AGENT BASED MODELING AND SIMULATION IN ECONOMICS

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Abstract: Agent models yield quick and direct results. Their usefulness derives from the possibility to reveal emergent connections between the system's components, experience in regards to the system's knowledge detailed processes and identify possible results outside typical thinking range.

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1. Introduction

As the world is becoming ever more complex so too the systems with which to analyze it must constantly improve. Planning and management instruments must grasp its complexity. North – 2007 - believes that in the future all computer simulations will be based on agent-systems, which is logical due to the natural mode in which agent models represent business affairs. Many of the future optimizations models will be based on agents as well as, due to the flexibility of the applied algorithm in agent based optimizations but also to their applicability in solving real-time optimization issues.

Agent based modeling and simulation is a new method of grasping complex business behaviors. Agent modeling accounts for the system's entire behavior. Behavior rules of individual components are defined and then used to create an agent-based model. The model is afterwards executed to reproduce the system's whole behavior. The results consist of a "bottom-up" modeling approach which allows organizations to transform their knowledge of individual conduct to comprehend the system's results on a global level. The agent based model thus predicts these types of connections which link the behavior of individual components to the effects resulting from the system. Organizations which use such a model can determine which combinations of individual actions and influences yield positive results or lead to negative ones.

Lab models can also be used to explore the range of results that use to be expected from the systems but also to simulate potential profits from possible future actions. Agent models yield quick and direct results. Their usefulness derives from the possibility to reveal emergent connections between the system's components, experience in regards to the system's knowledge detailed processes and identify possible results outside typical thinking range. The results of the connections between the system's components will allow users investigate possible interactions and simulate potential interventions. Revealing the links between micro and macro level behavior leads to increases in business results –sales. Extending the view of managerial strategy

by revealing the potential of unforeseen results allows businessmen make informed decisions.

2. Application based agent simulation

The development and simulation of agent models is applicable in many areas including the projection of improved systems for businesses and organizations, manufacturing operations, management of supply chains and stock networks, comprehension and interdependencies within institutions, such as assuring and reassuring, predicting consumers' reactions to marketing programs and other consumer market activities, projection of efficient markets, improving the efficiency of financial markets, increasing commercial profits, better managing of energy markets, restructuring electrical energy markets, improving company behavior, pedestrian traffic control and vehicle circulation, designing smart buildings or new community and information protocols for military and system's control.

Thus, on a virtual market for example, agents can represent investors' actions according to their own interests and interaction with other agents within the medium represented by that particular market. This allows the end users to study the implication of different decisions and strategies with the help of the simulation initially based on different states of the market. The results can then be interpreted through statistical analyses, data mining, logical analysis, thus utilizing one of the principal advantages of multi-agent modeling.

3. Modeling and simulation language

Swarm – Minar et al., 1996, *Repast* –Collier et, al., 2006, *JAS* – Sonnessa, 2004, and *Netlogo* – Wilensky 1999 are the most known modeling and simulation languages in the multiagent systems.

Usually a simulation language interacts with multi agent systems in the configuration phase. This means that basically, after the selection of the initial condition of the complex system, the observer becomes a spectator of the simulated evolution. If the estimate of the system's variables doesn't affect the result of the simulation, this leads to a correctly simulated model. In other cases though, alternative methods are necessary to resolve these issues. Such a method, called participative simulation –Resnick et al., 1997 accounts for a means to interact to these systems during simulation. Thus, during a participative simulation, each user can play the role of an individual system and can witness the behavior of the system as a whole. Such virtual mediums promote cooperation, coordination and negotiation between agents controlled by the pre-established behavior models –projected by the next user and due to being human-oriented can follow certain goals. The emergent behavior of the model and it's relations with the human user can render the dynamic of the simulated system more clear.

4. Principals of agent modeling

Agent modeling is based on a repetitive construction process. It begins with an initial description of the behavior of individual components or that of agents and the sustaining data. This description is later converted into a functionality model executable with the supplied data. The resulted model is carried out and the initial results are examined. The definitions of the behaviors are then updated based on the initial results, and the model is re-executed. This constant refining process is then continued until the

model reproduces both the behavior and the results of the targeted system. When the types of behavior are analyzed, the resulting model is completed and can be used to respond to different real business questions.

Agent based modeling and simulation is used for a variety of practical purposes in business to increase the expert's comprehension skills of the micro-level behavior and the use it at a macro-level or to extend the applicability area of future possibilities needed to be considered in the decisional process when working with fast-changing circumstances. Few haven't pondered the question what would happen if we knew what would occur if…? Who wouldn't write a list of possible future scenarios to cope with situations? Why does this happen? Even with the most precise models, surprises can come from many directions, including from unforeseen interactions and unexpected changes. In many cases, one of the most important sources of difficulties is the human mind itself.

Agent based models can be built over time, in easy steps. Each development stage ads new capabilities to the model and extends the range of business and questions that can be answered. Its phase structure allows it's usage by the end of each stage encourages constant feedback. This feedback renders the development both dynamic and focused. Thus the model can be rapidly adapted to the ever changing business needs and the gained experience on the developing model of the previous step can be instantly applied for the next model development. Applying knowledge discovered during model development is beneficial to future stages, because agent modeling intentionally implies learning about the system's data that is to be modeled and would amplify its benefits. Even more, because the user regularly receives feedback the managers' development is always assured on the right path to success.

The success of a simulation is thus measured by how close and accurate it mimics the simulation model from the real system. From this perspective, agent based simulation models succeed in reproducing through their structure real systems. Each participant of the real process or system can be represented in the agent model through an agent which simulates its real behavior independent of others. One of the essential characteristics in these simulations is the ease with which it accomplishes its validity. The user can simply express a few ideas by writing lines of code in a natural language and then the simulation can begin. During its progression the user can observe certain predefined interesting variables and can make decision. Recent works have allowed display representation in real time of the results of the simulation in 2 dimensions – RePast, JAS, Netlogo. The improvement of this possibility is currently attempted by representing it in three dimensions – Cacciaguerra et al. 2004. Recently, the latest Netlogo version promotes another form of three dimensional representation –Wilensky , 2005. However, there are limits due to the possibility of emergent complex agent behaviors in any agent simulation. There are two possible causes. The simplicity of the given agent based model is the first. It is doubled by the reductionism of each type of model. Such a limit is able to affect the accuracy of the results because it is common knowledge that the easier the model, the more it shifts from the system represents. In fact, it is very difficult to describe the exact behaviors of the model due to the intrinsic complexity of the interactions between the social participants. Thus in order to allow some degree of freedom, certain random steps are introduced which determine a lesser precise analysis. In these cases, a full description of the agent's behavior isn't possible because of the law of physical indifference of their interaction. Not all interactions can

be accounted for, some being evident while others remain hidden and from that position instilling unexpected behavior changes to the agents within those obscure interactions.

A second reason is linked to limited computing power. Regular software can't handle large quantities of data in a short period of time due to their processing methods –sequential not parallel. In this case, when forced with a typical problem of physical simulation, the lack of time can't resolved in the short duration of the simulation, thus rendering complex model experiments impossible. Furthermore, the analysis of physical systems is easier than that of social ones due to rigid restrictions and the obligation to prove statements that are behind them. Thus it is fairly difficult to implement agent models able to generate new and emergent behaviors. Still, by reducing the imperativeness of the statistical precision of model results, efficiently described difficulties, at least in part, can be overcome. For this it is very imperative that agent based models to be able to interact between them fast and on time in the virtual medium.

5. Conclusions

Modeling and simulation, done properly, provides a way for the analyst to discover the world and create new knowledge may be of practical importance to the efficient functioning and survival of a business. Each agent individually assesses its situation and makes decisions based on a set of rules. They may perform various activities related to systems that are, for example to produce, consume or sell.

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