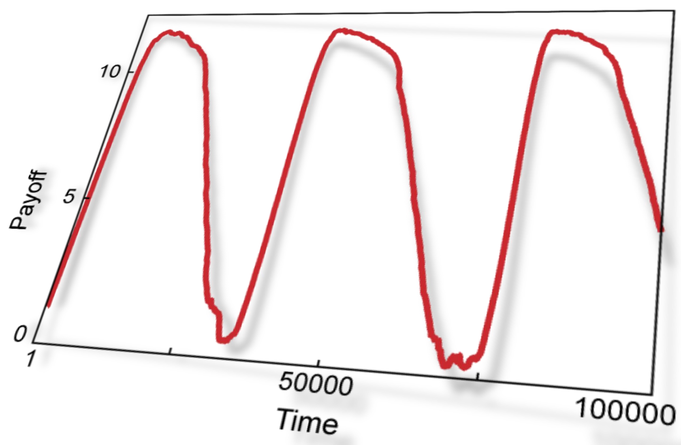
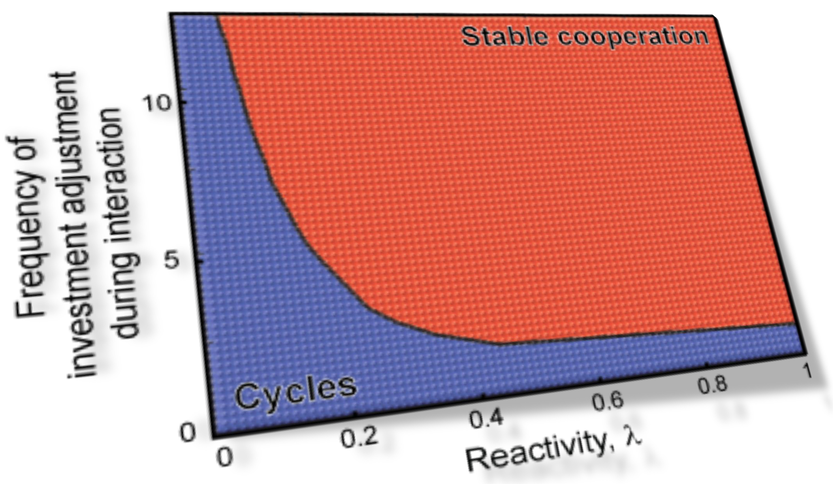
Counteracting Systemic Risk Caused by Reactive Cooperative Behavior

Gergely Boza (Evolution and Ecology Program, IIASA; Eötvös University, Budapest, Hungary)
Ádám Kun (Evolution and Ecology Program, IIASA; Eötvös University, Budapest, Hungary)
Ulf Dieckmann (Evolution and Ecology Program, IIASA)

Booms and Busts

Cooperative investment, an act that benefits others at own costs, is always at risk of being exploited by selfish behavior. We study continuous cooperative investments of individuals with **reactive investment strategies**, where investments depend on the actual partner's investment behavior, which is expected to provide a safeguard against exploitation. We show that the coevolution of such strategies can, however, induce systemic risk to the population as the spread of exuberant investors induces **investment cycles** with phases of low initial investment → defensive, cautious conditional investors → exuberant investors → exploiters → and non-investors. There are several ways to counteract these boom-bust cycles.





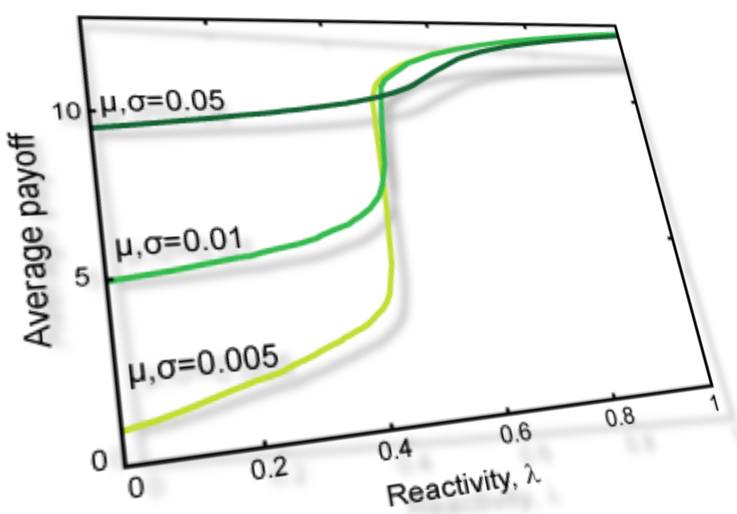
Reactivity

First, we define reactivity λ as a relation between the unconditional (u) and conditional (c) components of investment, so that

► at full reactivity (λ=1), investments are increased by the conditional component after the initial, unconditional investment only if one's investments are profitably reciprocated by the partner,

► at the other end (λ=0), large investments can be made during the interaction even in the absence of conditional investment component.

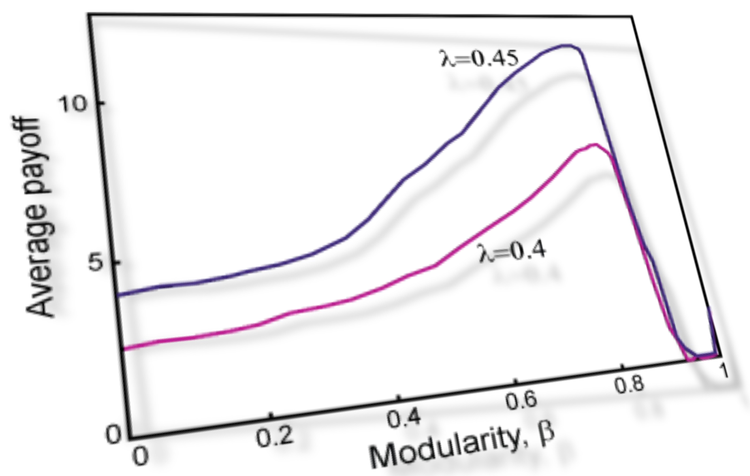
At low rate of reactivity, when the conditional component is less significant in making large investments, **no investment** is the only stable state, and investments can increase only temporarily, hence **investment cycles** appear. On the other hand, at **full reactivity**, where conditional component becomes important for large investments, cycles disappear and **cooperative investments become stable**.



Diversity

Second, we studied the effect of **increasing diversity of investment behaviors**. Here we increase the mutational variability (μ,σ) of traits u and c coding the investment components, hence increase strategy polymorphism (the darker the color, the higher the variability is). When strategy diversity is low (μ,σ=0.005), high payoffs can be reached only together with high reactivity (i.e. $\lambda \to 1$). However, in cases when boom-bust cycles would appear at low strategy reactivity ($\lambda \to 0$) in monomorphic populations, introducing **high strategy diversity** can **stabilize cooperation** with high average investments levels (μ,σ=0.05).

Modularity



Third, to model social interaction structure, we assume that cooperating individuals or agents form small communities, and that **transfer of knowledge** between these communities appears only at a limited rate β, so that

► when β is small, the population behaves as a well-mixed community, i.e. every agent can learn from any other agent from the whole population.

► On the other hand, when β approaches 1, the population reaches a modular structure, and information transfer is restricted only to the local community.

By decoupling investment behaviors between the local investor communities and setting back the spread of exuberant and exploiter strategies, optimal level of **modularity can stabilize cooperative behavior** at the systemic level.

Counteracting Systemic Risk

When individuals or agents make investments, countermeasures against exploitation or cheating are crucial for success. In our model of reciprocal investment game, strategy evolution typically leads to exuberant **investment cycles**. Here, what seems to be rational at the individual level, paves the way for systemic level risk. However, when **reactivity** – **diversity** – **modularity** are employed, individually or combined, stable investment levels can replace systemic level boom-bust cycles and can stabilize cooperative investment behavior.