

Spatial Divergence & Oscillatory TOCs

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The tragedy of the commons

Garrett Hardin:

*The population problem has no technical solution;
it requires a fundamental extensioin in morality.*

The tragedy of the commons

A tragedy of the commons (TOC) occurs when individuals acting in their own self-interest deplete commonly held resources, leading to a worse outcome than had they cooperated.

Keys to TOC

- Macro-scale:
 - game
 - environment
- Individual level:
 - divergence of incentives & pay-offs

Current frameworks

- Evolutionary dynamics arising from a TOC dilemma can be modeled in terms of changes in the frequencies of individuals from two populations, cooperators and defectors.
- Individuals interact and receive payoffs that depend on their strategy and the strategy of their opponent, where payoff can be modeled by the payoff matrix,

$$A = \begin{Bmatrix} R & S \\ T & P \end{Bmatrix}$$

representing the system's fitness.

- The outcome of TOC is measured by the frequency of co-operators and defectors $(x, 1 - x)$, and the resources.
- This framework is not a zero-sum game.

Current frameworks – equations & conditions

PhysRevLett.122.148102

- fitness

$$\dot{x} = x(1-x)[r_C(x, A) - r_D(x, A)] \quad (1)$$

r_C, r_D : context-dependent fitness payoff to cooperators and defectors, respectively.

- TOC's occurrence condition: $T > R > P > S$.
- To address the reproductive case: resource-dependent payoff matrices

$$A(n) = A_0(1-n) + A_1(n),$$

where $n \in [0, 1]$.

Individual-based coevolutionary game

- Intuitions on the emergent dynamics of social context and resources:
 1. to assess the influence of noise
 2. spatially explicit interactions
- Schemes:

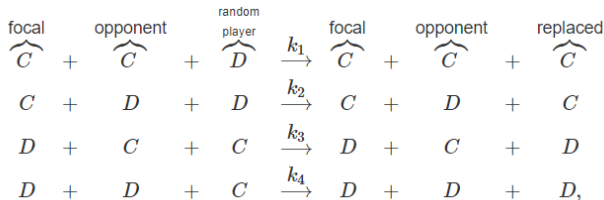


Figure: Transitions of cooperaters and defectors.

Individual-based coevolutionary game

- Results
 - Transition rate for #C and #D. Furthermore, the limiting frequency of cooperaters $\lim_{N, n_c \rightarrow \infty} \frac{n_C}{N}$
- Problems: is such frequency convergent or divergent?
 - Recalling a Cauchy distribution, or a Lorenz oscillator.
 - In other words, is the society ending up in tragedy?

Demographic noise and spatial structure

References

- Spatial Interactions and Oscillatory Tragedies of the Commons
Yu-Hui Lin and Joshua S. Weitz Phys. Rev. Lett. 122,
148102 – Published 12 April 2019
- Evolution of cooperation in stochastic games, Christian Hilbe,
Štěpán Šimsa, Krishnendu Chatterjee & Martin A. Nowak
Nature - Published: 04 July 2018
- Reputation helps solve the ‘tragedy of the commons’ Manfred
Milinski, Dirk Semmann & Hans-Jürgen Krambeck Nature -
Published: 24 January 2002
- Cooperating with the future Oliver P. Hauser, David G. Rand,
Alexander Peysakhovich & Martin A. Nowak Nature
Published: 25 June 2014
- Evolutionary games and spatial chaos Martin A. Nowak &
Robert M. May Published: 29 October 1992