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Games and Economic Behavior 51 (2005) 31–62

GAMES and Economic Behavior

www.elsevier.com/locate/geb

Learning, information, and sorting in market entry games: theory and evidence

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Received 20 January 2003

Available online 18 August 2004

Abstract

Previous data from experiments on market entry games, N-player games where each player faces a choice between entering a market and staying out, appear inconsistent with either mixed or pure Nash equilibria. Here we show that, in this class of game, learning theory predicts sorting, that is, in the long run, agents play a pure strategy equilibrium with some agents permanently in the market, and some permanently out. We conduct experiments with a larger number of repetitions than in previous work in order to test this prediction. We find that when subjects are given minimal information, only after close to 100 periods do subjects begin to approach equilibrium. In contrast, with full information, subjects learn to play a pure strategy equilibrium relatively quickly. However, the information which permits rapid convergence, revelation of the individual play of all opponents, is not predicted to have any effect by existing models of learning.

JEL classification: C72; D83

Keywords: Market entry games; Reinforcement learning; Fictitious play; Experiments

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0899-8256/$ – see front matter
doi:10.1016/j.geb.2004.04.007

1. Introduction

Theories of learning in games are increasingly being subjected to tests using data from controlled laboratory experiments with paid human subjects. The success or failure of various learning models has been assessed on the basis of how well these models predict or track the behavior of subjects in these experimental sessions. Given the usual short time horizon in experiments, researchers interested in testing models of learning have tended to concentrate on assessing their short-run fit. Long-run predictions have largely been ignored. One might reasonably be uncertain whether asymptotic results are likely to be relevant in experiments with finite length, or simply be interested in how subjects respond to novel situations. However, the long-run behavior of different learning models is often the same, giving clear hypotheses to test.[1]

This paper is a first attempt to see whether the *long-run* predictions of learning models do indeed help to explain behavior in the market entry game. This much studied game is a stylized representation of a very common economic problem: a number of agents have to choose independently whether or not to undertake some activity, such as enter a market, go to a bar, drive on a road, or surf the web, the utility from which is decreasing in the number of participants. Those choosing not to undertake the activity can be thought of as staying at home, staying out of the market, or simply not participating. Market entry games typically admit a large number of Nash equilibria. Pure equilibria involve considerable coordination on asymmetric outcomes where some agents enter and some stay out. The only symmetric outcome is mixed, requiring randomization over the entry decision. There also exist asymmetric mixed equilibria, where some agents play pure while others randomize. Given this multiplicity of equilibrium outcomes, an obvious question is: which type of equilibrium are agents likely to coordinate upon? Many previous experiments have been conducted in an effort to address this and related questions. See, for example, Rapoport et al. (1998, 2000, 2002), Seale and Rapoport (2000), Camerer and Lovallo (1999), Sundali et al. (1995), and Erev and Rapoport (1998). However, up to now, none of these studies has yielded evidence to suggest that repeated play leads to coordination on any type of Nash equilibrium, although in many experiments the average frequencies of entry in market entry games look remarkably like those generated by Nash equilibrium play.[2] That is, market entry games seem to represent a case where Nash equilibrium fails as a predictor of human behavior, at least at the individual level.

Here we investigate the alternative hypothesis that, given sufficient repeated play and adequate feedback, individuals in experimental market entry games should *learn equilibrium behavior*. This assertion leads naturally to further questions: what in practice is "sufficient" and what is "adequate"? How long should we expect to wait before agents coordinate on an equilibrium? What information is necessary? How do these factors interact, for example, does better information lead to faster convergence? In this paper, we attempt

[1] See, e.g. Hopkins (2002).

[2] But as Ochs (1998, p. 169) notes in a recent survey of experimental market entry game research, "... a common feature of all market game experiments ... is that the aggregate distributions [of entry rates] are not produced by Nash equilibrium profiles, that is, the *individual behavior* observed in all of these experiments is at variance with that implied by the best response conditions of a Nash equilibrium" (emphasis added).