

Chapter 6.5

Agent-Based Modeling for Simulation of Complex Business Systems: Research Design and Validation Strategies

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FOUNDATION IN ECONOMICS

The design science paradigm is foundational to the Information Systems (IS) discipline. It “seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts” (Hevner, March, Park, & Ram, 2004, p. 75). This includes research on agent-based IS. Work on intelligent agents has been explicitly identified as “a way to deal with the staggering variety and volume of data in distributed and heterogeneous environments” (March, Hevner, & Ram, 2000, p. 334). In today’s world of instant, anytime, anywhere communications, everything appears to be connected with everything else. Innovation in information technology appears to be constantly connecting stand-alone objects into distributed systems or business ecosystems. While the Internet has improved interconnectivity globally in the 1990s, Web services computing has begun to improve interoperability between spatially and functionally disparate elements. As

one consequence, decision making in business has become more complicated. Specifically, today’s connectedness has made recognition of interaction effects or feedback loops a crucial requirement in business planning. Often business strategies that make perfect sense at the company or individual level can aggregate up to industry-level conditions, which can have the adverse effect and for all incumbents. A primitive but instructional example is ad spending: companies often increase advertising activities and expenditures to boost sales to create a profit. However, if all competitors do the same, the strategy will fail. Instead of higher profits, the outcome will likely be higher cost and lower margins for everyone.

Agent-based research strategies have been identified as particularly suitable for the study of distributed systems and services (e.g., Sikora & Shaw, 1998). Despite its innovativeness, the core underpinnings of agent-based information systems (ABIS), including computational simulation, are from the same traditional disciplines that

undergird work in so many other management science areas. One of the best-hidden secrets in ABIS is that much of its foundation is based on theory and Nobel prize-winning work in economics. From the conceptualization of an “agent” to laboratory experiments and even computational simulation, all correspond with theory and work in economics.

Agent Metaphor

The “agent” metaphor used to anchor ABIS research is compliant with linguistics and rooted in economics. *The Merriam-Webster Collegiate Dictionary* defines “agent” as “one that acts or exerts power; something that produces or is capable of producing an effect; a means or instrument by which a guiding intelligence achieves a result.” Holland, an artificial intelligence scholar and pioneer of genetic algorithms and complex adaptive systems, borrowed the term “agents” from economics “to refer to active elements without invoking specific contexts” (1995, pp. 6-7). The field of economics that Holland was referring to is Agency Theory, which explains how to best organize the relationship between one party—the principal—who determines the work, and another party—the agent—who undertakes the work (Ross, 1973; Grossman & Hart, 1983; for a survey, see Sappington, 1991). Agency theory analyzes the costs of resolving two types of conflicts that can arise between principals and agents under conditions of incomplete information and uncertainty: adverse selection and moral hazard. Adverse selection is the condition under which the principal cannot ascertain if the agent accurately represents his ability to do the work for which he is being paid. Moral hazard is the condition under which the principal cannot be sure if the agent has put forth maximal effort (Eisenhardt, 1989). In ABIS an agent is understood as a representation of a decision unit or, in general, a knowledge processor and (when implemented) a software module. An agent is created to perform a task

or set of tasks, and it features some combination of the following selected properties: autonomy, activity, communicability, adaptability, and mobility (Prietula, Carley, & Gasser, 1998, provide a rich overview of the computational modeling of organizations). Depending upon the combination of tasks and the environment, the literature distinguishes between various categories of agents (overview in Wooldridge & Jennings, 1995).

Agent-Based Information Systems

The notion of agent-based IS subsumes the research strategy of agent-based modeling and laboratory experiments using computational methods. It follows the tradition of laboratory experiments as a tool in empirical economics established by Smith. He was awarded a Nobel prize for pioneering tests of predictions from economic theory by way of laboratory experiments (Smith, 1962; overview in Kagel & Roth, 1995). Smith “initiated the use of the laboratory as a ‘wind tunnel’ (a laboratory setup used to test prototypes for aircraft) in order to study the performance of proposed institutional mechanisms for deregulation, privatization, and the provision of public goods” (The Royal Swedish Academy of Sciences, 2002, p. 9; Vernon Smith’s prize lecture on “Constructivist and Ecological Rationality in Economics,” 12/8/02, Stockholm, is available at <http://nobelprize.org/economics/laureates/2002/smith-lecture.html>).

Simulation

Simulation in agent-based IS has benefited from Simon’s Nobel prize-winning work in economics; Simon has been credited with creating the disciplines of behavioral economics and the cognitive sciences. He understood simulation as “a technique for understanding and predicting the behavior of systems” (1996, p. 13). At its core, he referred to it as the creation of the artificial (as opposed to the natural) things that are synthesized by human beings, may imitate appearances

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