Norms as emergent properties of adaptive learning: The case of economic routines*

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Abstract. Interaction among autonomous decision-makers is usually modelled in economics in game-theoretic terms or within the framework of General Equilibrium. Game-theoretic and General Equilibrium models deal almost exclusively with the existence of equilibria and do not analyse the processes which might lead to them. Even when existence proofs can be given, two questions are still open. The first concerns the possibility of multiple equilibria, which game theory has shown to be the case even in very simple models and which makes the outcome of interaction unpredictable. The second relates to the computability and complexity of the decision procedures which agents should adopt and questions the possibility of reaching an equilibrium by means of an algorithmically implementable strategy. Some theorems have recently proved that in many economically relevant problems equilibria are not computable. A different approach to the problem of strategic interaction is a "constructivist" one. Such a perspective, instead of being based upon an axiomatic view of human behaviour grounded on the principle of optimisation, focuses on algorithmically implementable "satisfycing" decision procedures. Once the axiomatic approach has been abandoned, decision procedures cannot be deduced

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from rationality assumptions, but must be the evolving outcome of a process of learning and adaptation to the particular environment in which the decision must be made. This paper considers one of the most recently proposed adaptive learning models: Genetic Programming and applies it to one the mostly studied and still controversial economic interaction environment, that of oligopolistic markets. Genetic Programming evolves decision procedures, represented by elements in the space of functions, balancing the exploitation of knowledge previously obtained with the search of more productive procedures. The results obtained are consistent with the evidence from the observation of the behaviour of real economic agents.

Key words: Computability – Genetic Programming – Oligopoly

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1 Introduction

As Kenneth Arrow – himself one of the major contributors to rational decision theory – puts it, a system of literally maximizing norm-free agents "... would be the end of organized society as we know it" (Arrow, 1987, p. 233). And indeed one only rarely observes behaviours and decision processes which closely resemble the canonical view from decision theory as formalized by von Neumann, Morgenstern, Savage and Arrow.

What are then the characteristics of norm-guided behaviours? And where do norms come from? Can they be assumed to derive from some higher-level rational choice? Or can one show different kinds of processes accounting for their emergence?

In this work we shall discuss these issues and present an evolutionary view of the emergence of norm-guided behaviours (i.e. routines[1]) in economics.

We shall call *rules* all the procedures linking actions and some representation of the environment. In turn, representations are likely to involve relations between environmental states and variables and require the fulfilment of certain conditions (IF-THEN rules). It is a familiar definition in Artificial Intelligence and cognitive psychology (see Newell and Simon, 1972; Holland et al., 1986). Of course representations may encompass both environmental states and internal states of the actor; and the action part may equally be a behaviour in the environment or an internal state, such as a cognitive act.[2]

Further, we shall call *norms* that subset of rules which pertain to socially interactive behaviours and, in addition, have the following characteristics:

1) they are context-dependent (in ways that we shall specify below), and

2) given the context, they are, to varying degrees, event independent, in the sense that, within the boundaries of a recognised context, they yield

[1] For a general discussion on organizational routines and their role in economics see Nelson and Winter (1982) and Cohen et al. (1995).

[2] Clearly, this very general definition of rules includes as particular cases also the procedures for decision and action postulated by "rational" theories.