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Imitation and the role of information in overcoming coordination failures

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ABSTRACT

We consider minimum-effort games played in an arbitrary network. For a family of imitation behavioral rules, including Imitate the Best and the Proportional Imitation Rule, we show that inefficient conventions arise independently of the interaction structure, if information is limited to the interaction neighborhoods. In the presence of information spillovers, we provide a condition on the network structure that guarantees the emergence of efficient conventions. In contrast, if this condition is violated we will observe inefficient conventions, even in the presence of information spillovers.

1. Introduction

Coordination problems are inherent to many forms of social and economic interaction. Examples range from technological choice and software compatibility to the adoption of common systems of measurement (e.g. imperial vs. metric system), and include the private provision of decentralized public goods. At a more abstract level, many production activities contain elements of a coordination problem, where agents who work hard see their payoffs brought down by other agents who are hardly working. Usually, there are two kinds of problems arising in such situations: i) achieving coordination on the *same action* and ii) achieving coordination on the *right action*. In the present paper we focus on the second kind of problem and use minimum effort games, as popularized by Van Huyck et al. (1990), as a stylized model of such coordination problems, especially of the production type. The reason for this choice is that we are interested in the selection of efficient outcomes, and minimum-effort games provide an intuitive worst-case benchmark where inefficient outcomes might be particularly resilient.

We cast our model in a world of local interaction and information. An arbitrarily complex social network specifies both who interacts with whom and whom agents receive information from. In particular, we are interested in the case of *information spillovers*, i.e. scenarios where information transmission goes beyond the bounds specified by local interactions. This is in contrast to *local information*, where agents only observe their own neighborhood.

At the behavioral level, we assume that when deciding on the amount of effort to be invested agents follow simple imitation rules. Imitation seems to be a well justified behavioral rule in circumstances when the game itself is not properly understood, agents lack computing capacities, or simply want to economize on decision costs (see Alós-Ferrer and Schlag

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(2009) for a broader view and a review of the literature on imitation). Rather than choosing a particular rule, we will focus on imitation rules fulfilling two reasonable properties. First, an imitation rule is *salience-based* if it prescribes agents to choose actions that have earned maximum payoff with positive probability. Second, an imitation rule is *optimistic at the top* if an agent whose strategy earns the highest payoff will never imitate a strategy that earns a lower payoff. A first example of a rule fulfilling both conditions is the "imitate the best" rule where agents simply choose the action that has earned the highest observed payoff. A second prominent example is the natural adaptation to networks of Schlag's (1998) Proportional Imitation Rule.

These three elements (the local interaction and information system, the minimum effort game, and the class of imitation rules) specify a behavioral model of learning in networks. In order to study the circumstances under which certain equilibria will emerge, we are interested in the long run behavior of this system. In a first step we consider the case when agents only receive information from other agents they interact with, i.e. information is a local matter. In this case we find that regardless of the interaction structure the (inefficient) lowest effort convention will be the only long run equilibrium. Secondly, we analyze the case of information spillovers. We model this by assuming that agents not only observe their neighbors but in addition also observe additional agents. In this scenario, we show that if the network is large in the sense that the number of disjoint neighborhoods exceeds the size of the smallest interaction neighborhood, efficient (maximum effort) conventions are selected. Conversely, if this condition is violated the selection of inefficient conventions remains. The intuition behind this result is that once a cluster of agents chooses the highest effort level at least one player will earn the highest payoff and will be copied by agents at the boundary of this cluster. In this manner the efficient strategy may spread out contagiously. On the contrary, if one player in each disjoint neighborhood chooses the lowest effort level those players will earn the highest payoff and hence be copied.

Our model builds upon our previous work, and particularly on Alós-Ferrer and Weidenholzer (2008). In that work, we considered 2×2 coordination games and showed that, under information spillovers, a simple condition on the network guarantees that agents who imitate maximum observed payoffs will be able to coordinate on the Pareto-Efficient equilibrium in the long run. In contrast, as described above, here we consider a general class of imitation rules, and also allow for rule heterogeneity, i.e. different agents might employ different rules. Further, and also in contrast with our previous work, we focus on a more general and flexible model of information, where agents might sample a subset of the agents in their information neighborhoods. A third difference with Alós-Ferrer and Weidenholzer (2008) is that we consider minimum effort games with an arbitrary number of strategies and, hence, an arbitrary number of (Pareto-ranked) Nash equilibria. Last, while our previous work provided sufficient conditions for coordination on the efficient equilibrium, here we are able to provide a full characterization. That is, we provide an answer to the question of which convention will be adopted in the long run for every network.

1.1. Minimum-effort games

We focus on *minimum effort* or *weakest link games*. The relevance of these games and the basic strategic problems arising in them have been known for quite some time. David Hume (1739, Bk. III, Pt. II, Sec. VII.), writing in the 18th century, provided the following observation, which captures the dilemma faced by individuals confronted with a minimum effort game.[1]

> Two neighbors may agree to drain a meadow, which they possess in common; because 'tis easy for them to know each others mind, and each may perceive that the immediate consequence of failing in his part is the abandoning of the whole project. But 'tis difficult, and indeed impossible, that a thousand persons shou'd agree in any such action.

This example illustrates well the two most important strategic factors present in minimum effort games. First, minimum effort games exhibit strategic complementarities, i.e. the incentives to put in high effort levels are non-decreasing in the effort level provided by the others. Second, uncertainty about the other players' choices makes it very difficult to achieve coordination at high effort levels in large populations.

The strategic structure of a minimum effort game is encountered in a wide range of both social and economic interactions. For instance, in 1803 in his *Speeches in Parliament*, William Windham noted on the subject of defense that "The strength of a chain, according to an old observation, was the strength of the weakest link." More recently, Hirshleifer (1983) and Cornes (1993) studied the private provision of public goods when agents face a weakest link structure as present e.g. in the problem of building dykes to protect against flooding. Bryant (1983) and Cooper and John (1988) argue that coordination failures in minimum effort production technologies might be the source of underemployment in rational expectations models. Kremer (1993) argues that many production processes consist of several tasks or subcomponents and that one poorly undertaken task or one imperfect subcomponent might lead to a severe reduction of the product's final quality. Among the examples he lists are the Challenger catastrophe, where a single malfunctioning o-ring led to the loss of the space shuttle, or companies failing due to errors in marketing despite producing perfectly good products. In his model, the skill of employees determines the project's chance of success. In equilibrium, firms will seek to either only hire highly skilled

[1] We owe this quote to Skyrms (2006).