Project title: Evolutionary games and the enhancement of traits

Project leader: Dr. Gijs Schoenmakers

Function: Assistant Professor

Collaborators: Dr. Kateřina Staňková, Prof. Dr. Frank Thuijsman

Proposal: In recent years techniques from evolutionary game theory have been widely used to describe and predict biological phenomena. In a standard evolutionary game a (fixed) fitness matrix represents the reproductive capacity of individuals possessing certain traits when interacting with other individuals of the population. The key idea is that traits that are more beneficial to a species are more likely to be transferred to the next generation than less beneficial traits. While these simple games are computationally tractable, their predictive capacities are limited as they do not consider the possibility for individuals within a population to enhance these traits (for instance by training) within their lifetime.

In this project we propose to expand the realm of evolutionary games by including a component of trait enhancement (or skill improvement) into the games. In economic theory and game theory several models on this topic exist. The usual assumption is that experience leads to a higher production: The more one trains a certain trait, the more skillful with regard to this trait one gets. We propose to construct a model that consists of an evolutionary game and include a parameter that determines the enhancement of a trait within one generation. Reproduction, together with death and birth, takes place at discrete times, while in between these times individuals within the population work on enhancing certain traits, which might go at the expense of other traits. This phenomenon is modelled by making the fitness of each trait dependent on how skilled the previous generation was with respect to this trait. The models that we will develop will be then used for modeling interactions among different world countries when deciding their national pollution policies. Objectives of the project are: 1) to obtain theoretical results on equilibria, stability concepts and dynamics for the games with trait enhancement; 2) to use these games to explain real-world phenomena such as cumulative trait enhancement in deciding national pollution policies: individuals in later generations can become much more skillful at certain traits than their ancestors; 3) to validate the model using real data regarding emission levels in the world.

Requirements candidate: Highly motivated student with good English communication skills and proactive and resolute attitude, with a master's degree in (applied) mathematics or computer science (preferably game theory, optimal control or optimization) and experience with Matlab and/or Java programming.

Keywords: Evolutionary games, stochastic games, repeated games, game theory of pollution

Top 5 selected publications:

1. P. Uyttendaele, F. Thuijsman, P. Collins, R. Peeters, G. Schoenmakers, R. Westra (2012). Evolutionary games and periodic fitness, *Dynamic Games and Applications,* **2**, 335-345.

2. J. Flesch, G. Schoenmakers, O.J. Vrieze (2011). Loss of skills in coordination games, *International Journal of Game Theory,* **40**, 769-789.

3. G. Schoenmakers, J. Flesch, F. Thuijsman, O.J. Vrieze (2008). Repeated games with bonuses, *Journal of Optimization Theory and Applications,* **136**, 459-473.

4. K. Schüller, K. Staňková, F. Thuijsman (2017). Game theory of pollution: National policies and their international effects, *Games*, **30**, DOI: 10.3390/g8030030.

5. G. Schoenmakers, J. Flesch, F. Thuijsman (2007). Fictitious play in stochastic games, *Mathematical Methods of Operations Research,* **66**, 315-325.