Experiments and Agent Based Simulations

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Editorial Note

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Indeed management is still one of the favorite topics that folks from Economic Science Association 2005 European Regional Meeting invited the editors to review and publish the works presented therein that we gladly welcomed. Indeed the huge topic is still inexhaustibly appealing that many people from many different fields are still waiting for latest development and trend, despite the fact that science, albeit cumulative, is slow.

I am not going to add another speculation to particular unsolved problem nor give a quick tour about the current issue. It's been excellently covered by Novarese and Maffioletti in the next page. This tiny note would only again rephrase for the audience after many times being said and emphasized, that efforts in a field as wide as social sciences not only optionally, but sometimes mandatorily demand collaborative works that goes beyond disciplines or mere geographic trivialities.

It is very rare case to us the editors that we have an opportunity to scrutinize issues on human economic behavior in terms of decision theory down to very subtle moves, very specialized lab job (See, Ambrosino & Lanteri in this volume). Rare case that we encounter such solid empirical bases in various settings and repeated trials, way down to any possible detail that may beg questions yet allowed to be being questionable for us in due course. It's nothing like fancy accelerator or super-sensitive anti-particle detector worth millions of some monetary amount. It's simpler. But still it's something that we normally are not very easily being capable of. Collaboration evidently works in this case for the purpose of exchanging and sharing new information, findings, data, before finally the inherent discussion itself.

For that matter, geography should have been much less a problem for those in relatively closer area to do something together. It's commonsense. In fact, that commonsensical reasoning does not apply in our current circumstances. It fails. While we have been around for quite some time now, to name just one, extremely rarely that someone who has ever submitted to this journal is from around.

So much for the irrelevant noise. To the readers, this is the last issue customized to cover management with complexity sciences spectral insight built in. Enjoy.

The editors especially thank Marco Novarese, Yohanes Surya, Yohanis Kwee, for that without them, this volume will never look like what it now looks like.

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Introduction
Experiments and Agent-based Simulations
Toward a common framework

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In recent years, Experimental Economics and Computational Economics have increased their reputation as well-established areas of economic research. The Nobel Prize (2002) given to Daniel Kahneman and Vernon Smith showed the scientific quality reached by Experimental Economics as well as it contributed to the acceptance of this discipline by the scientific and scholar community at large. In the same time we assisted at the publications of a wide numbers of papers on simulations. The birth and growth of journals devoted to this issue; certifies the relevance reached by simulations today. The aim of this introduction as well as of the special number of this Review is to investigate how these two different methodologies and areas of economic research could be used to better describe and interpreted human economic behaviour. The papers included in this issue have been presented at the Economic Science Association 2005 European Regional Meeting, held in Alessandria, Italy (September 15-18th).

What have the two approaches in common?

In the motivation of the year 2002 Nobel Prize we can read that Kahneman was awarded "*for having integrated insights from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty*" and Vernon Smith "*for having established laboratory experiments as a tool in empirical economic analysis, especially in the study of alternative market mechanisms*". From these motivations, we can infer that the main areas of the Experimental Economics Research Agenda are:

a) to describe human behaviour in economic choices;
b) to study and implement different market institutions.

Experimental Economics has an empirical approach to economics, in particular, at a micro level. Subject's behaviour is investigated either to test theories, models or axioms or to define better rules of behaviours in markets, (where for better we intend more efficient rules). The implication of this analysis is to provide a descriptive theory of human behaviour by testing the descriptive validity of the standard economic theories or by testing the behavioural assumption of the prevailing paradigm in economics as well as by investigating the properties of a market institution.

On the other hand, Computational Economics, by modelling agent's behaviour and by simulating an "economic society" through agents interactions and rules allows a macro analysis. It allows, in fact, the construction - from the bottom to the top - of an "artificial society" which can mimic the real behaviour of subjects or agents. Hence, the aim of computational economics is more theoretical than descriptive. It is the attempt of modelling and forecasting what will be the results at a macro level if the agents were acting according to given rules and norms. Summing up, the main contribution of computational economics today seems to be the one of understanding how society and/or organisations emerge from a given set of agents and rules.

The link between the two research agenda is straight forward. Experimental Economics contributes to discover how real people behave and interact in determined contexts, while Computational Economics allows us to see how a particular society or behaviour emerges given a determined set of characteristics. Complementarities are apparent at this point.

However, historically speaking, the two disciplines developed in different environments. As a consequence, in the literature, their areas of intersections, at the moment, have been limited. In fact, the articles here presented want to give a contribution to a closer relation between them.

Experimental Economics was borne in the late forties (Novarese and Rizzello, 1999), while, in the fifties, we assist at the birth of Computational Economics. The invention of computers was a determinant to the birth of this novel approach. Computers, however, will partially change also the way in which Experimental Economics was run. As it has been pointed out by Mary S. Morgan (2004) and Novarese (2004) the two disciplines, vividly interacted with each other in those years. In that period, both the disciplines were strongly determined also by a practical approach to Science. The underlying motivation was, in fact, to discover how people behave in reality and how organizations work and develop in order to find out new strategies of industrial management. At the beginning, the scholars involved and interested in these areas of economics had a strong interdisciplinary approach, like among the others Simon, Cyert and March who were economists, psychologists, management scientists.

In that period the word "simulation" was used also to indicate real experiments in game theory designed to mimic problems related to firm organization and to train future managers. However, the link between the two methodologies was much deeper. In fact the first examples of works in computational economics were proposed by Herbert Simon and his scholars and discussed the use of an empirical methodology that could make possible to develop "behavioural" models in order to improve the power of explanation and forecast in Economics. Such models were build using computer simulations.

Careful observation of reality and description of the economic behaviour of participants in the experiments were the starting point of simulations. The two approaches were, therefore, naturally related. Cyert and March (1963) describe this approach to Economics in their work. Central is the need of realism. Realism is in fact the necessary premise to improve the comprehension of how really the economic systems work and how decisions are undertaken by individuals and organizations.

In particular, according to Cohen (1960) simulations allow the reproduction of more complex tasks and contexts at an individual and social level. The results of the latter approach can be used to design the routines and the rules in the application of the former one. Better predictions might be the auspicial consequence of this conjunction, while the birth of computer can allow the use of more sophisticated model of representation of reality.

This empirical attitudes to economics was not limited to the use of experiments or simulations, but it was integrated by the use of other methodologies as the protocol analysis: the observation of eye movements of subjects while are carrying out experimental tasks and interviews with managers or employees of an organization, analysis of official documents and direct observation of meetings within a firm (writing a report of the course of the meeting).

Between the first example of experiments, we should remember Simon and Barenfeld (1969) and Simon-Gilmartin (1973) work, whose aim was observing real behaviour in order to develop a descriptive and cognitive theory. Their experiment involved the observation of subject behaviour when facing a new piece configuration on the chessboard.

On the other hand, Cyert and March (1963) propose, instead, an experiment aimed at understanding the effects of individual interests on communication in a working group. They proposed, then, a model allowing to studying the level of price and production for oligopoly market. With respect to the traditional representation of agents in this kind of market, the model under analysis is much more complex. In particular firm choices take into account prices, level of production and the marketing strategy. Firms are analyzed taking into account their departments (sales, productions ...) and their different tasks and aims. Such units intersect one with the other and this determines the final outcome in term of prices and quantity. The firm is simulated using a flow diagram of its functioning, derived from the empirical analysis, and supported by the two experiments. In order to function, this computer model needs different assumptions and parameters. The choices of these parameters can be not neutral to the final results. The two authors were aware of this methodological problem which is too often eluded by contemporary research in agent bases computational economics.

The analysis of this point is just an example of the detailed methodological discussion proposed by the work recalled. Yet this stream of research has been largely neglected. The same Herbert Simon (1978), in a paper written some years later, notes that, while in normative microeconomics simulations have made large contributions, in positive microeconomics, their contribution has been modest. The proposed methodology was probably too different from the economic standard approach to be understood and of course to be undertaken. Experimental Economics itself contains more than one soul.

In the1950s experimental economics had not yet developed the recent methodology awareness of these days (see the April 2005 number of *Journal of Economic Methodology*). An experiment such as the ones carried out by Chase and Simon (1973), which analysed in details the behaviour of only three chess players and that was explained by the need to understand the real behaviour of these persons - represents an anomaly in the general framework of the discipline. Both experiments and simulations later have used very simple contexts which make it easier to control the environment (even if there is a recent growing stream that is trying to go back to some of these intuitions, see, for example: Novarese, 2003; Novarese, 2006).

There is another topic in which the unification of the research agenda of these two approaches can produce (and produced) positive results, shaping the development of both the approaches more than the previous stream. In the 1980s, Axelrod (1984) performed his well known studies. He invited

several individuals living in geographically distant places to repeat experiments many times using computer software. These replications showed that, in repeated games under uncertainty and impossibility to communicate, a cooperative behaviour emerges. In this case the outcome can be a Pareto optimal outcome rather than a Nash Equilibrium.

In Game Theory the connection between these two methodologies can be particularly productive. Researchers could use a mixed form of experiments where participants are humans as well as artificial agents. Simulations in this context can allow the study of more complex tasks as well as the analysis of the interactions among heterogeneous individuals. Both aspects that can be taken into account in a standard experiment but at a very high cost (the subjects sample should be very high). In this way (exemplified by the papers of Terna and Cappellini-Lamieri in this issue), simulations become kind of artificial laboratory where it is possible to find out unexpected and emerging results that could hardly be detected using standard models and, therefore, become a "technology to create evidence in economics" (Morgan, 2004).

To the possible intersections and complementarities between Agent -Based computational Economics and Experimental Economics is committed the work of Contini, Leombruni and Richiardi published in the present number. The work is mainly a review of the literature where some connections between the two disciplines are clearly pointed out and few interesting suggestions are given. The authors' research interests are in the area of Agent-Based Computational Economics applied to empirical research (note, yet, that Bruno Contini was also one of the pioneer of Experimental Economics in bargaining theory ; see, for example, Contini, 1968). Hence their opinion is important to illustrate the point of view of researchers working in the area. Of course the emphasis on particular points differs from the one expressed in this introduction, but this is due to the fact that the authors of this introduction are mainly experimental economists. So, the two works integrate and complete each other.

One of the possible area of complementarities that is underlined in their review it is the different role that might have Experimental Economics and Agent-Based Computational Economics (ACE) in simulating subjects choice over time. In Experimental Economics time is introduced either through repetition or/and through the introduction of a discount factor. However *rounds* are imperfect substitutions of time. As far as the experiment goes along, subjects realise that the experiment is going to end sooner or later. The effect is so common especially in game and public good experiments that it has been called *final period effect*. In this respect Agent-Based Computational Economics can allow almost infinite repetitions; as a consequence learning and time can be analysed in an easier and clearer way.

Contini, Leombruni and Richiardi express the auspicious increase in the relations between these two areas of research, auspicious that is also shared by other articles of these review. It is important to notice that this collaboration cannot proceed unless we tackle some methodological problems which are of extreme importance if to understand the different approaches and possible contributions of these two areas of Economics.

As seen even in the present brief review, by comparing the works of Simon and of his scholar with the one of Axelrod, the areas of possible collaboration between these two disciplines involve quite different methodological approaches. From one side there is the claim for a strong empirical need in building models and for a consequent realistic environment. From the other side, the use of

very simple context are the necessary condition to obtain clear cut results (in this way this latter approach is nearer to the standard one).

In addition we have to tackle other problems too. For example, Contini, Leombruni and Richiardi mention the possible use of "interaction between human and artificial agents". In standard Experimental Economics the use of artificial agents that interact with real subject is not precluded. However this interaction gives rise to a methodological problem. According to most of experimental economists, subjects participating in an experiment should know that they are playing with a computer not with humans, but the mere fact of knowing that you are playing with a computer can change your attitude from a more cooperative attitude to a less cooperative one (to deception in experiments, dedicated a special number of *The Journal of Economic Psychology* in 1998).

What the other three contribute are examples of the approach that we can call *Agent-Based Computational and Experimental Economics*.

The paper by Dal Forno and Merlone is an application of the idea of "grounded modelling" (GT). GT is a methodology to generate a theory from data that contains both inductive and deductive thinking. In a way GT resembles what many researchers do when retrospectively formulating new hypotheses to fit empirical evidence. In this framework, experiments become a way to infer quantitative as well as qualitative information on how models work and, on the way in which agents are motivated in their choices. This information can be important to understand how agents' behaviour can be modelled in simulations in order to understand, for example, the possible effects of team composition. Such kind of analysis is very difficult in a normal experimental set up (as a lot of agents are required) and consequently ACE can give a great help.

Simulations become the efficient way to understand and verify the possible effects of the presence of heterogeneity. However, it is important to note how the issue of modelling different behaviours becomes apparent at this point. The authors are aware of this problem.

Another problem is raised: statistical tests normally used in the interpretation of experimental results assume that observations are independent. In this line, it is also possible to think of a future scenario where simulation can be directly used to build the null hypothesis to be used in the statistical test.

The paper of Bravo and Tamburino belongs to the stream of research starting from Axelrod (1984). They propose a repeated public good game with the purpose of studying cooperative behaviour. As described by the literature on the topic, for example Bowles and Gintis (2004), a mix of simulations and experiments has always been a central tool in order to study the evolution of cooperation. By using a set of heterogeneous agents, Bravo and Tamburino's simulations produce macro results quite similar to those of standard experiments. In particular as far as the trend of the contribution rate is concerned and the reciprocal effect of different individual behaviours. However, the simplified behaviour of artificial agents prevents to analyse individuals behaviour more deeply. According to the authors it would be possible to reach a greater "empirical consistence". The price would be, however, a lost of simplicity. As usual, there is a trade off between the descriptive capacity of the model and its power. It is in fact very difficult to understand why people adopt opposite behaviours (cooperation versus non cooperation), since the inner motivations can be various and because different motivations can produce the same outcome). Moreover the interaction between individuals, which is essential to the study of such a problem, determines interdependency of one agent choice from the other agent choice. Actions or outcomes are not independent from a statistical point of view, and

[1] The answer of Cohen (1961) was, at least formally different: we must build models empirically based.

this must be taken into account when analysing the results. Comparing results from standard experiments with the simulations can be very important in this respect.

Ambrosino and Lanteri propose an experiment devoted to test real human behaviour. In this case artificial agents are used in the first part of the game, to create a given training environment (as in Novarese, 2006). By, using a coordination game they test "whether an interaction among individuals generates behavioural conventions", while in the meantime, studying "role of learning in the stabilisation of behavioural rules". Players faced a multiple repetition of game akin to those referred to as 'battle of the sexes' (interacting in given groups) with multiple symmetrical equilibria. The participants were also given a "fair solution", that is to say they faced an equal split situation, which is, yet, less efficient (a lower payoff for both of them). Artificial agents are used, in the first part, to create what we can defined as a focal point, playing always the same strategy. In other words they create a convention or an institution (according to the definition of Bowles, 2004).

In this kind of environment, a standard artificial agent would probably learn quickly to play the best strategy (that is the most preferred in the given environment). The results of the experiment show that, indeed, the majority of subjects converged to the predicted solutions but this is not completely true for all the participants. Surely this finding could depends on the number of repetitions (a crucial point, as just seen) and on the relative value of the experimental reward. Yet, it is also possible to say that human agents are not necessarily as malleable as sometimes economist thinks. Some persons are willing to shape their environment, even if this might imply a partial loss. Beside, individuals think and reflect on their environment and build some models that guide their choices.

The second part of the experiment proposed (a standard ultimatum game) suggests that individuals can internalise different kinds of rules even conflicting ones so that the final results can be descriptive as a weight average. Consider the following elements:

1) the social expectations is the choice A
2) the best choice is B
3) the final choice is C (that is a kind of mean value between A and B)

At this point we can ask ourselves one question: can we get some insights from this kind of individual results? Usually experiments are analysed looking at the mean or the median value of subjects choices, strategies or evaluations (treatment A versus treatment B) and not at individual levels. Simulations, as seen in this review, do, generally, the same. Extending the considerations by Feline and Foss (2004), this procedure violates methodological individualism as assume that environment is more relevant than persons and that all persons are "malleable". Is it possible to face this problem, using simulations? in other words: is it possible to simulate such kind of behaviour? Is it reasonable to think of subjects that change behaviour according to context or emotion or even a priori rules unknown to the experimenter?

People acts according and pushed by a variety of motivations and feelings. We believe that simulations might help us to understand and forecast the possible consequences. The control of environment should not preclude the awareness of complexity and heterogeneity of action of individuals.

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