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

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ABSTRACT

This article aims to provide a synopsis of agent-based modeling and how to adapt an agent-based research strategy for the scientific study of complex business systems. Agent-based systems have been a popular field of study in computer science for some time. While computer science-related research has been focused on the artifact itself, such as computational languages and algorithms, research in the management sciences is explicitly focused on business problems. Research in Information Systems (IS) has begun to advance knowledge in the use of agent-based systems as a means to seek different, computational explanations for business phenomena that have eluded scientific inquiry reliant on traditional—specifically, law and axiomatic—explanation (Kimbrough, 2003). The focus on business problems requires a different research approach than what is successful in computer science. Key modifications include first, the explicit articulation of benefits specific to the management sciences, and second, instrument validation.

Keywords: agent-based information systems (ABIS); agent-based modeling (ABM); complex-adaptive systems (CAS); laboratory experiments; multi-agent systems (MAS)

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 advertising: 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 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
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