[Review of the book Evolutionary Game Theory, J. Weibull, 1996]

van Damme, E.E.C.

Published in:
Journal of Economic Literature

Publication date:
1996

Document Version
Other version

Review of the book Evolutionary Game Theory, J. Weibull, 1996, Journal of Economic Literature, 34(4), 1952-1953, prof.dr. E.E.C. van Damme

Evolutionary game theory. By JORGEN WEIBULL.

Cambridge and London: MIT Press, 1995. Pp.
XV, 265. $30.00. ISBN 0-262-23181-6.
]Eh 96-0040

The standard justification of Nash's equilibrium concept is rationalistic: Fully rational players, knowing all aspects of the game, can predict exactly what their opponents will do and they optimize taking all this information into account. Since the beginning of the 1970s biologists have been working on evolutionary models in which the success of one individual depends on what other individuals are doing. Although these models can be formalized as (noncooperative) games, it seems inappropriate to use the standard rationality assumption to analyze them. Instead biologists developed their own tools of population dynamics and concepts of evolutionary stability. It turns out that the resulting concepts are closely related to the Nash equilibrium concept. In this book, Jorgen Weibull describes the links between the rationalistic and evolutionary approaches to analyzing games. While Weibull focuses mainly on the mathematical tools needed to understand the area, he also explains why the evolutionary approach is relevant to economics.

After having reviewed the core concepts from classical noncooperative game theory in Chapter 1, Chapter 2 describes the biologists' static approach. The context is one in which individuals from a single population are repeatedly matched in pairwise contests. The

question asked is under which conditions a monomorphic state in which all individuals are playing the same strategy is resistant against mutations, that is, each single mutant strategy that makes up a small fraction of the population will be driven out. Strategies that are stable in tbis sense are called evolutionarily stable (or ESS). Characterizations are provided and variations of this basic concept are discussed. The link with classical game theory is provided by the result that, if s is an ESS, then *{s,s)* is a Nash equilibrium of tbe symmetric two-player game that describes tbe situation. In fact, *(s,s)* has to be a proper equilibrium, in the sense defined by Myerson.
In Chapters 3 and 4, attention shifts to the dynamic approach that biologists developed. Each individual in the single population is supposed to be programmed to play a certain strategy. The individuals meet at random and, if the state of the population (the probability distribution over the strategies) is *x,* the payoff to an individual playing strategy *i* is «;(»:). The dynamic evolution of the state is supposed to be deterministic and given by ij = *gi{x)xi*. Chapter 3 is devoted to the analysis of the "replicator equation" in which the growth rate gj(x) of each strategy *i* is equal to how much better this strategy fares than the average one, gj(x) = M;(x) - *I,jXjUj{x).* Chapter 4 analyses more general selection dynamics, which either have the property that strategies that do better than others grow faster (payoff monotonicity), or which are such that strategies that do better than average grow (payoff positivity). Examples are given of (social) imitation processes that give rise to dynamics of this type.
The main results show that there are indeed close links between the static and dy

namic approaches to analyzing games. For a broad class of dynamic processes, (i) strategies that are (iteratively) strictly dominated get eliminated in the long run, (ii) limits of orbits must be Nash equilibria, (iii) only states that constitute Nash equilibria can be Lyapunov stable, (iv) only perfect equilibrium strategies can be asymptotically stable, and (v) ESS are asymptotically stable. There are also differences between the classical and the evolutionary approaches: the latter, for example, does not provide support for the elimination of weakly dominated strategies. In fact, discrete time dynamics may -not even eliminate pure strategies that are strictly dominated by mixed strategies.

Chapter 5 investigates whether the results can be generalized to multipopulation interactions. Individuals belong to *N* distinct populations (for example, buyers and sellers) and in each encounter one individual from each population is randomly selected to play an IV-person game. With *x* denoting the state of all populations, each population n now evolves according to a dynamic *x"* - g"(x)x" where g" has similar properties as in the one population case. The results are less satisfactory in this case. In particular, asymptotic stability of the state is equivalent to the state being a strict Nash equilibrium, hence, the evolutionary approach offers no justification for equilibria in which players have alternative best responses, such as, for example, equilibria in mixed strategies.

The book concludes with a concise introduction to the theory of ordinary differential equations, which ensures that the book can indeed fulfil its aim to serve as a text for secqnd-year graduate students in economics.

The book not only is a clearly written synthesis of some of the most important findings in the field, it also (albeit somewhat implicitly) points to fruitful directions for future research. A virtue of the dynamic approach is that it shifts attention from an analysis of the equilibrium state to an analysis of the underlying equilibriating mechanisms and the initial configuration. The equihbrium that is finally selected (if any) and the speed of convergence may well depend crucially on these latter aspects, so that a study of these is invited. As the author notes, the "formal modeling of social evolution of behaviors in a population of strategically interacting agents" is as yet a "not much researched arena." The book gives some examples of imitation dynamics that happen to fit the formalism developed by biologists. It remains to be seen whether this formalism helps to describe and analyze the human learning processes that take place in economic environments, such as in the experimental laboratory.

ERIC VAN DAMME
Tilhurg University