HDSC TANDEM PROJECT

Learning and Dynamics in Stochastic Multi-Agent Systems

How learning agents interact and adapt in complex stochastic systems

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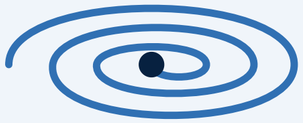
Speaker: Philip Hierhager · Technical University of Munich · HDSC Opening Symposium, 2 November 2026

Heilbronn Data Science Center

LEARNING AGENTS IN MARKETS, PLATFORMS AND SERVICE SYSTEMS

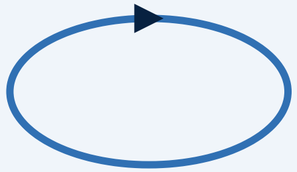
Agents learn from each other. Which dynamics can emerge?

SIMPLE ▶ COMPLEX



Equilibrium

Learning settles — efficiently or not.



Cycles

Strategies keep moving, forever.



Chaos

Irregular, never repeats, hard to predict.

ACROSS ALL LEVELS



Multistability and noise

Several stable outcomes coexist; noise moves agents between them.

GUIDING QUESTIONS

Which dynamics — simple or complex — can learning agents exhibit? And when do they reach the welfare-maximizing outcome rather than, say, collusion?

Chaos in learning: Sato et al., PNAS 2002; Galla, Farmer, PNAS 2013 · Algorithmic collusion: Calvano et al., AER 2020

WHY DYNAMICAL SYSTEMS

Learning is a dynamical system — and its theory maps what agents can do

Stability

Does learning converge, how fast, and to which outcome?

Bifurcations

When do cycles or chaos appear as the market changes?

Stochastic dynamics

How does noise tip agents between outcomes?

FIRST RESULT · FIRST-PRICE AUCTIONS

Standard convergence tools (monotonicity) fail, yet gradient-learning bidders **provably converge to the efficient equilibrium**, with explicit rates — via comparison principles from PDE theory, rarely used for learning in games.

NEXT

Map the complex side — cycles, multistability, chaos — and when learning ends in collusion instead of the efficient outcome, for stochastic agents in markets, platforms, service systems and healthcare.