Simulations, theory and experiments. Notes from an historical perspective

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Introduction

This paper aims at presenting the methodological approach to simulations, proposed at the beginning of the sixties by a group of scholars of the Carnegie Mellon University.
In that period, in fact, these scholars started to work on computer programs as a way to model human and economics behaviour.
This paper show the main features of such approach and its link with the general methodology that this research group proposed for economics, based on the need of more realistic hypothesis as a way to get better explanations and previsions of the social phenomena. There is so, also a link between simulations and empirical analysis, that is, in fact, the point of departure and the way to test models.

These works seem to have been neglected in the following development of Economics (for example the synthesis proposed by Clarkson and Simon, 1960, it is quoted just two times in all article available in Jstor and is never quoted in a specialized journal as Jass).
The same Simon 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 (Simon, 1978), especially in dealing with organization (Simon, 2000).
It seems yet that the works under exam can be useful in the actual debate on simulations, as many of the problems still to solve has just emerged. The solutions proposed are maybe not general, as based on a behavioural and cognitive approach, but are anyway worth of being considered.

1. The different typologies of simulations

The analysis starts from the paper of Herbert Simon and Geoffrey Clarkson - titled "Simulation of Individual and Group Behaviour", published in 1960 in the American Economic Review - in which they clarify many aspects of simulations, theory and econometric analysis, and of their reciprocal relations. In the same period, other authors published also papers dealing with simulations. Most of these scholars come from the same University as Simon. The papers were all published in important journals.

Clarkson and Simon define the following three kinds of simulation analysis. Among the three typologies of models there are, as usual when dealing with classifications, some possible intersections, beyond many obvious points of contact.

1.A. Dynamic macroeconomic

The main examples are the models used in the analysis of the business cycle and market behaviour. This situations can be handled with differential and difference equations or with the method of comparative static.
In this realm, simulations are seen as an additional technique for numerical analysis that can be useful because of computer speed and computational power. They can be used to manage more complexity and non linearity.

The use of simulations represents here a development in mathematical and econometric techniques and is just a different way to model a given situation. In fact, it is necessary to: (1) hypothesize a functional form of a function, (2) then it should be estimated with any of the available instruments; (3) at this point it's necessary to define all initial values necessary to the model.
Simulations will then generate a series of observations. Theri output is, in fact, a numerical series and not a mathematical general relation. This series of numbers can then be directly compared with real data.
In many cases it's possible that traditional econometric procedures give best results. In fact, here, a part from starting values, all the numbers of the series are generated by the program and then the input variables will probably be different from the real values, used in the traditional econometric analysis.
As observed by Cohen and Cyert (in Cyert and March, 1964), these differences reflect the fact that traditional models are "one period change models" while simulations are "process models", i.e. models characterized by an internal evolution.
When a model contain a feedback mechanisms, simulations could allow more accurate forecasting (an example is the analysis proposed by Cohen, 1960a).

1.B. Normative models developed in the management science

In this realm the complexity of the environment can be managed more easily and with greater flexibility by simulations than by mathematical techniques as linear programming.
The difference with the other two kinds of simulations is clear, as these models have a normative dimension and not a positive one.
This kind of simulations was very relevant and frequent in the period under exam. Shubick (1958) states that simulations was born in this realm (with military and management purposes).
Also Simon (1978), looking back at the development of these techniques in economics and management, stress the relevance of such procedures for American Business firms, in dealing with their inventory, cash-holdings and investment decisions. So the decisions procedures of these organizations are much different from the previous years ones[1]. These techniques allow, sometimes, firms to take almost rational decision, or, at least, to apply more powerful heuristics.

It's not surprising that the first authors to propose this procedure in Economics were scholars with an high tendency to interdisciplinary and with interest in management.
The same reason could also explain the low interest solicited among traditional economists.

1.C. Economic decision-making

Almost all economics models are based on some decision making process of an economic actors.
Also macroeconomic models can be read in this way. A demand curve, for example, can be seen as a representation of a series of decisions. So point a and c have many areas of intersection.
When we move from macro to micro models, and from normative to positive analysis, the behavioural elements became more relevant.

[1] That's an important notes to remember also for modelling (american big) firm's behaviour.

Again the usefulness of simulations is here related to the degree of complexity they allow to handle.
There is another important aspects, according to the authors. Computer allows, in fact, also to build agents that manipulate symbols and information, different from numbers (like words or sentences). This characteristic would permit to model situations in which the important factors cannot be represented as real numbers. Simon proposes two example of the limits imposed by the need to model all aspects with number: risk is represented with probability distribution and utility is analysed with a cardinal function.
Important aspects in decision making, cannot be represented using numbers. Computers can be programmed to allow a different modellization.

The next two paragraph proposes two example of simulations developed by the authors under exam, and falling into this third category.

1.C.I. The analysis and modelization of perception and memory storage of individual chess players

Simon-Barenfeld (1969) and Simon-Gilmartin (1973) build a computer program to model perception and memory of chess players.

The analysis is based on a detailed reconstruction of the real mechanisms working in this situations that is useful to recall here and to relate to the characteristics of the simulation.

During the first moments in which a skilled player is faced with a new game position, he does not appear to engage in a search of possible moves. In fact, he seems to be gathering information on the problem. This finding results from a series of empirical investigations, based on different procedures, like protocol analysis and experiment on perception (de Groot, 1965, 1966).

Another empirical findings is then considered: the way in which individuals look at the new position they are exposed to. This aspects can be analysed using the record of eye movement (a procedure used also in other experiments, see for example Rumiati, 1990). Such procedure (that can show the succession of fixations but not what information is being processed at each time) allows to observe that at each point of fixation the subject is acquiring information about the location of a piece at or near the point observed, and also information on the pieces around that bearing a significant relation to the fixed one.

A first general aspects should be noticed: also the software designed to play chess by "selective search" (as the one used by Simon) contain processes that can be labelled "perceptual" and it's then a possible way to model situations of this kind. Some kind of perception is, in fact, necessary to allow a selective search.
Simon and Barenfeld simulate the initial sequence of the eye movements of human subjects using a program called PERCEIVER.

A part from the empirical analysis, the program requires a series of other hypothesis, for example: for each of the pieces near to the one fixed, four aspects are detected: (a) if they defend the piece in exam, (b) if they attack it, (c) if they are defended by it, (d) if they are attacked by it. The order in which these items are noticed is relevant, as when a piece is noticed for one of the reason seen, the fixation is moved on it. It is also necessary to define the starting point of fixation (a piece near to the centre of the board)[2].

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[2] The author don't discuss the origins of fhese hypothesis and their relevance on the results. We'll come back on the problem of assumptions in simulations.

Pictures 1b and 1c (in appendix), taken, from the paper under exam, show a comparison among the path of fixations of respectively an expert real player and a simulated artificial player in the game position of picture 1a. Six of the human's player fixations fall in unoccupied squares (these can be related to problems of calibration in the analysis of eye movement, or can have other unknown explanations), while the artificial player always look at occupied squares. Nevertheless, Simon and Barenfel notices a considerable concordance between the objects of attention in the two cases (the same pieces and the same relations with their neighbours; these aspects can be seen better looking also at the output of the program reporting in detail the aspects analyzed, see picture 2). It should be noticed that PERCEIVER's focuses of attention don't rest on particular evaluation of the possible moves and development of the game, but just on a series of simple search rules.
At the end of the series of fixations, PERCEIVER identifies the Black pawn as under defended. Then it start a new exploration to find moves that could protect it (using the same perceptual processes as before). In this way it discovers three possible moves. One of this is discovered in the same way by the human expert used as a benchmark.

The main aim of this example is to show that a computer can use perceptual processes resembling those used by human subjects. PERCEIVER is, in fact, able to extract from the board almost the same information of a skilled human player. The detail of the processes should yet be best understood also because, there are important aspects unknown that should be hypothesized. The program can consequently be improved.

There is a second aspects that define the human performance in chess game perception: the capacity to retain the information gathered and to reproduce it in the memory. This aspect is reproduced with another program.
Again, the analysis starts from experimental results showing that the ability of real players to reproduce a chess position after a few seconds' exposure to it depends sensitively on:
a) his chess proficiency and
b) on the meaningfulness of the position.
This is again a central aspect in the work under exam, as Simon and Barenfel (p. 369) states that "an explanation of chess perception must be consistent with this data if it is to be regarded as satisfactory".
The explanation should also be consistent with the known characteristics of human short and long term memory. Simon's analysis of this aspects is based on the idea of *chunck*[3]. Here it is defined as "any configuration that is familiar to the subject and can therefore be recognized by him. Chunks differs among individuals, in the case of chess, according to their experience and level of skills.
If a configuration of relations is recognized as familiar it can be represented in memory by a single chunk. In this way the short term memory can retain many more relations than if they must be held independently. Then expert players can retain in their short term memory much information, given an exposition of the same time.
Subjects can usually held in their short term memory only about seven chunks (and in such a short term they can probably transfer to long term memory only one chunk).

This part of the perception process is simulated using a program called EPAM, that was originally developed in a different setting, where it was able to make correct predictions on the effects of familiarity in rote verbal learning.

The new complete program concatenate PERCEIVER and EPAM and aim to simulate the memory for chess position of both a weak and a master chess player (Simon and Gilmartin, 1973).

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[3] "Chunk is a technical term in psychology, meaning any unit of knowledge that has become familiarized and has a place in the memory index. As it has a place in the index, a chunk is anything you can recognize in your field of expertise" (Simon, 1997)

It is composed by two main parts:
(1) a learning component that stores in the long-term memory a varying amounts of information about simple recurring patterns of pieces on a chess board, proposed in a training session;
(2) a performance component that: (2a) detects the pieces on the board; (2b) recognizes patterns (the recognition depend on the chunks -i.e. on the patterns - that have previously been stored in the long term memory; only these sequences can be recognized) and stores them in the short term memory (that is limited in capacity and than contain a maximum of seven names); (2c) decodes the information in the short term memory and reproduces as much of the original board position as possible.

Picture 3 (in appendix) show the output of the second part of the program.

To test the validity of the model, different nets of patterns were build by proposing to the program a series of usual chess positions (drawn from games in the published literature).
Two kinds of net were build, with different dimension, standing for different level of ability of a player (Simon and Chase, 1973, showed that chess skills depends in large part upon a vast and organized long term memory of chunks; see also Simon, 1978).
The performance of MAPP in recognizing patterns was then compared (in different direction and in quantitative and qualitative terms) to that of an experimental sample of master and class A chess players. It resulted again a qualitative resemblance between real and simulated behaviour (a similar percentage of pattern recognised, the same pattern recognized more frequently). The program is then again able to account for the main features of the human performance.

A neoclassical representation of this situation would probably have lead to a model to generate the best moves. This program, on the contrary, try to account for real human decisions.
As seen, the simulation just described are, in fact, based on a detailed reconstruction of the real human processes, in relation to the different steps of the perception mechanism of chess board positions. The main distinctive features of such mechanisms are empirically individuated and extrapolated from the reality, using many kind of methodologies: experiments, protocol analysis, eye movement analysis …, and looking at analysis from different domain (not only from studies on chess, but also on memory; perception in other situations …).
These empirical practices are generally used in psychology. In economics they are widely not seen as useful or even "scientific", also because the interest is generally focused, at maximum, on testing models predictions, and not in finding real hypothesis on behaviour. Neoclassical Economics, in fact, don't take care of the realism of its hypothesis.
Experiments, so, should just reproduce the simple theoretical environment and are built to test theories. Different instruments, and different kind of experiments and of analysis are necessary, on the contrary, when the interest is also directed to understanding real behaviour and not only in testing model (this is a second step in the empirical analysis and it requires different kind of data from the previous one) as I have noted in Novarese (2003). In this paper I individuated, yet, a new stream of experimental research (*experimental cognitive economics*) whose aim is also that of entering the black box of human reasoning and than resembling the empirical methodologies recalled here (Simon is, in fact, one of the main reference of this new stream).

As seen in the previous paragraph, is obvious that this kind of modelization requires naturally a simulation approach.

Another important aspects is related to the generality of the proposed modellization. Chess is taken as an example, of a more generalized kinds of situations.
The same elementary processes that have been employed to simulate problem solving and learning in chess, operating in essentially the same way, produce the same known features of the human perceptual performances in other perceptive tasks. Therefore, similar programs revealed able to describe perception in different environment.

This generality can be read in another direction too. Recalling also Simon, 1978, we can say that chess behaviour analysis stress the relevance of the information stored in long term memory. Direct retrieval of possible action as a result of familiar pattern, provides a basis for professional performance in many other areas. Where familiar situation are faced[4], we can expect more sophisticated behaviours and levels of performance, than in new areas. We should also expect that this model do not imply history-free path of action. On the contrary learning becomes more and more relevant.
In chess, players differ in their skills, and the difference are related to their experience, both in term of number of board position seen, and of their characteristics. Two players with the same training (in term of number of position faced), can perform differently, if their chunks differs, because of the different positions faced in the past. So, individual knowledge of an individual is based on his own experience. This idea is coherent with a path dependent analysis of learning mechanism and decision making (see Rizzello, 1999).

This model could then represent a general reference for other models of learning, based on simulations, to be developed.

In the same period, a similar methodological approach (with more problems because of the more complicated situations faced) were proposed also by Cyert and March, to describe and model the behaviour of another economic agents: the firm[5].

1.C.II. The simulation of oligopolistic firm's behaviour

The analysis proposed by Cyert and March (1964) represent a big effort to build a realistic theory of the firm, empirically founded and going beyond the traditional economic vision (when the analysis was realized, the main theory of the firm was that proposed by the general equilibrium model; the theory of transaction cost was still not well know and studied).

methodology of the empirical analysis

The first part of the contribution in exam is, in fact, again based on an empirical analysis realized on the field, looking at several real organizations' behaviour.
The firm studied operate in oligopolistic markets.

The empirical effort is based on the analysis of
a) different kind of internal documentations (receipts, letters, memoranda ...),
b) interviews with the members of the firms,
c) direct observations of decision making processes (a member of the research group participated to the main meeting of some of the firms, eventually verbalizing it).
Two experiments on organizational communication complete the empirical evidence available.
For example the authors describe four problems of decision, in which expectations, available information and their interpretation play a crucial role.

main empirical results

These last aspects are central, because firm's decisions rely on estimations of alternatives costs and payoffs, and on a vision of the world that are generally partial and different from the reality, also because only a subset of the possible available choices is generally taken into account.

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[4] As pointed by Egidi, 2002, it's also possible that some pattern of action can be extended to new situations, showing some elements of similarity with those in which a given strategy has been learned.
[5] Similar approach can be found in other of the applications developed in that period and surveyed in many of the paper recalled.

Firm's organization and characteristic influence both perception and exploration of the alternatives. There are, besides, always conflict of interests among the different internal sub-groups.
There is also a strong inertia in the decision processes (alternative more similar to those taken in the near past have an higher chance of being accepted).
It's also relevant the order in which the different possibilities are found and then evaluated. If alternatives are generated sequentially, the first that allow a satisficing payoff is, in fact, chosen.

a general model of firm behaviour and some applications

This general findings are used to propose a general theory of the decisions making into a complex organization.

The general models is not formalized. It's based on a series of general ideas.
The authors develop in detail some specific formalized models, as simplified examples of the possible applications of the general ideas. All these applications are realized using computer simulations, that for the authors represent the natural theoretical language to model this theory. Even if the examples proposed are simplified in respect to the general model, in fact, simulations (and flow charts) are the only way to manage such complexity.
The main problems related to simulations are also presented and discussed during the presentation of the examples. The book has also two methodological appendix, on simulations and on explanation and forecast in economics. We'll recall them in the next paragraph.

In synthesis the model proposed as examples are the following.

1) The first one is a *particular model of duopoly*, in which an ex-monopolist faces a "new firm". The main decision is related to the level of the production.
An important feature of all these models, is that firms have a goal that represent both the variable(s) to take care (the variable to maximize in the neoclassical model) and a criteria to take the main decision (the level that the variable should reach, i.e. a level of aspiration). The goal is here the profit.

The decision are based on an estimation of the market price. The real price can be different from the estimated one.

For both agents, the process start with a forecast of demand, costs, and of the reaction of the other firm and with the definition of the desired profit (based on a mean of the past profits; the ex-monopolist compute the mean on a longer number of years; the new firms take also in exam its relative productive capacity).
In the second phase, given the results of the previous step, each actors look for the best available choice. If such alternative don't allow to reach the desired profit, there is a new step in which the function of costs (according to the empirical analysis performed, Cyert and March think that, because of the "inertia" of each organization, there are always costs that can be reduced, given appropriate conditions forcing to do that; this process or re-examination stimulate the firm to reduce its cost; in the model under exam, costs are reduce of a 10% percentage) and demand are estimated again.

Picture 4 (in appendix) proposes a comparison between the markets shares of the two firms in the model and that of two real firms, in a duopoly similar to that under exam (the two firms are: the American Can Company and the new entrant is the Continental Can Company).

This comparison is not supposed to prove for itself the validity of the model, even if the fit is very good. According to the authors, in fact, the model proves that given a series of conditions, it is possible to fit the real data. The problems is related to such assumptions. As in the model there

are many degree of freedom (many parameters), it possible that a set of its series could be able to fit the real data. Even if in this particular case, such parameters are few, and most of them were defined a priori, the difficulty remains.
This is one of the main problem related to simulations, on which Cyert and March insist in the book and on which we'll come back later.

2) Another example is that of a *department of a discount*. In this case the oligopolistic market is composed by the three discounts of a city.
According to the authors the model could be extended, with few differences, to the other departments of the same firm or to other discounts, as the decision processes are very similar.

The general goal of this organization are related to the sales and to the mark-up on the costs.
These decisions are taken accordingly to a general model (again based on empirical observations of the real functioning of the department under exam), based on four principles:

a) the firm is seen as a coalition of individuals characterized by different personal goals; the conflict that born from this situation is solved (or at least the solution is searched, even if not necessarily successfully) thanks to: (i) the use of a "local rationality" (division of the problems in sub-problems assigned to sub-units for the solutions, and then specialization in the decisions: for example sales department is the main responsible for sales, the production department is the main responsible for production ..);. (i i) the fact that the coherence of the rules is weak (so allowing to keep together different goals); (iii) a sequential attention at the problems (with the consequent possibility of different an not coherent solutions in different moments);
b) firms try to avoid, uncertainty, using rules of reaction in the short period and making the environment more known through negotiation (standard procedures, industrial traditions ..);.
c) "problematic research": the search of new solutions is driven by the problems faced (a mechanism of search different from more systematic kinds ones, as the search aimed to understand: technical approach vs. science). Then search is oriented by one problem, and motivated by that problem. It's also distorted by the characteristics of the organization;
d) organization learns and then evolves, modifying its goals and its rules.

Picture 5 (in appendix) proposes a representation of the general functioning of this procedures, using a flow chart.

This general model is specified (and partly simplified) for the department under exam.

Where possible, the previsions of this model are compared to the reality. The data available (i.e. the data gathered by the firm) doesn't allow to test all parts of the model.
There are good data on the prices and on the mark-up. Using as input the data on real costs and on the classifications of each goods, the program produces as output a price for each items. These prices can be compared to the real ones decided by the department. In the 95% of the cases, the model gives a perfect prevision. The model has a good capacity to forecast also the liquidation prices of some items and the special offers (it is designed to individuate when a liquidation price or a special promotion will be proposed)

3) The last example proposed is a *general model on price and production for oligopolistic firms*.
The program represents, for the author a first attempt, to build a general model and should be further developed.

In respect to the traditional models is yet much more complicated, as it takes into account several aspects.

The choices that a firm should take are: the price, the level of production and the marketing strategy. Each of them can be related to a sub-division of the firm, that operate with a relative independence from the other departments.

An (agent based) model of the oligopoly market results from the interaction of many firms, represented by a similar model but with different starting conditions and parameters.
Firms interact both trough market price and demand, and with a reciprocal attention when a price should be defined.
The model generates a detailed series of decisions, related to the internal results and aims, for each of the firms and a market price and quantity.

The analysis of this general model is just a first step, and allows authors to discuss an important question: the relevance of the parameters on the general results of a simulation.
They try to individuate the parameters that have a significant influence on the output. This analysis is based on a regression of the main output variable of the model on a selection of parameters.
Some of them, show in fact, a strong influence, while others seems to be less relevant.
As the authors say, this problems is related to the lack of empirical observations on some aspects (when the research on the field started, the model and the parameters were, obviously, still to be planned, and so not all the empirical aspects relevant for it were gathered; besides, there are aspects that cannot be seen).
To solve this problem, some of the parameters should probably be modelled and get as results of learning mechanism of higher level.

Simulations and the methodology of Economics

As seen in the examples, simulations are introduced by the authors under exam, as a necessary tool for managing complex models, based on realistic hypothesis founded on empirical findings of different types. The need for realism is a central point in the methodological program of this school, from which the other aspects follow in a related way and it is seen as a necessary condition to allow a better comprehension of the reality, and maybe also a better prevision, thanks to the fact that more complicated models can be performed using computers. The complication in models is strongly related to the search for more realism (Cohen 1960b).

Unrealistic hypothesis are, yet, not refused a priori (also in the models seen here there are many aspects not empirically tested) but cannot be accepted if they are proved to be false and if a more realistic one can be found (and should be found), independently from the performance of the model.
Even traditional models are not refused for itself. Computer programs allow to express theories in a new different mathematical languages and allow then new possibilities that can be added to the other available languages (verbal language, graphics and maths).
When possible, simulations should be performed in parallel to traditional mathematical models, has both of them has limits and advantages.
Simulations are less general, as they need more information than traditional models and their results are a series of number. That's not necessary a limit, it's just a different characteristics, that has many positive implications.
In fact, for example, these series of number make it possible to test immediately the theory more easily than traditional models.
That's particularly important because using simulations it is possible, not only to handle very complex situations, but also to build theory that are intrinsically dynamic, and not only based on one period movements.
As real data are dynamics, in this way it's easier to compare theory and reality (but again, empirical verification is not so relevant for some of the traditional economist).

Cohen 1960 proposes other positive elements related to simulations.

- In respect to aggregate economic modelling (Cohen 1960b), a micro approach have many advantages. Markets, for example, become emergent phenomena, arising from the interaction of a series of firm (whose heterogeneity can also be modelled, while this characteristic is more difficult to be accounted for it in traditional micro models and it's excluded in aggregate theorization[6]). It's possible that factors that differ among agents and that are excluded by aggregate models (or that are not explainable by them) could compensate each other in aggregate set. But that's not necessary, as this individual effects can also have a strong effect on the general result. A micro modelization is then a better way to proceed.

Even firms can be modelled as emerging from the individual characteristics of their members (see Novarese 2003, where the relevance of this aspects is empirically analysed). Cyert and March (1964) include, more or less directly, this aspects in their models, taking into account the conflict of interests and the role played by the different departments in a organization.

In simulations, heterogeneity can be related to some differences posed by the researches but can also results from different learning processes, given the same general model (as, for example, in Simon analysis of different chess players, that differs in relation to the length of the training and can differ also in relation to the positions faced).

- The assumptions are easy to modify and change than in traditional analysis[7].

This new methodology reflect themselves also in the relation with Econometrics that is not refused by a simulation approach. There is on the contrary a need to interact. The new approach, besides, poses new problems and requirements (proposed by Choen 1960b as another critical factor for the development of simulations; Cohen and March 1964 recall them and give some preliminary ideas of the possible direction in which find a solution), as econometrics developed in strict relation with traditional one-period models[8].

The novelty of the approach under exam and its attention to empirical analysis is reflected also in the variety of empirical data and analysis used. Consider the following examples.

- Simon and Chase, 1973, propose an experiment with a detailed analysis of the behaviour of just three chess players. Their aim is that of understanding how they play, not to test a model.

Experimental economics is generally used to test theory and there is generally no attention in understanding why players behave in that given way (see Novarese 2003).

- Cyert and March proposes a series of case studies, as a way to understand how firm takes decisions.

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[6] But that has the disadvantage to increase the costs of the analysis, as it make necessary also a wider study to individuate all possible kinds of agents and to model them

[7] Simulations allows to work with formal models also to non mathematical economists. They should, yet, be able to manage computer simulations. In the last years more and more economics courses are starting to include such skill, but in the 60s it was probably not so, and this can be another factors able to explain the low interest in this approach.

The suitability of easy programming language were posed by the same Cohen as one of the crucial factors for the development of this approach. It's possible that the development of object oriented programmation helped to increase the role of simulations in economics (Prietula et al, 1978).

Clarkson and Simon (1960) and Simon (2000) pose also the attention on the relevance of the development of "heuristic programmation" allowing to simulate system that manage non numerical values.

[8] It's not possible to analyse here this aspect, that are just mentioned in the studies under exam. In short, the problems recalled are related to:

-criteria to postulate and estimate more complicate functional forms have to be developed,

- the estimations of the parameters (to be done before the simulation is run and representing one of the possible way to solve the problem seen) poses other problems as most of them can be generated by simultaneous equations of a model;

- it is necessary to devise test allowing to define the goodness of fit of simulated and real data (considering also that real data can have measure problems)

Case studies are another tool that economics tend to avoid, for many reasons. There is still no methodological agreement on how to conduct them and present their data[9]. The main problems are related to the way decisions are analyzed. The researcher can, also unconsciously, be influenced by his persona ideas and interest in gathering information. His presence can influence the behaviour of the subjects under exam. There is also an obvious problem of generality of the results found[10].
Simon (1992, p. 20) has yet an answer to such criticism: "If you are trying to understand what firms are and how they operate, you will learn a lot from this kind of very detailed study of the processes of decision ..Of course, we should not stop with five firms. Biologists have described millions of species of plants and animals in the world, and they think they've hardly started the job. Now, I'm not suggesting that we should go out and describe decision making in a million firm; but we might at least get on with the task and see if we can describe the first thousand. That doesn't immediately solve the aggregation problem, but surely, and in spite of the question of sampling, it is better to form an aggregate from detailed empirical knowledge of a thousand firms, or five, than from direct knowledge of none. But the latter is what we have been doing in economics for too many years".

The authors in exam don't discuss in detail this specific problems of the empirical analysis (probably also because at that time there were a different status among economist for the empirical research; for example the contemporary, more rigorous, way to present experimental results developed later, see Novarese and Rizzello 1999) but stress the need of getting better data and observations on real behaviour. as a condition for the development of simulation techniques and of the more general (behavioural) economic methodology.
March and Grunberg (in Cyert and March, 1964, p 366) put the empirical analysis as the starting point of their methodology. They think, in fact, that economics should be seen as part of the study of human behaviour and than it need true empirical hypothesis that can be used in all contests and models.
Cohen 1960a states that simulations are especially adapted to the development of a behavioural models of the firm at a micro economic level. This statement can be extended to the general behavioural micro-modelization.
To take full advantage of simulations, it is then necessary to obtain a great body of empirical materials[11] (Cohen 1960a). Computer programs can represent a framework around which organize the collection of data.
This is a positive elements, but again also a possible bound, as to develop a behavioural approach, a lot of data are necessary and they should be very detailed and so complicated and costly to collect (this can be another factors able to explain the low success of this approach)[12].

This views of the economic requires, obviously, a dialogue with other disciplines (psychology first of all).

Conclusion

This paper proposed an analysis of the methodological approach to economics developed and proposed by a series of authors in the sixties. This approach can be defined cognitive and

[9] Also because of privacy problems of the firms under exam.
[10] The fitness of the specific model proposed by Cyert and March can be also attributed to its peculiarity and lack of generality.
[11] Simulations requires also a detailed analysis of working principles and institutions (in that there is a parallel with experimental economics).
[12] The costs comprises also the "mental" difficulties of a more interdisciplinary approach by the economist that should be, in fact, less specialized to perform it (in the recalled papers, empirical analysis, theoretical modelization and computer programs were all present together), losing the advantage of division of the labour.

behavioural, because of the attention to real perception and decision making and to the role assigned to learning processes.

One of the main point of departure is constituted by the wish to relay on more realistic assumptions, as a condition for better a understanding and forecast of the reality. This idea lead to the need of more data and of different empirical methodologies (see also Simon 2000).
Simulations are seen as the most important, even if not unique, way to modelise the resulting complexity.

The papers discussed individuate a series of problems and need, that are related to the kind of general approach pursued, but that have, in some cases, also a more general validity and seems then useful for the contemporaneously debate on simulations (that is not necessarily linked to a behavioural approach and based on realistic assumptions), as many of the problems seems to be again present, as testified by Testfatsion 2002.

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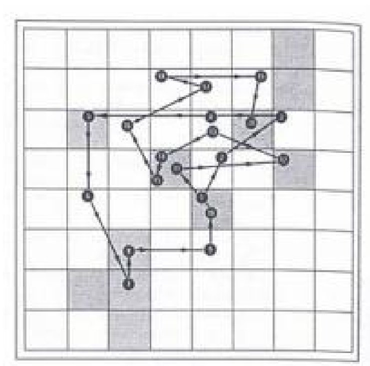
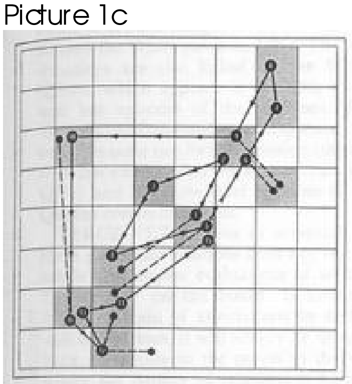
Appendix: pictures

Picture 1a

Picture 1b



Picture 1c



Picture 2.

Table 1. Sequence of Fixations and Noticing Acts; PERCEIVER Program.

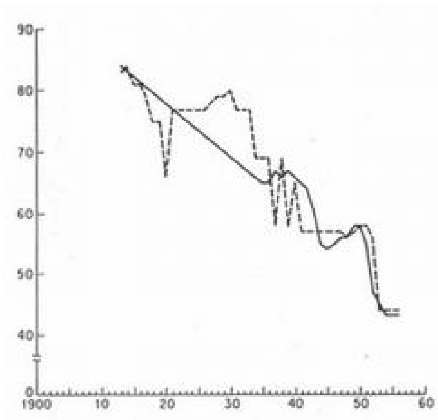
1. Black pawn (K4)	attacked by	White Knight
	defended by	Black Knight
2. Black Knight	attacks	White pawn (Q5)
3. White pawn (Q5)	defended by	White Knight
4. White Knight	attacks	Black pawn (K4)
5. Black pawn (K4)	attacked by	White Queen
	defended by	Black Knight
6. Black Knight	attacked by	White Bishop
	defended by	Black Bishop
7. Black Bishop	defended by	Black King
8. Black King	defended by	Black Knight
9. Black Knight	attacked by	White Bishop
	defended by	Black Queen
10. Black Queen	attacks	White pawn (N2)
11. White pawn (N2)	defended by	White King
12. White King	defended by	White Rook
	defended by	White Queen
	defends	White pawn (N2)
13. White pawn (N2)	attacked by	Black Queen
	defended by	White Queen
14. White Queen	attacks	Black pawn (K4)
15. Black pawn (K4)		

Picture 3.

```
OO BC OO OO OO BC BK OO
OO BP OO OO OO BP OO BP                     Chess
BP BN OO BP OO BP BP OO                     Position
OO OO BP WP OO WP OO OO
WP OO WP OO WP OO WQ OO
OO WP BQ OO OO OO OO WP
OO OO OO OO OO OO WP OO
OO WK OO WC OO WB OO WC
ATTENTION IS DIRECTED TO THE FOLLOWING      Salient
PIECES FOR POSSIBLE PATTERNS:               Pieces
WK12, WC18, WQ47, BN62, BK87,
  WP41-WP58, BP76-BP78                      Primary List
IF FEW PATTERNS HAVE BEEN RECOGNIZED,
ATTENTION WILL BE DIRECTED TO:
BC82, WP27-WP38, BP61-BP72, BP53-BP54,      Secondary List
EXIT AT 81                                  Pattern
62                                    (A)
EXIT AT 62
12                                          Discrimination
EXIT AT 12
18                                          Process
EXIT AT 18
47
EXIT AT 47
87                                    (B)
RECOG: N1187 = BK87BC86BP76BP78BP67         Pattern N1187
EXIT AT 67
56
RECOG: N265 = BP46BP55                      Pattern N265
EXIT AT 45
53
RECOG: N155 = BP53BP64                      Pattern N155
EXIT AT 64
82
EXIT AT 82
72
RECOG: N275 = BP72BP61                      Pattern N275
EXIT AT 61
27
RECOG: N5 = BO77BP68                        Pattern N5
EXIT AT 38
EXHAUSTED POSSIBILITIES W O FILLING STM
STM: BN1187 WN265 BN155 BN275 WN5           Patterns in
                                              Short-term Memory
XX XX XX XX XX BC BK XX
XX BP XX XX XX BP XX BP
BP XX XX BP XX XX BP XX                     Reconstructed
XX XX BP XX XX WP XX XX                     Chessboard
XX XX XX XX WP XX XX XX
XX XX XX XX XX XX XX WP
XX XX XX XX XX XX WP XX
XX XX XX XX XX XX XX XX
```

Figure 2. Example of a MAPP run. Position M1. Net N15.

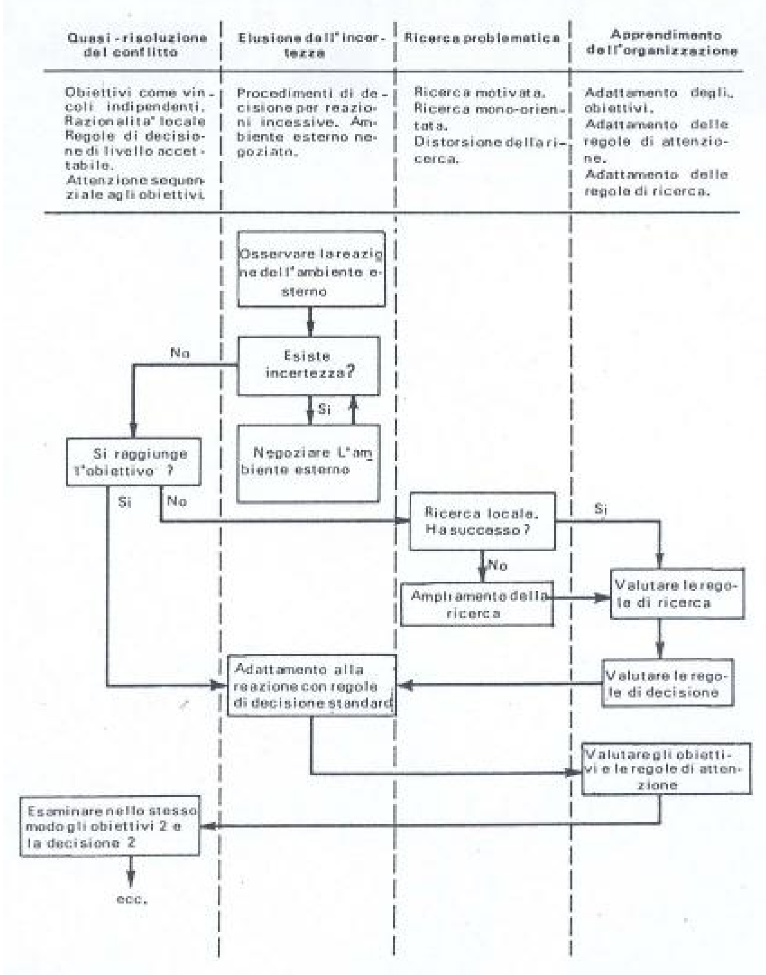
Picture 4



The vertical axis reports the ratio amont the market shares of the ex-monopolist and of the other firm. The horizontal axis show the year. The dashed line represents the true data.

Picture 5

Fig. 6.1. - Processo di decisione dell'organizzazione in forma generalizzata



source Cyert and March (1963), italian version (1970)