Systemic-risk dilemmas

emerging from reactive investments

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THE INVESTMENT CYCLE

We study the factors that promote the emergence and stability of cooperative exchanges based on continuous investments, performed by individuals with **reactive investment strategies**, through which agents continuously reevaluate and adjust their investments according to the gains obtained from an exchange. We show that the coevolution of such strategies can induce systemic risk. Particularly, the spread of exuberant investors induces **investment cycles** with phases of low initial investment → cautious conditional investors → exuberant investors → exploiters → and non-investors. We present four ways to counteract these boom-bust cycles.
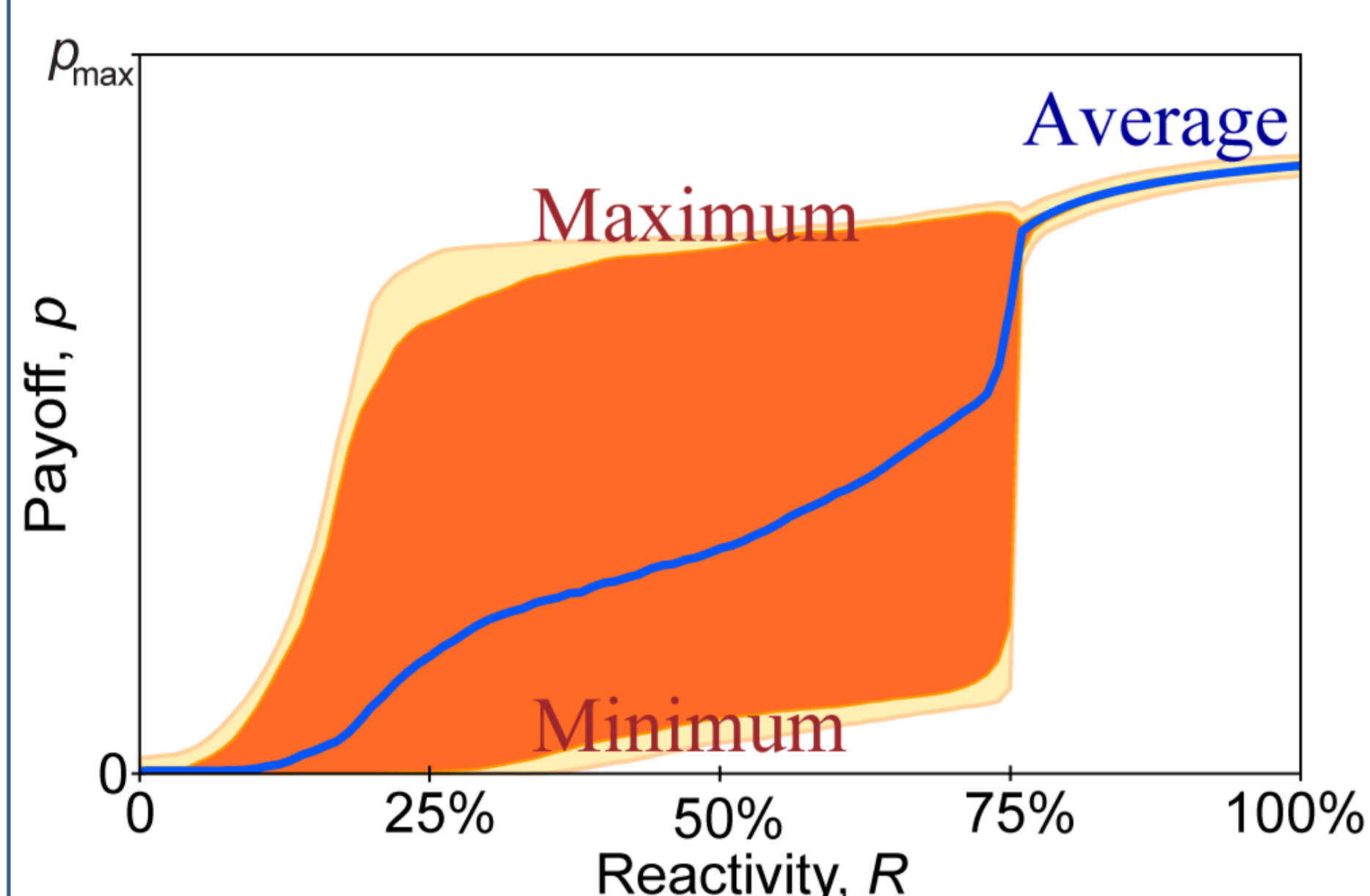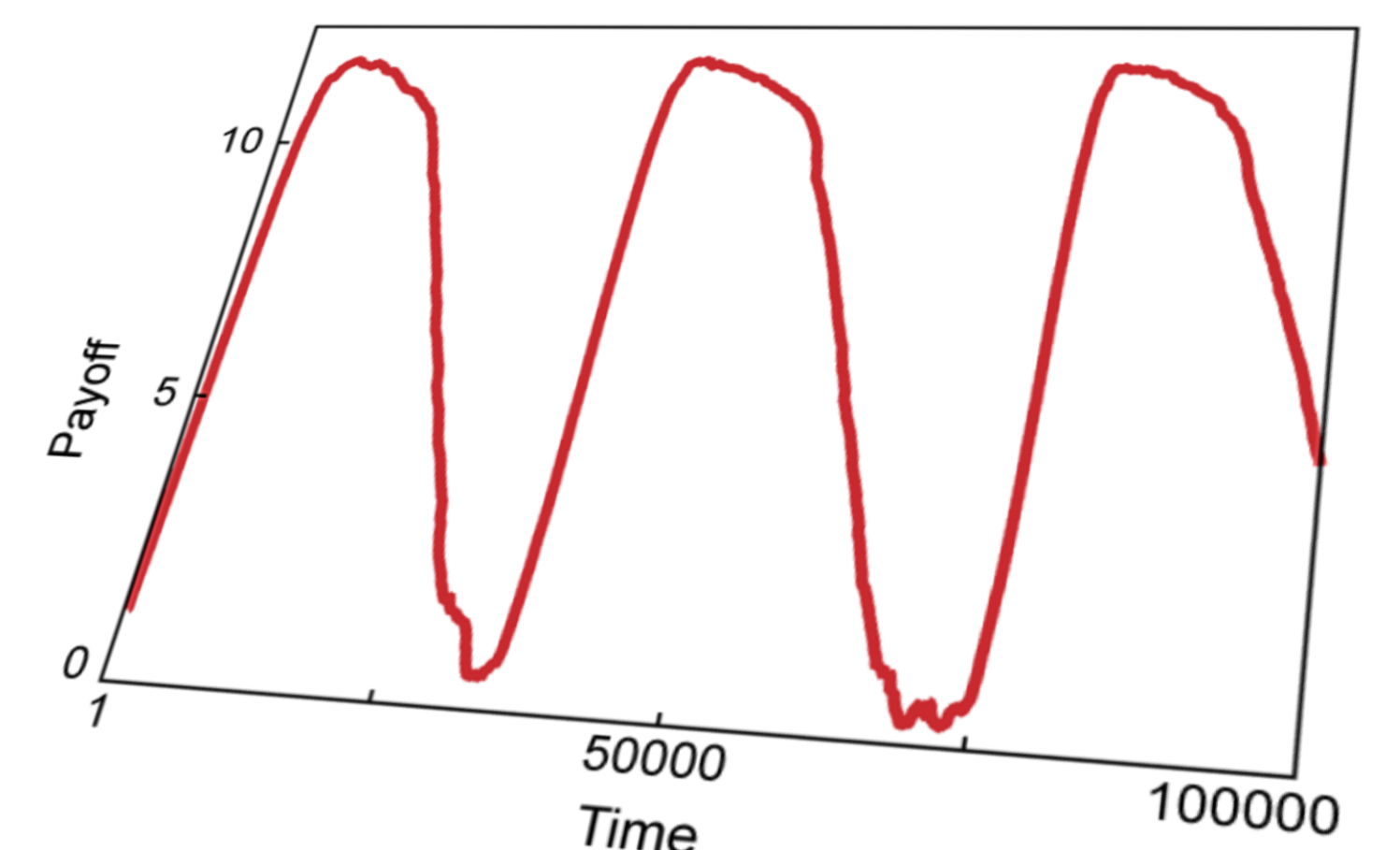
REACTIVITY

REACTIVITY R is defined as a weight between the unconditional (u) and conditional (c) components of investment, so that:

► at full reactivity (R = 100%), investments are increased by the conditional component after the initial, unconditional investment only if investments are profitably reciprocated by the partner,

► at the other end (R = 0), unconditional investments can be made during the interaction even when a partner does not reciprocate investments at all.

At a low rate of reactivity, when the conditional component plays a less significant role in making investments, **no investment** is the only stable state, and investments can increase only temporarily, hence **investment cycles** appear (orange shaded area depicts the amplitude of cycles). However, at **full reactivity**, where the conditional component gains importance for large investments, cycles cease and **investments become stable**.

DIVERSITY

DIVERSITY of investment strategies emerges with the increase of strategy innovation rate I, i.e. the rate at which agents update their strategies to a slightly altered strategy of their role model, hence increase strategy polymorphism.

When strategy diversity is low (I ~ 0.005), high investment levels and thus high payoffs can be reached only if reactivity is high ($R \rightarrow 100\%$).

On the other hand, high strategy diversity ($I \rightarrow 1$) can stabilize high investment levels dampening the boom-bust cycles that would appear at low reactivity in monomorphic populations ($R \rightarrow 0$).
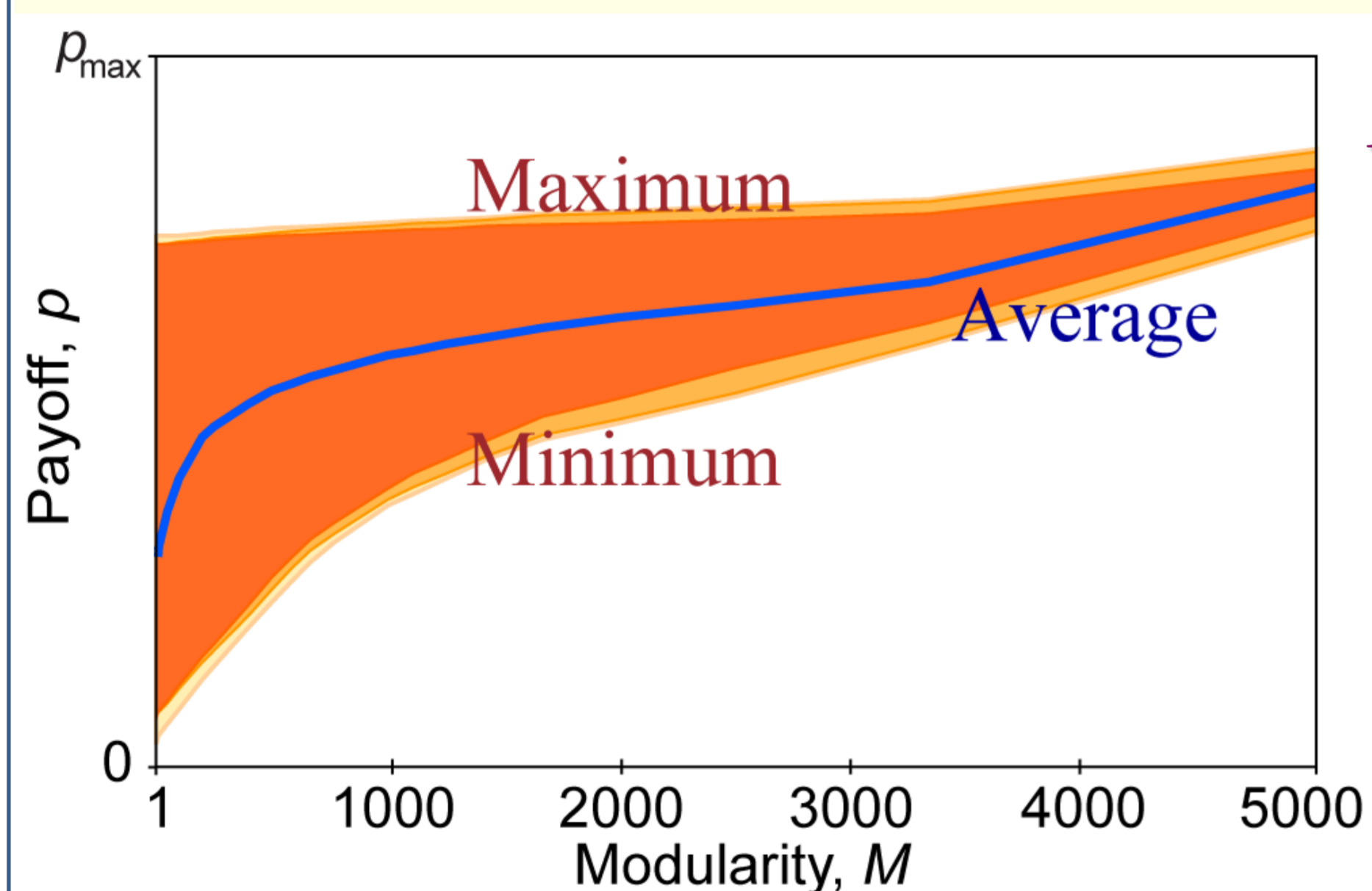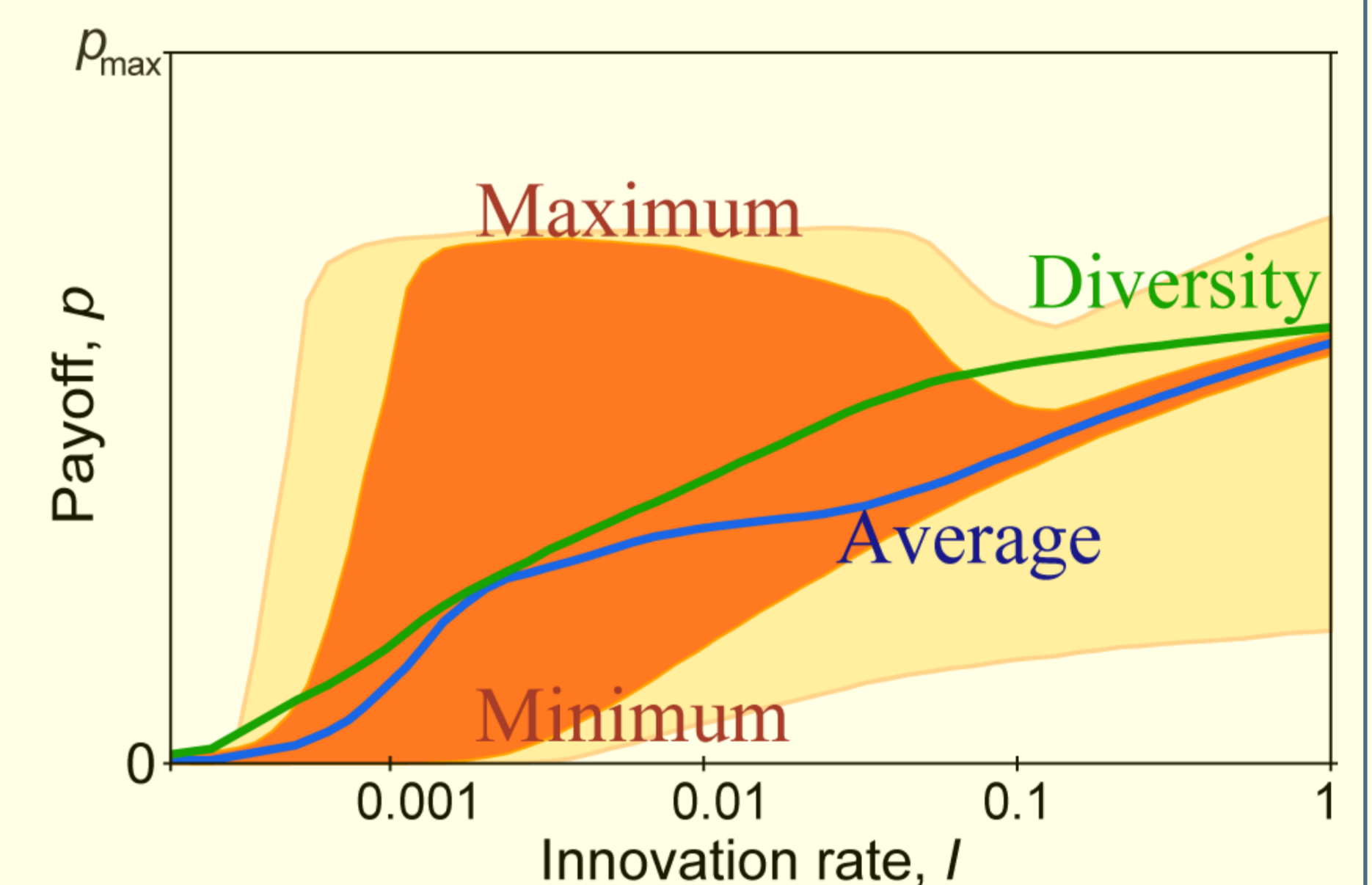

MODULARITY

MODULARITY M results from the assumption of a social interaction structure, in which agents are divided into small communities, and where inter-module investments and inter-module imitation appears only at a limited rate.

Our results suggest that in societies with modular structure systemic level volatility is constrained, as boundaries between modules act as barriers. Investment decision are **decoupled** across the population, the spread of exuberant or exploiter strategy types is restrained, and modularity maintains strategy diversity in the system as a whole providing an efficient countermeasure against boom-bust cycles.

HETEROGENEITY

HETEROGENEITY H is introduced as a difference in the attributes of modules, such as differences in the cost of investment, in module size, in innovation rate and in selection strength.

Our results indicate that heterogeneity facilitates the emergence and stability of high investment levels by **enhancing the polymorphism** of investment strategies, **decoupling** investment decisions across the population, and restraining the spread of exuberant or exploiter strategy types even in cases of low modularity.
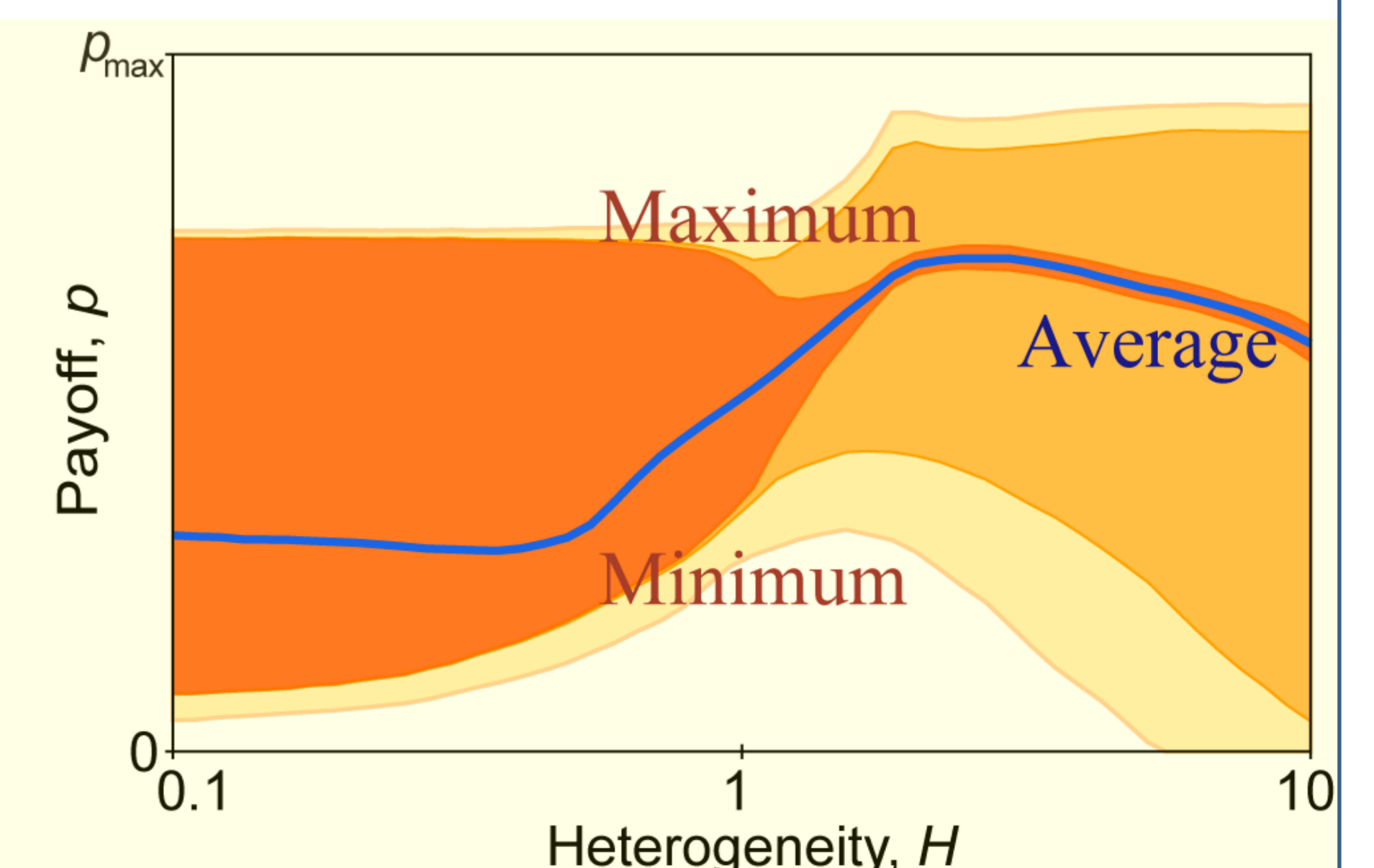
COUNTERACTING SYSTEMIC RISK

Countermeasures against exploitation or cheating are crucial for success of maintaining high and stable investment levels in a society. 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 to systemic level risk. However, when **reactivity** – **diversity** – **modularity** – **heterogeneity** are employed, separately or combined, stable investment levels can replace systemic level boom-bust cycles and can stabilize investment behavior at high levels.