

**EL FAROL REVISITED: A NOTE ON EMERGENCE,  
GAME THEORY AND SOCIETY**

**By**

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## **El Farol Revisited: A Note on Emergence, Game Theory and Society**

Some years ago Brian (Arthur 1994) published a seminal article on the problem of resolving the crowding conditions at his favorite local bar El Farol, in Santa Fe. The informal setting and its seating problems provided a striking metaphor for a basic coordination problem that occurs in many contexts. Arthur provided an imaginative and deep solution to an every day minor problem.

A simple version is as follows: Say 100 people like to go to listen to the music, but all dislike overcrowding. They all have the same taste that indicates that they enjoy attending if there are 60 or fewer individuals, but would prefer to stay away if there is a higher number than 60 in attendance. Each individual has a large set of rules of thumb that he or she utilizes. The rules are of the variety such as do not go the bar if last time there were over 60 present; or go if the you think the trend 81, 71, 62 will continue. As long as an individual's rule of thumb works he stays with it, when it fails another rule is tried. Arthur's simulations showed that the mean attendance was around 60 although the numbers were in constant fluctuation.

This article together with other articles such as a stock market simulation (Arthur et al., 1995) helped to launch an important evolutionary approach to emerging norms of human behavior.

A reasonable question to ask is: "does conventional non-cooperative game theory also have a satisfactory answer to the bar attendance problem? I suggest that it does not. Formally, with common knowledge there exists a mixed strategy non-cooperative equilibrium (NCE) where each individual randomizes between going and not going on a 60:40 basis. This gives the same mean as the evolutionary approach but the mechanism of 100 independent simultaneous randomizations, while feasible, is an unsatisfactory positive description of human behavior. There is no learning or any reaction to the information gleaned from experience. It might fit 100 well trained students of noncooperative game theory who have been trained that a non-cooperative equilibrium solution is not only descriptive, but normative, even though it appears to be neither.

John Nash commented in discussing his differences with the von Neumann stress on cooperative game solutions for other than two person constant sum games, that von Neumann was a European and that John's solution reflected a more natural American way.<sup>1</sup>

In contrast with either static cooperative or noncooperative game theory, Arthur's agents, for better or worse, are reacting to every experience at the bar and coming out with a solution with the same expectation as the noncooperative game mixed strategy equilibrium. The El Farol

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<sup>1</sup> Personal discussion when we were graduate students after I had noted that von Neumann in a personal discussion on the train from New York to Princeton indicated that he was not satisfied with either the non-cooperative equilibrium of Nash or the value solution of Shapley because they were too specific for the level of abstraction provided by the game theoretic models. He felt that at best a static equilibrium theory would delineate a set of outcomes. I suggested that the Shapley value provided a valuable benchmark, but von Neumann did not appear to be convinced.

bar problem is a **coordination** problem of central concern to the social sciences. Is there any room for a different solution? In all of such problems **context matters** and **initial conditions matter**. I suggest that context matters to the extent that the nature of the context will signal as to whether a higher order organization is required than that indicated by the bar problem.

There are many activities in human society for which the bar problem appears to be an extremely natural solution. These include much of consumer activities such as shopping in general, betting on the horses, or baseball, playing the stock market and indulging in low objective information voting. A pleasant time at El Farol requires much less than explicitly cooperative behavior. Rule enforcement and the often high resource costs of the coordinating and enforcing mechanism are not called for.

The solution for the El Farol problem is as Arthur suggested. The context is a small bar with an Irish music night. The initial conditions can best be described as a randomly picked day in the life of an ongoing establishment. The fluctuations in patronage were “good enough” at the time that they did not call for El Farol to try to create a higher level organization. The aggregate behavior of the individuals provides a sufficient signal as to whether a higher level of coordinating device is required.

Except under situations of heavy flux, rule of thumb selections appear to work well enough in situations such as the El Farol or the stock market, each producing a viable evolutionary dynamics. When there are events such as a major bubble, the soup of individual rules does not always appear to be sufficient to produce viable coordination. It is then that the individuals acting as a society and polity will deem it desirable to devise the appropriate rules to bound the activities and pay for the physical resources and bureaucracy needed to keep the aggregated individual activity within bounds.

There are many other situations in society where the cost of the rules bounding the process appears almost immediately. The rules of the road and the control of nuclear weapons supply two examples. Before discussing them, two comments that are highly relevant are noted. One is from experimental gaming and the other is from biology.

The first comment was made soon after my first serious interest in experimental gaming. This came in 1955 when I met Sidney Siegel, a fine experimental psychologist. I started to work with him in 1956 and through him became interested in the possibilities of joint work in economics and psychology. In connection with experimental gaming I met John Kennedy, then chair of the psychology department at Princeton. At one point in our discussion when I was sketching out a fairly crude market game, Kennedy said: Tell me the result you want and give me control of the briefing and I will get you the result you want<sup>2</sup>

In subsequent years when I became interested in business gaming and war gaming as well as experimental gaming I began to appreciate the critical role of the pre-game briefing and its relationship to setting the context and providing considerable cues and possibly dangerous biases to the players.

Much of economic experimental gaming is rigid rule gaming; a great deal of war gaming is free form gaming that may be assisted by small formal model packages to calculate items such as expected damages after an airstrike. From the viewpoint of game theory rigid rule gaming obeys the modeling conditions that all of the rules of the game are formalized and are common knowledge. Even there a verbal or written briefing is usually given to the players to set context. In contrast, free form gaming (such as the PME or politico-military exercise) does not have all of

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<sup>2</sup> I have left off the quotes as I did not write down the wording precisely at the time, but that was the gist of the comment.

the rules given at the beginning of the game. A detailed context is provided by the control. During the game the teams may challenge the refereeing group arguing for a change to other rules as being more reasonable than the current rules. The second type of game is explicitly evolutionary and new knowledge-seeking. The first is implicitly more analytically oriented and rigid.

The second comment I wish to note comes directly from the research work in biology of Leo Buss (1987, page viii). He states: “At the heart of my argument is the simple observation that the history of life is a history of the elaboration of new self-replicating entities by the self-replicating entities contained within them (or the incorporation of some self-replicating entities by others).

Analogy is often a dangerous tool. It is reasonably clear to many of us to talk about a self-reproducing cell or human, it is less clear to talk about a self-replicating nation state. Perhaps the closest description is that it is a self-renewing entity. Richard Ruggles who specialized in national statistics, in order to illustrate definitional problems in statistics used to illustrate them with the story: “This old axe has been in the family for 100 years and is still as good as new. It has had seven new handles and five new heads but still works fine”.

Many human affairs are best considered as a “game within the game” or for those who dislike the game analogy, they may be considered as a behavioral process embedded within a set of rules where the rules are provided by a higher and somewhat more conscious or rule based reactive agency. The agents, be they the customers at the bar, the automobile drivers on the road, or the formal and informal activists for nuclear inspection are involved with problems at different levels of complexity and will have a different need to pay for a coordinating device.

Many societies have had a legislature and judiciary for some time. All living organisms are to some extent environment setters, and humans, possibly more than others including social insects such as ants or bees devote much of their time consciously changing their environment.

Over the last few decades there has been a considerable growth in evolutionary game theory where the intentional randomization by optimizing agents present in formal game theory is reinterpreted as a statistic over a collection of simple hardwired organisms. It appears that this development of game theory is best suited to cells or insects rather than higher order animals or humans. The Arthur solution fits neither evolutionary game theory nor noncooperative game theory. Where does it fit? It offers an insight to the solution of a large class of everyday problems in an organized mass society. These include problems where noncorrelated nonstrategic, low information behavior does not yield considerably less than explicitly strategic behavior, given that the environment including the institutions of the society needed to permit that form of behavior are extant and provide sufficient enforcement to limit the individual behavior to a set of alternatives easily handled by his or her rules of motion.

Let us contrast the bar problem, with the “side of the road driving problem”. A rough glance at Google<sup>3</sup> indicates that 66% of the world’s population live in countries that drive on the right and 34% live in countries that drive on the left. The predominant change has been from left to right. A suggestion has been made as to why the left was chosen by England in the Middle Ages. If a stranger passed by on the right an individual’s sword hand was at the ready if there were trouble to be faced. There are many casual stories, but they all have a single punch line: a convention was adopted. It differed from country to country, but in each instance it was deemed to be worth while and was obeyed.

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<sup>3</sup> <http://www.i18nguy.com/driver-side.html>

The advent of the automobile forced societies to formulate the rules of the road formally and consciously and to spend resources on institutions designed to enforce them. The radical change in environment required a higher level of organization for survival to be supplied fairly quickly.

There is a large and basically normative literature in cooperative game theory where an underlying basic axiom is that a solution should be efficient, however in the modeling, often the cost of attaining the efficiency is not made explicit<sup>4</sup>. I suggest that the switch to a higher level of organization is invariably associated with a new resource allocation where the resource costs fall on the more primitive organisms. Good economics, biology and ecology call for an understanding of the reallocation of resources between the lower and higher order systems. The evolution of cooperation has been studied considerably by randomly matched pairs so popular in mathematical economics. Getting the political deal done, keeping the bureaucracy honest and efficient, following the axioms of Las Vegas and New York, leaving a little on the table for the dealer or making sure that Murphy has had his drink, all call for handling a heterogeneity of purpose and complexity leading to the emergence of higher order self renewing systems. This is not yet captured in either the formal mathematical or the agent based models.

It is not axiomatic that when the environment becomes more complex that the organisms can necessarily adjust, even though failure may challenge survival. The third example selected is universal nuclear inspection. A viable supra-national organization with sufficient enforcement abilities does not yet exist. It is needed. Can the current nation states produce such an institution? It is not obvious. A call for universal inspection is a call for another layer of complexity. The leaders of some nation state such as China, the United States or Russia have to propose a system in which that state itself invites inspection.

This paper began with the story of El Farol and noted the Santa Fe Institute stock market. It ends somewhat gloomily with questions concerning the need for more complex institutions to provide the guidance that is not explicitly signaled by the agents at El Farol. Each layer of complexity appears to change the timing of the processes.

These comments are not a negative critique of the fundamental originality presented in Arthur's work; on the contrary his work offered a macro-dynamics for the amount of coordination and choreography that can arise from the individuals viewed as cells within a social body. They set us up for the next steps in having the higher order institutions for human coordination and governance emerge. This development must provide for an emergence of higher organisms that steer between the simplistic idiocy and fantasy of a Rousseau and the pragmatic pessimism of a Hobbes.

Arthur, W.B. 1994. Inductive Reasoning and Bounded Rationality. *American Economic Association: Papers and Proceedings*, 84: 406-411

Arthur, W. B., Holland, Palmer Stock market

Buss, L. *The Evolution of Individuality*. 1987, Princeton: Princeton University Press

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<sup>4</sup> Although Shapley and I have discussed the "correction" of the characteristic function used to represent a game in coalitional form with an  $\epsilon$  or  $\epsilon s$  charge to all coalitions of sizes  $s$  to reflect organization costs.