Chapter 17
Agent-Based Modeling of the El Farol Bar Problem

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ABSTRACT

In this chapter, the authors study the self-coordination problem as demonstrated by the well-known El Farol problem (Arthur, 1994), which has become what is known as the minority game in the econophysics community. While the El Farol problem or the minority game has been studied for almost two decades, existing studies are mostly only concerned with efficiency. The equality issue, however, has been largely neglected. In this chapter, the authors build an agent-based model to study both efficiency and equality and ask whether a decentralized society can ever possibly self-coordinate a result with the highest efficiency while also maintaining the highest degree of equality. The agent-based model shows the possibility of achieving this social optimum. The two key determinants to make this happen are social preferences and social networks. Hence, not only do institutions (networks) matter, but individual characteristics (preferences) also matter. The latter part are open to human-subject experiments for further examination.

1. INTRODUCTION

The El Farol Bar problem, introduced by Arthur (1994) has over the years become the prototypical model of a system in which agents, competing for scarce resources, inductively adapt their belief-models (or hypotheses) to the aggregate environment that they jointly create. The bar’s capacity is basically a resource subject to congestion, making the El Farol Bar problem a stylized version of the central problem in public economics represented by the efficient exploitation of common-pool resources. Real-world examples of this problem include traffic congestion and the congestion of computer networks. The numerous works that have analyzed and extended along different lines
of this problem show that perfect coordination, that is, the steady state where the aggregate bar’s attendance is always equal to the bar’s maximum capacity, is very hard to reach, at least under the common knowledge assumption (Fogel, Chella-pilla, & Angeline, 1999; Edmonds, 1999; Atilgan, Atilgan, & Demirel, 2008; to name just a few).

In fact, with best-reply learning, as stated by Arthur, “any commonality of expectations gets broken up: If all believe few will go, all will go. However, this would invalidate that belief. Similarly, if all believe most will go, nobody will go, invalidating that belief. Expectations will be forced to differ” (Arthur, 1994, p. 409). On the other hand, works where best-response behavior has been replaced with reinforcement learning (Bell & Sethares, 1999; Franke, 2003) show that perfect coordination is possible and that it is, indeed, the long-run behavior to which the system asymptotically converges (Whitehead, 2008). However, it is an equilibrium characterized by complete segregation: the population split into a group of agents who always go (filling the bar up to its capacity all the time) and a group of agents who always stay at home.

While the literature relying on reinforcement learning has shown the possibility that the El-Farol fluctuation problem can be solved bottom-up, the price is a group of people who have been discouraged by previous unsuccessful attempt and decide to quit completely. This quitting decision is something similar to what we have learned from the long-term unemployment theory: the unemployed give up job searching after making a series of efforts with no avail. This group of people who quit and share very little or none of the public resources may further become the disadvantageous class in the society. In fact, in the El-Farol Bar case, if we consider attending a bar as a social-engagement opportunity to gain more information and social connection, then the quitting can imply social exclusion or isolation. Therefore, the El Farol Bar problem is not narrowly just an economic distribution problem, it may become a social segregation problem characterized by a group of people who fully occupy the available public resource and a group of people who are discouraged, ignored, and completely marginalized.

In this chapter, we pose the question as to whether a state of perfect coordination with perfect equality, that is, a state where the bar attendance is always equal to its capacity and all the agents go to the bar with the same frequency, can be reached and, if yes, under which conditions. We will refer to this special state as the *socially optimal equilibrium*, as we implicitly assume that, among all states in which the scarce resource is always exploited to the full, the aggregate utility is maximized by its equalitarian division among the agents. In fact, the equality, or fairness, of the outcomes in the El Farol Bar problem is an issue that has been largely neglected by the literature on the subject, with a paper by Farago, Green-wald, and Hall (2002) being, to the best of our knowledge, the only exception. However, while this work considers the possibility of reaching a fair outcome through the imposition of a fee by a central planner, in the present chapter we consider whether the efficient and fair outcome can emerge from the bottom up, through the process by which the agents’ strategies co-evolve and adapt.

In this chapter, we sequentially introduce two modifications to the original setup (Arthur, 1994), both of which represent a step towards the development of a ‘socially oriented’ version of the El Farol Bar problem. The first of these modifications concerns the structure of the agents’ interaction and is represented by the introduction of a social network connecting the agents and through which the agents can access the information regarding their neighbors’ choices. While in the original setup the agents base their decisions on global information, represented by the bar’s aggregate attendance, a feature that is likely to cause herding behavior, making it very difficult for them to coordinate, we may wonder whether coordination will be improved if, instead, the agents make use