

# 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:

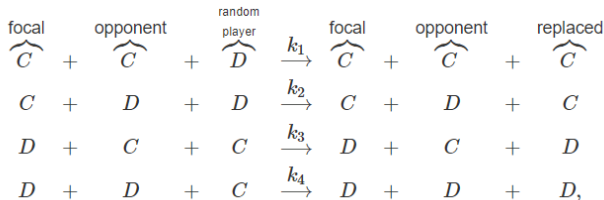


Figure: Transitions of cooperators and defectors.



# 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?

## 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