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Climate Policies Under Wealth Inequality

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Main Focus & Objectives

- The interplay between wealth inequality and climate cooperation
- Analyse how inequality and social structure impact climate policy success
- The influence of these wealth disparities on achieving public good thresholds

Related Work

References and studies that support the project

Social Diversity Promotes The Emergence of Cooperation in Public Goods Game
Francisco C. Santos, Marta D. Santos & Jorge M. Pacheco

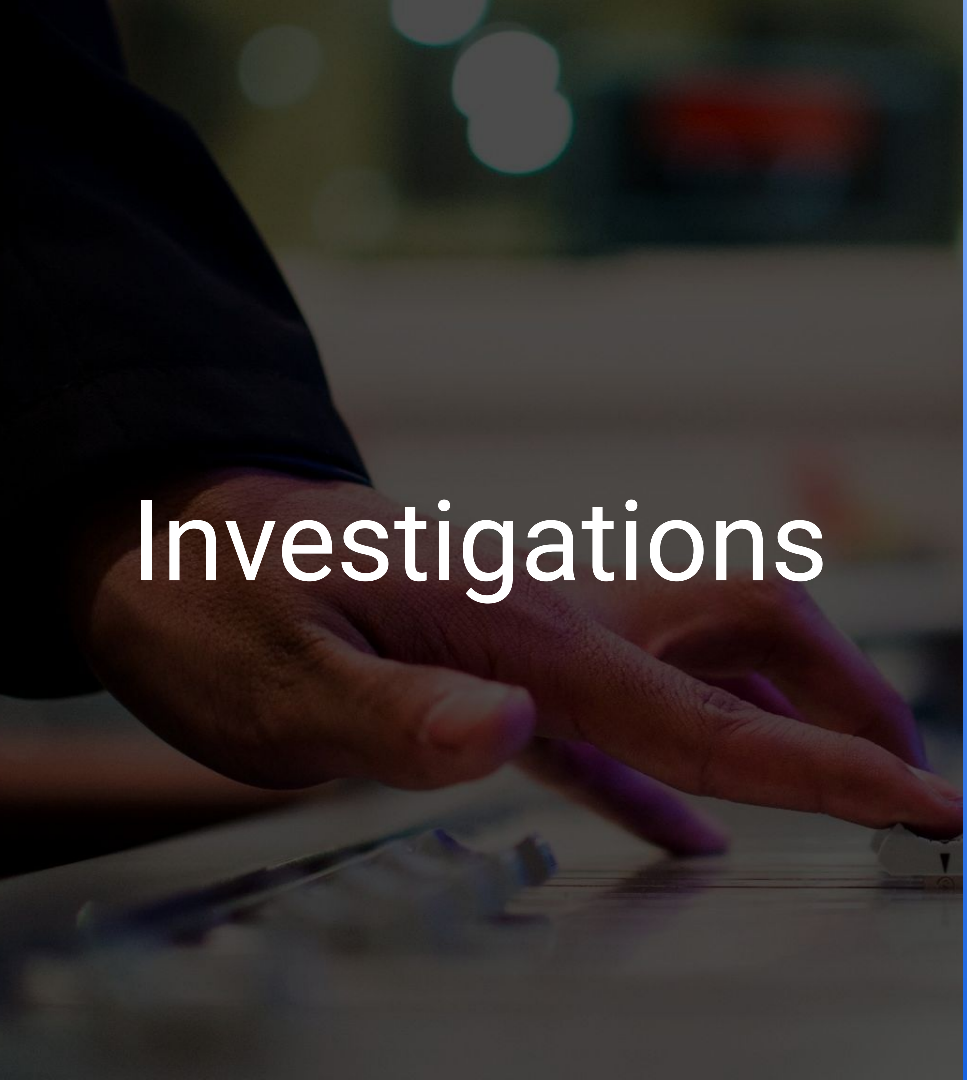
Dynamic instability of cooperation due to diverse activity patterns in evolutionary social dilemmas
Cheng-Yi Xia, Sandro Meloni, Matjaž Perc and Yamir Moreno

2008 2011 2015

Risk of collective failure
Francisco C. Santos and Jorge M. Pacheco`

What's new in this paper?

Investigation on effect of wealth inequality and homophily!



Investigations

- Wealth inequality
- Homophily
- Cross-group influence
- Size of subpopulations
- Wealth gap

Practical Aspects and Reproduction

Step 1: Defining the game model

- **Population Simulation**:
  - Split population into rich (20%) and poor (80%).
  - Strategies: Cooperation (C) vs Defection (D).
- **State Space Representation**:
  - All system states represented as a tuple (C_R, C_P).
  - Scalar projection to simplify transitions for W, transition matrix.
- **Fitness Calculation**:
  - Payoff-driven, based on group contributions and thresholds.

Fitness Calculation

Per strategy in each subpopulation

$$f_R^C = \frac{1}{\binom{Z-1}{N-1}} \sum_{j_R} \sum_{j_P} \mathbb{P}(j_R, j_P)\,\Pi_R^C(j_R + 1, j_P)$$

Practical Aspects and Reproduction

Step 2: Key calculations

- **Transition Matrix**:
  - Probabilities of moving between states.
  - Adjusted diagonals ensure probabilities sum to 1.
- **Stationary Distribution**:
  - Solved using eigenvector computation to find long-term state probabilities.
- **Average Group Achievement**:
  - Weighted sum of success probabilities based on the stationary distribution.

Transition Matrix Calculation

Going from strategy X to Y, in subpopulation k

$$T_k^{X\to Y} = \frac{i_k^X}{Z}\left((1-\mu)\left[\frac{i_k^Y}{Z_k - 1 + (1-h)Z_l}\left(1+e^{\beta\left(f_k^X - f_k^Y\right)}\right)^{-1} + \frac{(1-h)i_l^Y}{Z_k - 1 + (1-h)Z_l}\left(1+e^{\beta\left(f_k^X - f_l^Y\right)}\right)^{-1}\right] + \mu\right)$$

Practical Aspects and Reproduction

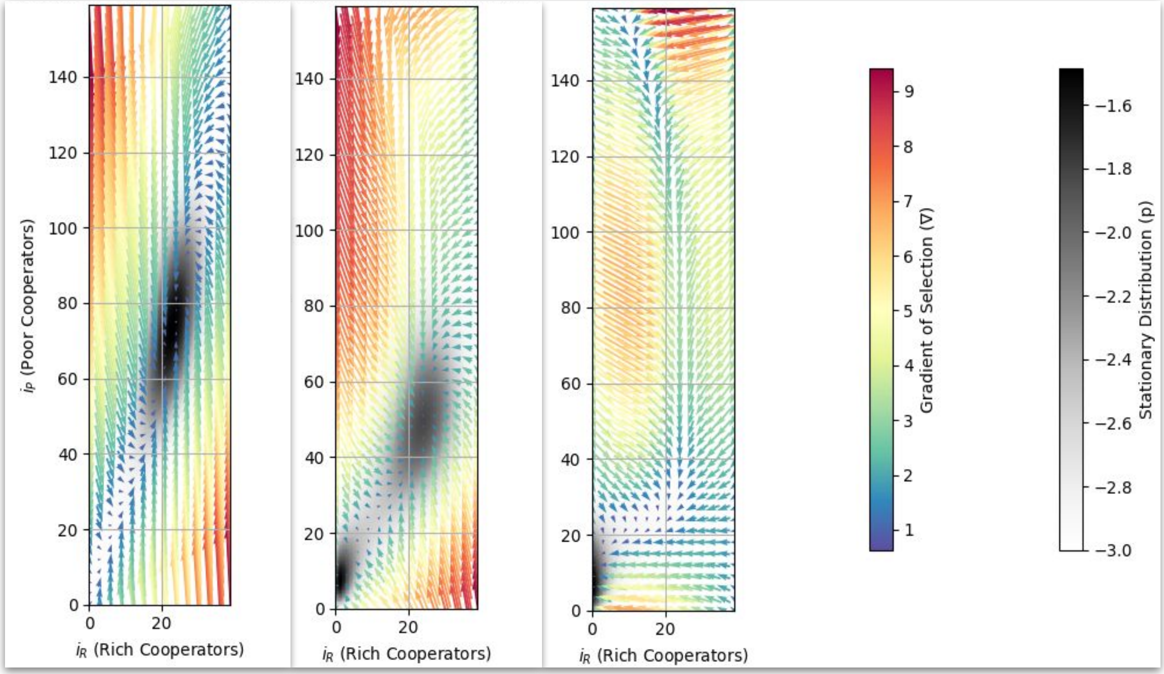
Step 3: Putting it all together & visualisation

- **Game Model Implementation**:
  - Developed custom model for simulation.
  - Unfortunately could not use EGTTools since model required greater control over multi-population dynamics.
- **Plotting**:
  - Used Matplotlib for visualisations:
    - Group achievement vs. Risk
    - Stationary distributions, gradient of selection (GoS)
    - GoS vs. cooperators in each subpopulation

Results

Stationary Distribution and Gradient of Selection

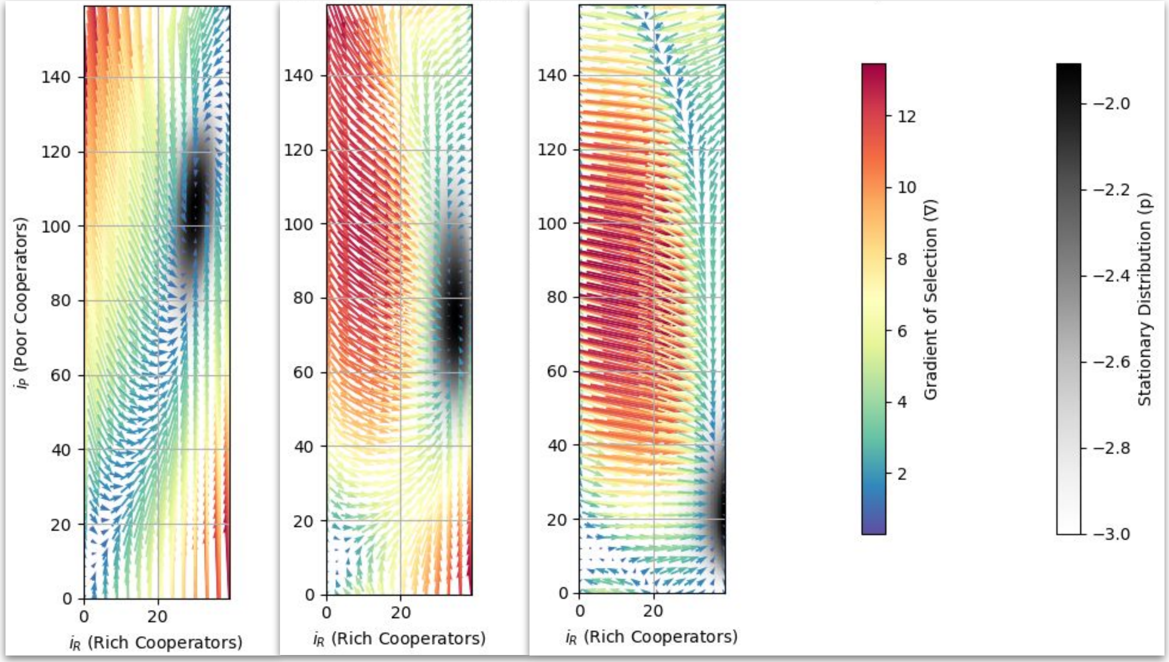
r = 0.2
h = [0, 0.7, 1]



Z = 200; Z_R = 40; Z_P = 160; c = 0.1; N = 6; M = 3cb; b_P = 0.625; b_R = 2.5

Stationary Distribution and Gradient of Selection

r = 0.3
h = [0, 0.7, 1]

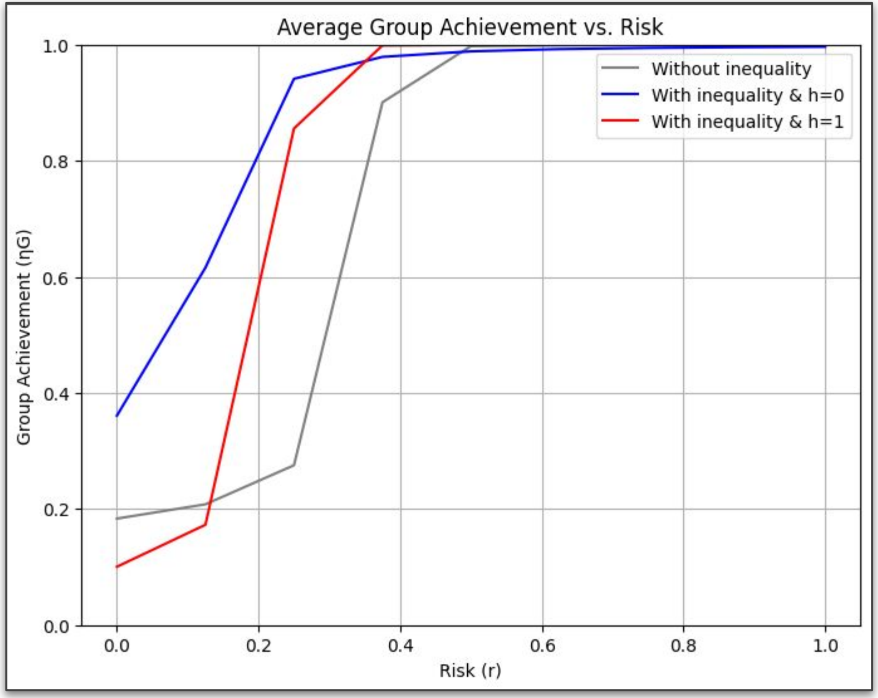


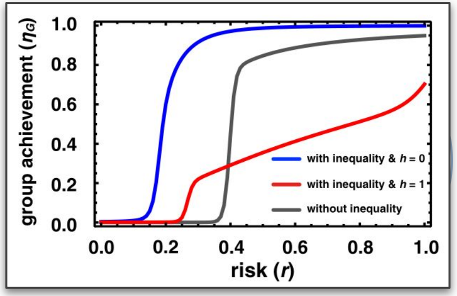
Z = 200; Z_R = 40; Z_P = 160; c = 0.1; N = 6; M = 3cb; b_P = 0.625; b_R = 2.5

Average Group Achievement as a function of Risk

r in the interval [0, 1]
h=0, or *h*=1, or no equality

Z = 160 (not 200); N = 6; M = 3; β = 5





Evolution of Rich/Poor Subpopulations

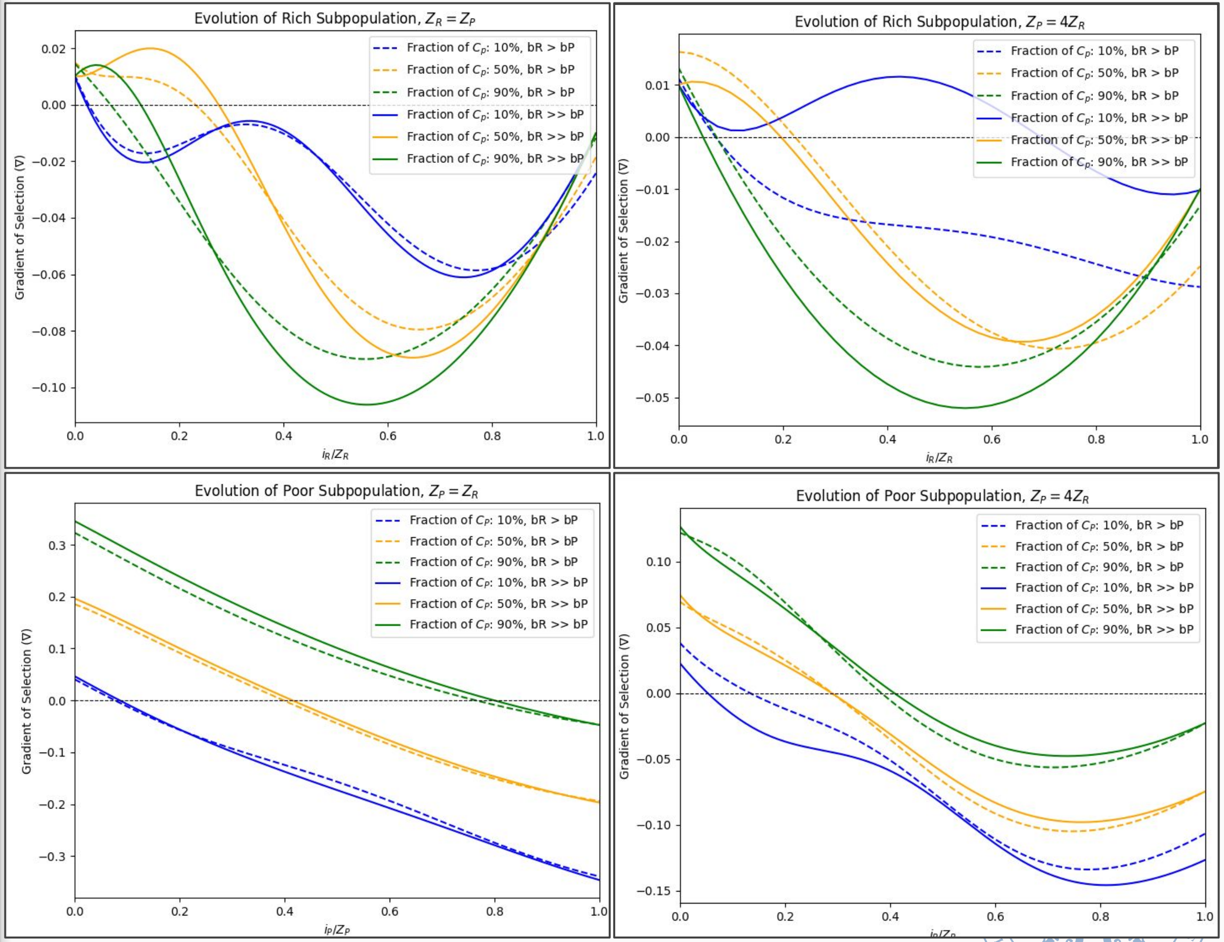
While freezing the evolution of the other

GoS for Z_R vs. i_R/Z_R

GoS for Z_P vs. i_P/Z_P

When $Z_P = Z_R$ and $Z_P = 4Z_R$

$Z = 200$; $N = 10$; $M = 3$; $\beta = 10$; $h = 0$; $r = 0.3$



Discussion

Effect of homophily and risk

While inequality may hinder cooperation in the presence of high homophily, it can **paradoxically promote** collective action

Discussion

The question we've all been waiting for...

Success in climate action requires:

- High risk perception - risk must be acknowledged
- Localized goals - small group sizes
- Low homophily - imitation of successful peers, without class discrimination

References

[1] J. M. P. Vítor V. Vasconcelos, Francisco C. Santos and S. A. Levin, "Climate policies under wealth inequality," PNAS, 2014.
[2] F. C. Santos and J. M. Pacheco, "Risk of collective failure provides an escape from the tragedy of the commons," PNAS, 2010.
[3] M. D. S. . J. M. P. Francisco C. Santos, "Social diversity promotes the emergence of cooperation in public goods games," Nature, 2008.
[4] M. P. Cheng-Yi Xia, Sandro Meloni and Y. Moreno, "Dynamic instability of co-operation due to diverse activity patterns in evolutionary social dilemmas," EPL, 2015.
[5] E. Fernández Domingos, "Egttools: Toolbox for evolutionary game theory," https://github.com/Socrats/EGTTools, 2020.
[6] J. Sell and T. P. Love, "Common fate, crisis, and cooperation in social dilemmas," Advances in Group Processes, 2009.