Spatial Models & TOC

修格致

IRSGIS
Peking U

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Table of Contents (also TOC)

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.

Reputation helps solve the 'TOC'

Nature 2002 如果每个人都可以任意过度使用资源，那么在很多的社会困局中，TOC 都会涌现。公共资源实验的结果，通常是群体受益的情形不会出现。由于个体和国家都会出现在多个社会博弈中，这些社会博弈的交互通常会产生复杂的结果，这些结果往往保存了公共资源。**非直接互惠**就是基于名声的一种策略，它可以高度保存合作意愿。本文证明了改变公共物博弈和非直接互惠的轮次可以对保存公共物有着很高的价值。但是如果非直接互惠不存在，对公共物的保护行为很快就消失了。改变博弈给了所有人更高的收益。在很多社会博弈中，名声可以作为一种通货。我们的方法可以验证很多社会问题的可解性。

Current frameworks

- Evolutionary dynamics arising from a TOC dilemma can be modeled in terms of changes in the frequencies of individuals from two populations, cooperaters and defecters.
- 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

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

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:

Individual-based coevolutionary game

- Results
  - Transition rate for #C and #D. Furthermore, the limiting frequency of cooperaters $\lim_{N,n_c\to\infty} \frac{n_C}{N}$
- 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?

Individual-based coevolutionary game

Demongraphic noise and spatial structure

Coexistence in cities

- *City* is a concrete of aggregate effect. Such complex is not only the sum of different parts, but also the chemistry through each part.

- The resource of cities?
  - Citizens, which are usually somewhat *evenly* distributed spatially.
  - Firms, diverse in reliance on amongst distances.
- The costs of cities?
  - Dynamics of input and output.

Establishing models

- Task: Predicting the emergence of new firms over a city's space.

0. Collect financial statements of companies and the decay of communication distances, establish the IOs of every trade and the current cross matrix;
1. Vectorize the factors of different firms by reliance on differnet trades;
2. Establish a dynamical matrix of size $kN \times kN$, new companies may emerge at some optimal location to take charge for urban development;
3. simulate until it ends or a sufficiently long time;
4. Evaluate the diversity of trades and the fitness of industrial structures.

Expecting

- Some cities' industrial structures may lead to TOC: companies harm their city when pursuiting their own benefits.
- Diversity of cities diverges according to the initial conditions since both the specialization and diversification exist.
- Emergence of new companies ‘spatial and size distribution.

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

reference