Micro- and Macro-Dynamics in Hidden-Action Relationships with Limited Information

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Principal-agent models usually assume the economic agents to be gifted: They are, for example, endowed with perfect foresight, can access information whenever it is required, and possess the cognitive capacity to process and interpret the accessed information (Axtell, 2007). There is, however, evidence the these restrictive (or simplifying) assumptions do not represent the characteristics of real-world decision makers (Simon, 1957), who are usually endowed with *less intelligence* than assumed by economic models. We are particularly interested in (i) the robustness of the incentive mechanisms derived from principal-agent models to limitations in the principal's and the agent's intelligence, and in (ii) the incentive mechanisms which emerge over time if the principal and/or the agent are characterized by limited intelligence.

In this paper, we set up an agent-based model of the hidden-action problem first introduced in Holmstrom (1979). We limit the principal's and the agent's intelligence, which is why they cannot come up with the optimal solution immediately (as usually assumed in principal-agent models) but have to search for efficient contracts over time. We implement limited intelligence in the following two ways: (1) Both decision-makers have limited information about the environment in which they operate, and, in consequence, they also cannot perfectly predict the environment. They are, however, endowed with the capability to learn about the environment, whereby we shape the efficiency of the learning mechanism by variations in cognitive capabilities (in terms of memory). (2) The principal only has limited access to the range of actions the agent can select from when acting on behalf of the principal.[1] He, however, possesses the capability to search for the optimal action over time by employing a hill climbing procedure and by performing a local or a global search in each step.

Our results indicate that macro-dynamics are driven by a trade-off between imprecision in the prediction of the environment and the principal's strategy when searching for the optimal contract: Recall that the principal can select between a local and a global search when searching

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[1] The principal-agent model introduced in Holmstrom (1979) assumes full accessibility of the range of actions for the principal, which is why he easily can find the optimal action and derive the optimal contract for exactly this action.

for actions for the agent to take. The decision as to perform a local or a global influences the speed at which the contract found by the principal converges to the optimal one (Yang, Yao, & He, 2007). We show that the closer the found contract is to the optimal one the lesser is its robustness to imprecisions in the prediction of the environment caused by limited intelligence, as even slight fluctuations in the predicted environment might cause that contracts become infeasible from one timestep to the other. Whenever the contract found by the principal becomes infeasible, the principal has to reset his search for the optimal contract and start from the beginning. We refer to this observation as *Sisyphos Effect*.

For the micro-level we find that limited intelligence unfolds interesting behavioral dynamics: We show that limitations in the access to information about the environment triggers excess effort in agents: They make more effort than required for the optimal solution when acting on behalf of the principal. Interestingly, the extent of excess effort is driven by the agent's decision and cannot be easily affected by the principal, while the probability of making excess effort can be controlled by the principal by means of the emerging incentive mechanism.

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