Journal of Economic Behavior & Organization 112 (2015) 266–288

Contents lists available at ScienceDirect

Journal of Economic Behavior & Organization

journal homepage: www.elsevier.com/locate/jebo

The evolution of social learning and its economic consequences☆

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ARTICLE INFO

Article history:
Received 26 March 2013
Received in revised form 26 January 2015
Accepted 28 January 2015
Available online 14 February 2015

Keywords:
Imitation
Learning strategies
Evolution
Natural selection
Market inefficiencies

ABSTRACT

We use an evolutionary model to simulate agents who choose between two options with stochastically varying payoffs. Two types of agents are considered: individual learners, who rely on trial-and-error methods, and social learners, who imitate the wealthiest sampled individual. Agents adapt to changing environments within one generation by using their respective learning strategy. The frequency of the agent types adapts between generations according to the agents' acquired wealth. During the course of evolution, social learning becomes dominant, resulting in three major effects: First, for better or worse, the decisions of social learners are more exaggerated than those of individual learners. Second, social learners react with a delay to changes in the environment. Third, the behavior of social learners becomes more and more detached from reality. We argue that our model gives insights into economic systems and markets.

1. Introduction

A large part of what separates us from most other animals is arguably the ability to learn from one another, and not just from nature. Precious little of our knowledge is strictly gained from personal experience, and much is learned from someone else (who, in turn, probably also had learned it from others) – either by direct instruction or by imitation. Focusing on the latter, we can see that there are fields in which our behavior is governed purely by imitation: Very few people invent their own articles of clothing and food without ever having seen anyone else wear or consume them before, and a whole range of 'appropriate' behaviors that govern our daily routine was picked up through observation and imitation.

Such imitative learning is also part of economic behavior. One in three institutional investors, who often receive considerable remuneration for their knowledge and independent judgment, say that their stockbroker was "influential" in their decision to buy a stock. Only one in four said that they had "conducted their own analysis" (Shiller and Pound, 1989).[1] Imitation influences the competitiveness in Cournot markets (Huck et al., 1999; Apesteguia et al., 2007).

When humans learn from others, they imitate the successful. Even three- and four-year olds preferentially learn from successful models (Birch et al., 2008). Investors place a disproportionate amount of money in funds whose returns in the past 12 months were exceptional – even though these funds tend to do much worse than average in the following period

☆ We are grateful to Robert Boyd, Peter Norman Sørensen, Nicolaas Vriend (the editor) and two anonymous referees for helpful comments. B.B. and P.H. thank the Deutsche Forschungsgemeinschaft (SFB 618) for funding.

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[1] Since the survey was conducted by questionnaire, social learning is likely under- and individual research over-reported.

http://dx.doi.org/10.1016/j.jebo.2015.01.010

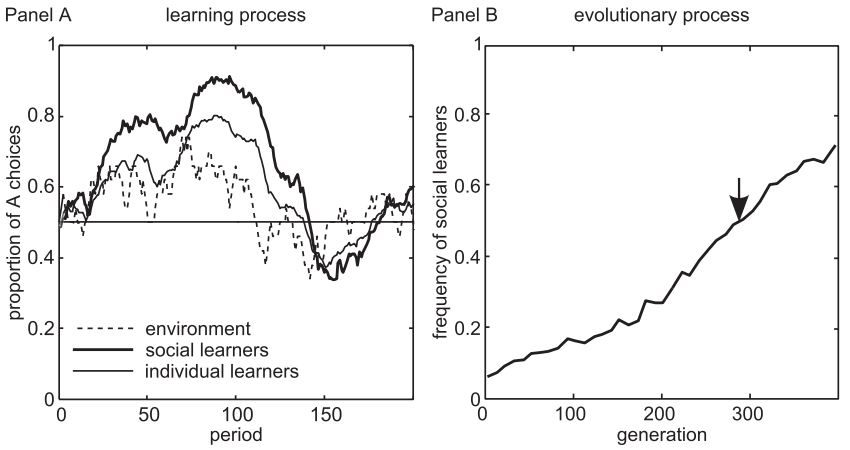

Fig. 1. (A) Exemplary simulation run with a population consisting of 50% social and 50% individual learners. (B) Exemplary evolutionary run showing the frequency of social learners.

(Economist, 2011). And the history of bubbles, from tulipomania to subprime, is the story of outsiders becoming market participants because they watch others make huge profits (Shiller, 2003; Tett, 2009).

But given the tendency of people to adopt successful behaviors or strategies, these cultural traits should become more frequent over time. New variations of learning strategies may enter the market through creative processes or mistakes, whereas scarcity of capital creates competition that will weed out unsuccessful learning strategies. These three ingredients – variation, competition, and preferential replication of successful strategies – are sufficient to give rise to an evolutionary process. E.g. the investment strategy invented by a successful portfolio manager survives and is copied by others, while unsuccessful strategies disappear – either because their agents now have less capital at their disposal, leave the market, or choose to imitate the successful agents. Although this process is not natural (Darwin, 1859) but cultural, it will still have similar features (cf. Weibull, 1995; Gintis, 2000; Hammerstein and Hagen, 2005; Mesoudi et al., 2006). This leads to the evolutionary theory of economic behavior which Alchian (1950) has described in his seminal article in 1950.[2]

The model we have in mind is that of a society in which thousands of individuals engage in different learning strategies, and the frequency of different strategies is itself dependent on how successful these strategies have been in the past. This model, with stochastic underlying values, independent choices of all individuals, and the interconnectedness through learning from others, is too complex to lend itself to analytical solution methods. That is why we engage in agent-based simulations. We thoroughly check these simulations for robustness to changes in the set-up and parameter values.

Our work is based on the assumption that imitation of success gives rise to the forces of evolution. Instead of introducing a presumably rational or irrational strategy and study the resulting phenomena, we observe which learning strategy prevails and how abundant it becomes in equilibrium. Then we analyze how the behavior of a population in equilibrium relates to the environment. Our model is discussed in Section 2, a detailed elaboration of our findings is given in Section 3, the connection of these findings with real world phenomena and comparisons with existing models is part of Section 4.

Using the evolutionary framework, we assume that agents with distinct learning strategies adopt different behaviors, interact with other agents in the population, and reproduce according to the fitness (or "wealth") they aggregate during their lifetime. A quick presentation of the model can be found in Fig. 1. The environment is characterized by two options, *A* and *B*, whose payoffs cannot be directly observed and fluctuate over time. Consequently, none of the options will always be better than the other. Within each generation, individuals adapt by repeatedly choosing one of the options according to a fixed learning strategy. Between generations, those individuals with the most success replicate at a higher rate, which leads to an adjustment of the frequency of the learning strategies. Therefore, our model has a nested structure: *What* an individual learns varies within each generation and is adapted to the environment; *how* the individuals learn varies between generations and is adapted to the composition of the population. The model thus differs from other models in that the behavior of the individuals flexibly adjusts according to the learning strategy (panel A), whereas the learning strategies adjust over a larger time scale (panel B). A detailed model description can be found in Section 2.

Imitative behavior has been studied previously in the context of informational cascades (Banerjee, 1992; Bikhchandani et al., 1992; Anderson and Holt, 1997; Ziegelmeyer et al., 2010). Informational cascades may arise if choices are made sequentially and previous choices by others can be observed. In most of the models, one individual after the other has to decide between two options. The decision can be based on a private signal that is noisy and on observation of the choice of previous individuals. After a certain amount of individuals have chosen one option over the other, the reliability of the information

[2] Alchian himself has described his approach as "reverting to a Marshallian type of analysis combined with the essentials of Darwinian evolutionary natural selection" (Alchian, 1950, fn 7 on p. 113).