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Study on Agent-based Innovation Behavior Research Technique

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Abstract

The agent-based computer simulation method is available for complex system studying. The innovation system has characters of emergence and evolution; it is also a complex system. In order to build agent-based computer simulation model for innovation behavior studying, processes of question analysis, property abstract, model environment constructing, model agent building, model parameter adjustment, model running and result analysis have to be processed.

Keywords: agent; simulation; innovation behavior; innovation system ;

1. Introduction

The study of enterprise's innovation behavior needs to introduce new means. The qualitative analysis method has been the major way to study the innovation behavior for a long time. It provides validity to a certain degree in studying, but it shows obvious insufficiency also: the qualitative analysis is not very definite and it is multivocal, lack of verification and manipulation. Generally, quantitative analysis means are used to remedy the shortages of qualitative analysis means, but it is also not comprehensive since social questions are always too complex in structure and too huge in scale, and the mathematical modeling for quantitative analysis which is highly abstracting and simplifying is also insufficient accurate and objectivity.

The advancement of computer technique provides us a new quantitative method, the agent-based computational simulation, to help study enterprise's innovation behavior. This simulation method has

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been used widely in social system and economic system. Lane (1992) proposed the concept of agent-based computational economics firstly. Epstein and Axtell (1996) established an artificial social system: sugars cape. Sandia National Laboratories (1996) explored an agent-based economic system, ASPEN. Other works such as the social emergence and evolution, market forming process from bottom to up, etc., have been done, but it has seldom be used to study innovation behavior.

In order to research innovation behavior through agent-based simulation, the agent-based computational simulation technology should be applied in the explanation to innovation behavior and the emergence phenomenon, to modeling and analyze innovation behavior and to achieve the effect of understanding and predicting real innovation behavior. This paper detailed the modeling process of agent-based innovation behavior model.

2. Characters of Innovation System

Complex system is relatively to the simple system (for example linear system) and the nonlinear system. Complex adaptive system is a representative complex system. Under specific external condition, complex adaptive system may form specific space and time structure, it can do self-organizing, self-studying, self-adapting, and it unceasingly evolves, survives, multiplies and develops. Emergence and evolution are two important common attributes in all complex systems.

The technical innovation system is a complex system, and also a complex adaptive system. It is known that technological change are not only to be found in individual firms or in research institutes, but also in a broad societal structure in which firms, as well as knowledge institutes, are embedded, so the innovation actors are not only firms but also institutes. The innovation may refer to incremental, emergent, or radical and revolutionary changes in thinking, products, processes, or organizations. Actors in innovation system collect resources as input of their output, the innovation achievements. Once their innovations are achieved, new products or new markets emerged. Successful actors have to drive themselves to new steps; failed actors have to change themselves to adept new environment, this is shown as evolution. So the innovation system gives out its characters of emergence and evolution as a complex adaptive system.

2.1. Emergence in Innovation system

The emergence in innovation system is not only the output of new products, but also the economic effect in macro scale. The innovation system is a complex adaptive system which is constituted by massive independent policy-making agents. All innovation agents complete independent decision-making in the local environment situation where it can sense; each agent's decision-making and motion can affect merely the limited environment. However, many agents' correlation in innovation system forms a complex network. Such network does not have a central master. Some macro scale attributes will emergence from bottom to up when we observe on the overall innovation system.

2.2. Evolution in Innovation system

The innovation system evolves unceasingly. In innovation system, innovation actors are not only following fixed rules, but also studying and changing themselves continuously to change its own strategy and adapt the environment. The changes on actors will possibly accumulate to evolution of innovation system.

3. Agent-based Innovation System Simulation Modeling

3.1. Agent-based computational model

The agent-based computational model is featured as bottom-up modeling style and emergence. Generally, the modeling is not started from the understanding of the whole objective system from up to bottom, but from bottom to up, e.g. the modeling started from one of the individual units which compose the system. Basic behavior rules of the individual units are abstracted, and programmed in computer to be "agent" in the agent-based computer simulation model. During running of the model, the agents act with each other under the control of rules. Their action may be direct relations between agents, relations of agents to environment or indirect relations among several agents. Results of their actions could be read through analysis to output of the model; and the macro phenomena of the results are read as emergence. The emergence can be utilized to explain realistic complex system.

3.2. Agent-based innovation simulation system

Based on above agent-based modeling idea, used with modern computer technology, an artificial innovation system could be established on computer. The artificial innovation system is composed of massive microscopic agents, these agents' condition and behavior existence important difference. Compares with the conventional model, these agents have richer internal cognitive structure and more behavior independencies.

There are widespread agents who are living and interacting in the artificial innovation system model. Competition and cooperation occurred among them. In order to pursue benefit, each agent has to adjust his behavior and action rules according to the interaction between agents, agents and environment. The innovation system influences agents' behavior and the agents' behavior are restricted by the environment also. Under the limitation and adjustment of rules, agents in the artificial innovation system model will run from random to disciplinarian, and the system shows to be self-organization.

After the innovation agent's initial behavior condition and behavior pattern, as well as the interaction rules were determined at the starting of the model, the innovation behavior develops automatically along the time. The adaptive changes occurred in agents' rules will lead to agent's evolution, and the evolution process may be described as the natural selection pressure what directly acts on the innovation agent behavior process, but it is not described as the law of group' s motion. The evolution may be deemed as the macroscopic, whole, dynamic behavior of all agents, and it is the phenomenon what microscopic agent's behavior accumulated naturally also. Natural selection's pressure causes the innovation agent to carry on the behavior simulation and the innovation unceasingly to adapt the circumstances, the innovation agent has the coordination evolution.

From above analysis, we can see that the merit of the agent-based innovation simulation method is that the difference and evolution of innovation agent's condition and behavior may be expressed and be simulated. Therefore, this method provides a deeper level and broader scope research tool for scholars.

3.3. Advantages and goals of agent-based innovation simulation system

The primary mission of traditional innovation research technique is to explain why, when and how does the innovation behavior play the role. The research based on agent-based innovation simulation method (AISM) wishes to give out new explanation to the innovation behavior question and the realistic question under the instruction of complex adaptive system theory with the application of the powerful computing equipment. This research technique is helpful to understand that the innovation system runs orderly and evolutionarily according to innovation agents' attention to their personal profit only without controlling and planning from up to down. So, the AISM research is the research on macro mechanism

from the point of micro action of enterprise's innovation behavior, and also research on the enterprise's behavior from the view of macro mechanism.

The AISM research provides an artificial system to process experience on innovation problems, however, normal innovation research technique cannot provide direct social test as normal social problems. Through AISM, an artificial social system could be built on computer, the artificial agent in the system could be simulated in wide arrange. After researching and testing on artificial agents' situation and status, together with the statistical analysis on relationships between agents, researchers on innovation behavior can realize and know laws in reality innovation.

3.4. The modeling process

Currently, the computer simulation is always performed on agent-based computational platform, the modeling processes are abstracting, environment modeling, programming, testing, adjusting and experiencing.

- Question Analysis. The modeling should be started from knowing the research goal and boundary. In this step, task of the modeling should be confirmed.
- Property abstract. Properties of environment and unit around the research target should be considered to be abstracted to be utilized into the next modeling process. The major rule for property abstraction are simplifying and simulating of the function of the target units.
- Model environment constructing. Both in reality circumstance and simulation model, the innovation units have to lie themselves in a environment for their surviving and communicating. In the simulation model, the environment is always described as environment parameters. These parameters are sorted to be statistical parameters and restrictive parameters. The statistical parameters are macro description of all agents; the restrictive parameters are limitation to system running, it is always shown as functions of the statistical parameters. During modeling, all environment parameters should be coded to be recognized and accepted by the model agents.
- Model agent building. It is the key procedure for the building of agents. Agents in AISM are normally representation of the adaptive units in reality technical innovation system which is given properties of the abstracted characters of reality innovation units, it is the key for ATIS modeling, needs to consider comprehensively. Sorts of agents, rules, renewal of the rules, and so on, should be take into account in this process.
- Model parameter adjustment. Through the above three steps, a model could be built. Tests of feasibility confirming have to be processed. During the testing, all modeling parameters and settings have to be tested and adjusted according to the testing results to meet the desired targets. The process may be a long procedure, and the test may be done for many times.
- Model running and result analysis. After parameter adjusted, real running parameters and settings should be inputted to the model and a simulation could be carried out. Output data should be collected and bring to analysis.

4. Modeling Example --Enterprise Innovation Behavior Model

The enterprise innovation behavior model is built on REPAST, it is composed of environment, agents and rules. Its environment is a two-dimensional grid, agents are represents of enterprises, and they can migrate in space and adapt the environment through studying and developing. Rules are set to control the evolutionary process and their innovation behavior, see table 1.

The model simulation runs under the following procedures:

- Agents distribute: agents are set to desired position in the modeling space.

- Parameter setting: each agent is entrusted certain initial fund and status parameters.
- Running and output data: after parameters settled, the model could run and output data. Data can be used to analyze agent's behavior.

Table 1.The attributes and rules of enterprise agent

Properties	Details
Attributes	Vision, moving ability, fund, experience, innovation success ratio, metabolism
Rules	moving, decision-making, produce, experience accumulating, cooperation, apperceive

5. Conclusions

Agent-based computational simulation provides a new method for research enterprise's innovation behaviors. This method has displayed the high serviceability and the validity. But this method lacks at the corresponding modeling standard now; meanwhile, it needs heavy modeling work. Agent could not accurately simulate realistic social members' initiative behaviors. These questions will be done with the further development of system science and computer science.

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