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Equilibrium selection with coupled populations in hawk–dove games: Theory and experiment in continuous time ☆

Volker Benndorf, Ismael Martínez-Martínez, Hans-Theo Normann *

Düsseldorf Institute for Competition Economics (DICE), Heinrich-Heine-Universität Düsseldorf, Universitätsstraße 1, D-40225 Düsseldorf, Germany

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Abstract

Standard one- and two-population models for evolutionary games are the limit cases of a uniparametric family combining intra- and intergroup interactions. Our setup interpolates between both extremes with a coupling parameter κ. For the example of the hawk–dove game, we analyze the replicator dynamics of the coupled model. We confirm the existence of a bifurcation in the dynamics of the system and identify three regions for equilibrium selection, one of which does not appear in common one- and two-population models. We also design a continuous-time experiment, exploring the dynamics and the equilibrium selection. The data largely confirm the theory.

JEL classification: C62; C73; C91; C92

Keywords: Evolutionary game theory; Experiment in continuous time; Hawk–dove game; Replicator dynamics

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* Corresponding author.

E-mail addresses: benndorf@dice.hhu.de (V. Benndorf), ismael@imartinez.eu (I. Martínez-Martínez), normann@dice.hhu.de (H.-T. Normann).

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1. Introduction

Evolutionary game theory makes an important distinction as to whether players interact within a single population or between two (or more) disjunct populations (Cressman, 2003; Friedman, 1991; Weibull, 1995). When matched with opponents in a single population, players earn the expected payoff as if playing against the aggregate strategy of their own population, so only symmetric strategies can survive. With a two-population matching, each member of the group of, say, row players is matched against a rival from the group of column players. Here, polarization in behavior can occur and the populations may specialize in different strategies. The same evolutionary forces can thus imply qualitatively different results, so the distinction of single- and two-population settings is crucial.

The compartmentalization of one- and two-population models may, however, not always be appropriate. A two-population analysis requires that players exclusively receive their payoffs from interactions with the external population. Likewise, in a one-population setting, players never interact with opponents from other populations. Both these assumptions may not be warranted: why should players in a two-population game not interact at least occasionally within their own population? Why should agents in a single population setting not sometimes be also exposed to interactions with agents from other populations? It seems plausible that the interaction will often be mixed.

For non-human players, examples where the one- and the two-population cases overlap are abundant in resource conflicts. Animals will predominantly compete for resources with other members of the same species (intra-species competition). But there will also be inter-species competition (Birch, 1957)—think of different predatory mammals fighting for prey and water, or of various sessile organisms competing for light interception and soil. Inevitably, intra-specific and inter-specific competition overlap.[1]

An example with human players can be found in Mailath (1998). Traders bargain either within their own village or encounter visitors from a different population. The game is hawk–dove in both cases but the analysis is one-population in the first case and two-population in the second and the evolutionary selection mechanisms differ starkly. But beyond these polar cases traders may, of course, interact at the same time both with players from their own village and with visitors.[2]

The notion that intragroup and intergroup interactions overlap makes sense when agents do not condition their strategy on the population from which an opponent stems. This will be the case when players cannot identify which population a rival is from, that is, when group membership is determined by indiscernible factors such as geographic location and religious or political views. Even when they can identify the groups to which other players belong, they may still not be able or willing to condition their strategy on this identification.[3] A firm's strategy may involve a managerial structure or incentive scheme that cannot be switched on and off depending on

[1] Connell and Sousa (1983) and Schoener (1983) provide surveys of works on inter-specific competition. Kennedy and Strange (1986) show how the density of salmon fry in an ecological niche appears to be influenced by the presence of both older salmons (same species, different generation) and trout (different species).

[2] Somewhat similarly, Roll (1994) interprets stock market traders performing fundamental analysis as doves and traders gathering information only from price movements as hawks. As suggested by a referee, Roll's original model is formulated for one population but could easily be extended to consider two populations, perhaps in different countries or different types of market participants, for example, pension funds vs. hedge funds.

[3] Taking a different approach, Selten (1980) assumes that players can condition their strategy based on the information available to them.