Evolution and Perfect Competition

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Arising in biology, Evolutionary Game Theory (EGT) dispenses with payoff maximization in games and postulates instead dynamics with an infinite population of agents who are randomly matched in pairs to play a (finite) two-player game. The key concept is that of an Evolutionarily Stable Strategy (ESS). This is a population profile – a frequency distribution of strategies – that cannot be invaded by a small proportion of mutants behaving differently, i.e. according to different frequencies. The key findings of EGT are, first, that an ESS is always a Nash Equilibrium (NE), and second, that it is asymptotically stable in the Replicator Dynamics. In this dynamics, strategies that perform better than average thrive at the expense of those that perform worse than average in the population.

Typical economic situations like oligopolistic competition, rent-seeking problems, or provision of public goods cannot be modeled as two-player games played by randomly matched pairs of agents out of a large population. Rather, competition takes place between a reduced number of players, each of them simultaneously influencing the payoffs of all other players (through prices, aggregate production, etc.), that is, an N-player game.

The notion of ESS was adapted by Schaffer (*Journal of Theoretical Biology*, 1988) to the case of finite populations and N-player games. A finite population ESS is a strategy under which, if it is adopted by the whole population, any single deviant (mutant) will fare worse than the incumbents after deviation. A finite population ESS needs *not* be a NE. Instead of maximizing the payoffs of any given player, an ESS maximizes *relative payoffs* – the difference between the payoffs of the ESS and those of any alternative 'mutant' behavior.

Alós-Ferrer and Ania (*Economic Theory*, forthcoming) show that the concept of finite population ESS has interesting implications in economics. Consider any *aggregative* game, i.e. a game where payoffs depend only on individual strategies and an aggregate of all strategies. For instance, in a Cournot oligopoly, the aggregate will be the total industry output. Suppose further that there is strategic substitutability between individual and aggregate strategy. We call this *submodularity*. For example, in Cournot oligopolies the incentive to increase individual output *decreases* the higher the total output in the market is. Then, we define an aggregate-taking strategy (ATS) to be one that is individually optimal given the value of the aggregate that results when all players adopt it; that is, we consider aggregate-taking behavior as the natural generalization of price-taking behavior.

We find that an ATS is evolutionarily stable in any aggregative game with a submodular structure. Further, any strict ATS is strictly globally stable, meaning it resists the appearance of *any* fraction of such experimenters, and the unique ESS. This has a natural counterpart in the supermodular case (strategic complementarity), where any ESS must be an ATS.

We also show that a strictly globally stable ESS of an arbitrary, symmetric game is always the unique, long-run outcome of a learning dynamics based on imitation and experimentation. As a corollary, this holds for any strict ATS of a submodular aggregative game.

This generalizes previous results for the Cournot oligopoly obtained by Schaffer (*Journal of Economic Behavior and Organization*, 1989) and Vega-Redondo (*Econometrica*, 1997). Other examples of aggregative games range from rent-seeking games to common-pool resource extraction games. In our view, these results might be taken to provide an alternative, evolutionary foundation for the perfect competition paradigm. In contrast to the large-population approach, this foundation does not rely on agents being negligible.

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