Data Science Research Project

Agent-based Modelling for Market Diffusion Research

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Abstract

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1 Introduction and Research Question

1.1 Introduction

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1.2 Research Question

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2 Literature Review

2.1 Agent-based Modelling and Simulation

2.1.1 Definition and Concept of Agent-Based Modelling

Agent-Based Modeling (ABM) is an innovative and powerful modeling and simulation approach used to study and understand the dynamic behavior of complex systems (Macal & North, 2005). The core concept of ABM is to evaluate the impact on an entire system by simulating the behavior and interactions of numerous autonomous individuals within it, known as agents. The fundamental premise of ABM is that even complex phenomena can be understood and simulated through a series of autonomous agents following specific interaction rules (Zheng et al., 2013).

Unlike traditional equation-based modeling methods, ABM employs a rule-based approach to construct models (Dorri et al., 2018), making it particularly suitable for simulating complex dynamic systems. In ABM, each agent is endowed with the ability to make autonomous decisions (Macal & North, 2009), acting based on its own state, surrounding environment, and interactions with other agents

(Macal, 2016). These agents not only influence their physical and social environment but are also influenced by it, forming an intricate network of interactions.

A key feature of ABM is its capacity to capture heterogeneity within a system, allowing for the simulation of agents with diverse characteristics and behaviors, thus more accurately reflecting the diversity of the real world. Through ABM, researchers can observe and analyze how complex behaviors and patterns at the system level emerge from simple rules at the individual level. This "bottom-up" modeling approach makes ABM a powerful tool for studying emergent phenomena, adaptive behaviors, and the evolution of complex systems.

In ABM, agents are core elements with multiple characteristics, including autonomy, heterogeneity, proactivity, and reactivity. They can make independent decisions, interact with each other, learn and adapt, perceive their environment, and act according to specific rules (Davidsson, 2001). Agents typically possess bounded rationality, goal-oriented behavior, and variable internal states. These features enable ABM to effectively simulate individual behaviors and overall dynamics in complex systems.

2.1.2 ABM modeling process and technical implementation

The ABM models contains three main components: agents, environment, and interaction rules.

ABM Components	Description
Agents	Autonomous individuals with specific attributes and behavioral rules
Environment	The context in which agents operate
Interaction Rules	Governing agent-to-agent and agent-environment interactions

Table 1: Main Components of ABM

Modeling Process Steps, here I refer to Jennifer (Badham et al., 2018) and Gilbert's ABM specification sheet (Gilbert, n.d.):

1. Define model purpose and scope.
2. Identify and characterize agents.
3. Determine agent behavior theories and decision rules.
4. Establish agent relationships and interaction theories.
5. Design the environment.
6. Choose an ABMS platform and development strategy.
7. Implement learning and evolution strategies.
8. Incorporate security mechanisms.
9. Develop interaction protocols.
10. Collect relevant agent data.
11. Validate agent behavior models.
12. Run simulations and analyze output results.
13. Link micro-level agent behaviors to macro-level system behaviors.

2.1.3 Application areas and advantages of ABM

2.1.4 Application of ABM in complex systems and social science research

2.1.5 Theoretical contributions and future development of ABM

2.2 Platforms and Building Philosophy of ABM

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2.5 Network Structure and Diffusion

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3 Methodology

4 Simulation and Results Analysis

4.1 Design of the Experiment

Index	N	p	q	Agent Proportion	Iter
Sim 1	1000	0.01, 0.02, 0.03	0.3	[0.001, 0.099, 0.009, 0.891]	25
Sim 2	1000	0.02	0.3, 0.4, 0.5	[0.001, 0.099, 0.009, 0.891]	25
Sim 3	1000	0.01	0.3	[0, 0.099, 0.01, 0.891] [0.003, 0.099, 0.007, 0.891] [0.005, 0.099, 0.005, 0.891] [0.007, 0.099, 0.003, 0.891] [0.01, 0.099, 0, 0.891]	25
Sim 4	1000	0.01	0.3	[0, 0.1,0.009, 0.891] [0.003, 0.097, 0.009, 0.891] [0.005, 0.095, 0.009, 0.891] [0.007, 0.093, 0.009, 0.891] [0.01, 0.09, 0.009, 0.891]	25
Sim 5	1000	0.01, 0.015, 0.02 0.025, 0.03	0.3	Prop innovator: 0.1, 0.2, 0.3, 0.4, 0.5 Prop Influencer: 0.01	5
Sim 6	1000	0.01	0.3	Prop innovator: 0.1, 0.2, 0.3, 0.4, 0.5 Prop Influencer: 0.01, 0.02, 0.03, 0.04, 0.05	5

Table 2: The Parameters of the Experiment for Each Simulation

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