game theoretic explanations can also be useful to formalise “the obvious and evident”, thus providing a stricter and clearer explanation of the stability of the particular situation being analysed. David M. Kreps makes a similar point, stating that game-theoretic analyses contribute: a unified language for comparing and contrasting common-sense intuitions; the ability to push intuitions into slightly more complex contexts; and the means of checking on the logical consistency of specific insights with small changes in the assumptions (Kreps, 1997:88-89).

Finally, EGT is also criticised for a lack of novelty. On this Gerald Silverberg (1997) claims that “…all of the approaches we have examined [including EGT] were purely selectionist: all possible entities at time zero are already present in the population, no new ones are added, and the only possibility is that some will be eliminated and the relative shares of others will change. True evolution, of course, also involves the creation of novelty in real time via random mechanisms. Instead of a strategy space of low dimension and full support, the modelling framework must be expanded to a more complicated space, high dimensional and/or effectively infinite, and only sparsely occupied.” To address this criticism, more complex models that are capable of generating new strategies are required. Acknowledging this limitation, some authors have already started to provide such models (see for instance, Lane (1993), Silverberg and Verspagen (1996), and Vega-Redondo

(1996)). However, these attempts are still very limited and this remains a topic for further research, not only in EGT but also in evolutionary economics in general.

Despite its limitations, EGT still shows real promise from an institutional perspective. We offer three reasons for why institutional economists should be interested in this recently developed tool. Firstly, the methodological debate about the application of EGT to the social context is relatively recent and clearly incomplete. The independent development of EGT and evolutionary economics raises the question of what is the more appropriate methodological link between EGT and this field of economics. Institutional economists, who acknowledge the relevance of Veblen's work on evolutionary economics, have the opportunity to contribute to the economic literature related to EGT which until now makes no mention of Veblen's work at all (see, for instance, Weibull (1996; 1998), Vega-Redondo (1996), Samuelson (1997), Mailath (1998), Matsui (1996), and Van Damme (1987; 1994)). Secondly, the formal character of EGT provides an opportunity to incorporate into mainstream economic research, some topics frequently associated with the "old" school, by supplying a framework that allows the replication of results by the research community. In particular, EGT may provide the tools to formalise some of the main tenets and ideas of Veblen's theory of socio-economic evolution. Finally, there are many research projects within the EGT literature which may appeal to institutional economists. For instance, here we could mention: (a) the work on the "evolution of preferences" based on the so-called "indirect evolutionary approach" proposed by Werner Güth (see, for instance, Bester and Güth's (1998), Güth and Yaari (1992), Güth (1995) and Dufwenberg and Güth (1999)); (b) the study of the "evolution of social norms" in specific economic settings – an excellent example here is provided by the work of Rajiv Sethi and E. Somanathan (1996) which examines the problem of the exploitation of a common property resource within an evolutionary game theoretic framework– and (c) the "economic anthropology" of Herbert Gintis and Samuel Bowles, which is based mainly on EGT tools, which by itself provides an extensive research agenda for institutional economists. Among the specific topics they have addressed we can mention: the importance and origins of reciprocity, fairness and co-operation in primitive societies and the measure of social norms and preferences using experimental games (see, *inter alia*, Gintis, (2001), Henrich et al.(2001), and Bowles and Gintis (1998)).

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