

FOREWORD

During the last decades, mainstream economics were almost exclusively concerned with the properties of equilibria under strong rationality assumptions. If taken into consideration at all, learning played a most minor role in the dominating discourse. Typically, it was defined as the process through which exogenously generated additional information is incorporated on an ongoing basis in a standard equilibrium framework. Few considered that learning could do anything more or different than insure convergence to the rational equilibrium. The idea that the very structure of an economy might evolve in a complex manner as result of the individual learning and adaptation processes remained largely confidential.

This is rapidly changing. In the last years, the concepts of individual learning and evolution increasingly gained legitimacy in the eyes of the profession. Extensive efforts have been done to the experimental study of individual learning processes, to the analysis of the characteristics of existing learning models, to the understanding of the way the interaction among individual learning processes can lead to the emergence of economic structures and condition the economic outcome. A number of iconoclastic sounding questions naturally arose, such as: Do learning processes necessarily insure convergence to an efficient equilibrium? Are they always compatible with utility maximization? Can one better explain real phenomena by taking into account specific learning processes? Is it possible that the process of learning be at the core of economic fluctuations? Can it explain in a straightforward manner real world occurrences that are hard to justify from a narrow rational perspective? Are social norms explainable as the result of an evolutionary process?

The papers presented here are state-of-the-art contributions in some of the most important issues and questions at stake in the current research on learning and evolution in complex economic environments. They include important advances on specific topics, while giving a fairly wide and balanced introduction in the general field of investigation.

Jasmina Arifovic's "Evolutionary Dynamics and the Transition across the Nash Equilibria of a Tacit Coordination Game" investigates evolutionary adaptation in repeated coordination games with multiple equilibria, when the updating mechanisms for the players' strategies are given by genetic algorithms. The authors show that the players spend most of the time near some Nash equilibria of the repeated game, but drift from equilibrium to equilibrium over time. Thus, any equilibrium can be reached at some point of time. However, the time spent in pareto-inferior equilibria is negatively correlated to the number of players. An

important contribution of the paper is that it provides a basis for modeling the emergence of fluctuations and transitions in individual agents expectations. These, in turn, may generate permanent sustained fluctuations at the macro-level that are not caused by exogenous changes in fundamentals but result from endogenous changes in expectations. These results are obtained without recourse to the unrealistically strong assumptions on expectation coordination found *e.g.* in the sunspot literature. Moreover, the model appears to better capture features of the experimental findings in coordination games than previous models based on evolutionary game theory and adaptive behavior.

In “Implications of routine-based learning for decision making”, Thomas Brenner interrogates the properties of learning procedures when the agents have a fixed model of the situation they are facing, but insufficient knowledge about the usefulness of different actions. Does this type of learning converge or not to utility-maximizing behavior? What are the characteristics of the learning process that can explain a possible failure to converge? To answers these and related questions, Brenner considers a situation where N individuals repeatedly play on identical multi-arm bandits. These individuals adjust their behavior over time by using some combination of the principal learning routines encountered in the literature – variation, satisficing, imitation, collection of experiences. Thus, although the individual outcomes and payoffs following a given decision are not influenced by the previous and current choices made by others, the decisions themselves may. Some strong results of the paper are that variation precludes convergence to a unique choice of action by all individuals. On the other hand, satisficing, imitation, and collection of experience may lead all agents to choose the same non-optimal action. In many instances, the results are not compatible with the expected utility maximizing hypothesis. Conversely, it is possible to delineate restrictions on the learning situation under which expected utility maximization appears a satisfactory approximation of routine based learning.

The paper by Herbert Dawid and W. Bentley MacLeod, “Holdup and the evolution of bargaining conventions” addresses a classical dilemma of industrial organization: In the absence of complete *ex ante* contracts to divide the surplus, any party investing in a joint venture may not capture all the increase in value from its investment and, thus, may have an incentive to invest less than collectively optimal. This inefficiency, however, would disappear if, *e.g.*, there was a stable social norm blocking the distribution of any surplus whenever any of a party does not receive a fraction of the joint surplus sufficient to fully compensate its effort. Thus motivated, the main question studied by Dawid and MacLeod is whether the endogenous evolution of investment and bargaining behavior may lead to the emergence of stable efficient norms. The question was recently positively answered in the case where only one of the parties makes an investment. The authors show that this result does not extend to the case where both parties make complementary investments. This powerful conclusion is of great importance as it helps delineate conditions under which exogenously imposed legal institutions are necessary to insure efficient behavior. Moreover, it transcends the sole hold up problem by shedding new light on the properties of bargaining conventions and on the relationship between the Nash and endogenous bargaining solutions, among others.

Compared to exchanges in good and services markets, political exchanges are characterized by a weaker link between individual actions, political outcomes, and individual benefits. Possibly for that reason, models based on the standard rationality paradigm typically lead to counterfactual conclusions. In “An evolutionary model of voting”, Juan D. Montoro-Pons and Miguel Puchades-Navarro present a model of voting behavior where the usual strong rationality assumptions are replaced by the hypothesis that the voters use a classifier system. That is, their voting behavior is represented by a system of conditional “IF (condition) THEN (vote)” rules. Several rules typically apply to a given IF condition. The classifier system implies that the agent will choose the rule to which it assigns the highest value, the fitness of the rule being a function of the experience that the agent had with this rule in the past. The model indicates that electoral participation is significantly affected by the population size, by the discounting, and by the perceived benefits of electoral participation. Moreover, the paper gives some insight on the possible link between alternative redistributive policies and political outcome, and suggests a rich rational basis for electoral abstention. The model appears to better capture stylized facts on voting behavior than the more traditional public choice models.

Nicolas Vriend, “A Model of Market-making” is concerned with a most fundamental problem in economics. Markets are not *a priori* primitives, but result from voluntary decisions by economic agents. To investigate the possible emergence and properties of a market when there is no exogenous intermediary or random matching mechanism to bring together buyers or sellers, Vriend considers a decentralized economy with a large number of buyers and sellers. There are many commodities, but each agent is interested in consuming only a few of them. Although there is no aggregate uncertainty (the aggregate demands *e.g.* are common knowledge) the agents do not have any spontaneous information about their respective characteristics. Thus, they do not know in advance whether or not interacting with another agent will lead to a fruitful exchange. However, agents may communicate with others, at a cost, and thus acquire information on the others. This creates the possibility of meeting potential trading partners. The analysis concentrates on the ways firms competes in this framework, and on the existence and properties of a symmetric Nash equilibrium in the firms strategies. A number of powerful and appealing results emerge, in particular that at the equilibrium typically each buyer has some monopsony, each seller some monopoly power: A firm can attract only a limited number of buyers, and a buyer can visit only a limited number of firms. More remotely, Vriend’s model provides a most promising platform for investigating diverse important and little understood issues on the functioning of markets, such as the role of liquidity or the usefulness of middlemen.

In “Connecting adaptive behavior and expectations in models of innovation: The Potential Role of Artificial Neural Networks”, Murat Yildizoglu critically reviews the way the expectations conditioning the R&D decisions of firms are modeled in most of the literature. He argues that an approach is needed that lies between the unrealistically strong a rational expectations hypothesis and the standard rule-based models where decision rules are either constant over time or evolve according to pure imitation-mutation dynamics, by combining backward

looking learning with adaptive expectations. Specifically, he proposes a bounded-rationality framework where the agents use an internal model of their environment to simulate the possible consequences of their decisions. The internal model itself is updated as a function of the discrepancy between predicted and actual consequences of the chosen decisions. The approach is applied to a model of an industry combining a genetic algorithm and an artificial neural network to model the decision-making and internal model updating process. Numerical investigations document the fact that the incorporation by the firms of expectations about their environment improve their performances, this, fairly independently of the structure of the underlying neural network.

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Le Lac Mort, July 2002