

Applying the agent-based modeling technique to business games

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Abstract

A simple definition for a business game is that it is a game which simulates a competitive industry where participants manage business firms. Business games were created in response to the need of virtual environments, where participants could be exposed to many of the challenges present in the real world.

The purpose of business games was to provide an accurate replication of the real world so that learning processes can occur. Despite their purpose, business games continue to be neither perceived as realistic nor understandable. This essay proposes the application of agent-based modeling to help solve these two correlated problems.

This study presents an agent-based model of consumer behavior whose inter-disciplinary foundations were drawn from the neoclassical theory of choice, Hull's drive theory and artificial intelligence.

In parallel with the development of the model of consumer behavior, a business game was created to implement the model. The game was also intended to provide additional informative elements which could enhance the comprehension of the participants, thus creating a more transparent business game.

In terms of theoretical results, the agent-based model developed in this study originated an emergent behavior similar to the one expected from standard models. Moreover the agent-based model provided additional flexibility and solved some of the dilemmas presented by standard models. The results of the experiments provided significant evidence to sustain the hypothesis that an agent-based model can provide additional information enhancing the comprehension of the participants of a business game.

Keywords: Business game, realism, transparency, agent-based approach, demand model, neoclassical theory of choice, drive theory.

1 Introduction

Management skills are among the most difficult soft-skills to acquire. The absence of a “rehearsal space” is especially critical in management, since learning has been considered the only long-run competitive advantage of a business organization (?). According to ?, it was in response to this need that a new generation of “practice fields” was created – the business games.

A simple definition for a *business game* is that it is a game which simulates a competitive industry where participants manage business firms (?). As model-based games (?, chap. 6), business games can be divided in three major components: the decisions, the model which processes the decisions, and the results which derive from the model execution.

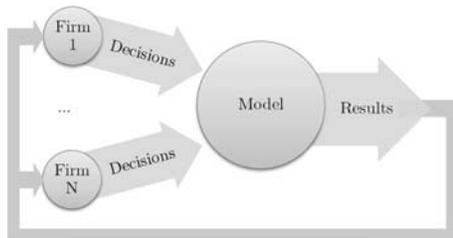


Fig. 1.1: The principal elements of a business game: decisions, simulation model and results.

Although models represent core elements in all games, in business games the model assumes critical importance. The model of business games is a representation of the dynamic environment of an industry where the several firms compete. All the structural elements of a business game depend directly on the design of the model: decisions are submitted directly to the model and

results are directly extracted from the model (?, chap. 6).

? were the first researchers in the field to criticize the obscurity surrounding the underlying model of business games. Until then participants were not provided with any knowledge of the internal workings of a business game and designers refused to disclose the inner mechanisms of their models.

Such was the impact of the secrecy surrounding the internal algorithms of the business games that researchers as ? considered it a major obstacle to the realism of the games and the primary cause of the inability of participants to perceive cause-and-effect relationships.

Supporting the claim of lack of realism and understandability of business games were a number of surveys (???) which reported that academic students considered business games not realistic and were not able to completely understand the game results.

This study proposed itself to address these two interrelated problems, the lack of realism and the difficulty to understand cause-effect relationships through the creation of a transparent game. The scope of this study was however, limited to the area which, according to ?, was classified by participants as one of the most problematic areas of business games: the simulation of the marketplace.

2 State of the art in demand models

The difficulties inherent to the creation of a transparent business game were closely connected to the limitations of the models used. The majority of the models proposed in the field of busi-

ness games were equation-based models which modeled the complex relationships resultant from the interaction of consumers and firms through mathematical equations.

The flexibility of the equation-based models was limited which hindered the realism of the models and the information provided by these models was also minimal since demand results were derived solely from the decisions inputted. The details of the mathematical model used were not disclosed to the participants since researchers ? claimed that the exposure of the such models enclosed the risk of converting the business game into more of a prediction challenge than a true decision making propeller.

This study attempted to solve the lack of realism and the understandability of business games by applying an alternative to the equation-based approach: agent-based modeling. This modeling technique appeared as an interesting and flexible alternative to equation-based models. Agent-based modeling conveyed the possibility to model each consumer and its interactions which could open new possibilities in terms of additional realism and degree of information provided.

The challenges of applying the agent-based technique, still a novel technique to the field of business games ?, were various. First, agent-based modeling is a novel technique in the field of business games and few researchers referred or presented consistent work in the area. Secondly, the existing agent-based models of consumer behavior (??) were focused in simulating specific economic phenomena and did not represent flexible models for business games. Third, it was not clear if the large quantity of informa-

tion comprised in agent-based models could be effectively presented to the participant as a means to enhance his comprehension of the game.

As a means to overcome the numerous challenges a first very simplistic agent-based model of consumer behavior was developed. The purpose of this model was the simulation of a realistic marketplace where the participants could interact. The foundations of the model were drawn from microeconomic theory following the example of the existing models for business games.

3 Conceptual model

From the first simplistic version other few four conceptual models of consumer behavior were iteratively developed: linear, cobb-Douglas, tax-rate and drive model. The models were also inspired by the classical economic theory of consumer behavior. Classical economic theory proved to be flexible framework for developing consumer or general human behavior. Microeconomic concepts such as the utility function, the marginal utility and elasticity of price guided the development process validating it and creating a powerful abstraction. Notwithstanding the potential associated the major challenge lied in understanding and customizing the framework to simulate specific behaviors.

A major dilemma was the inclusion of a sense of satisfaction by each consumer. At extremely low prices it wouldn't seem realistic that a consumer spent entirely his budget on a product. The solution for this problem was the introduction of a "money product" to the utility function and the creation of a diminishing marginal utility

associated with each product.

Notwithstanding the advantages of using microeconomics as the theoretical foundation for the models, ideas from other fields such as artificial intelligence and psychology (Hull's theory) contributed to a more complete model. The final model was inspired by the ideas of ? and simulated the evolving necessities of the consumer, which influenced his reasoning process and consequently his purchases.

The evaluation of the realism of the models was based on the correspondence between the emergent properties of the agent-based models and the properties of models studied in the literature review. Agent-based models produced the same emergent behavior expected from standard models and provided additional flexibility. Even though the final model did not simulate many features of a real consumer, such as marketing effects, loyalty and direct interaction between consumers, it was a step closer to that objective.

4 Implementation

The conceptual model of consumer behavior was not the exclusive outcome of this study. A novel business game, implementing the drive model was developed. The differentiating factor of the game was the fact that it comprised a number of additional informative elements, not present in state of the art business games, such as:

- Simulation in virtual time portraying the evolution of the behavior of consumers and the performance of firms during the execution of the model.
- Statistical information detailed

in timeline and market share charts.

- Information regarding the behavior of each individual such as his decisions, his satisfaction state or his purchases.

5 Results

The results of the experiments provided significant evidence to sustain the hypothesis that agent-based models can provide additional information which enhance the comprehension of participants. The results were very encouraging showing a considerable improvement of the perception each participant had of his comprehension of the game in the presence of informative elements.

This study aspired to represent a small step in the direction of the new generation of business games, the agent-based business games. The agent-based approach brings a new perspective to the design of business games. Hopefully someday business games will have rich agent-based models for the different entities present in business - consumers, firms, suppliers. Hopefully in the future, the business game will represent truly a virtual environment where novice and expert participants can understand and learn through a "try and error" process the business reality.

The evolution of this business games will probably be closely connected to a number of interdisciplinary fields such as artificial intelligence, agent-based economics, marketing and psychology. The research work still to unfold appears, in this context, as a fascinating challenge.

6 Future work

Rather than a complete solution, this study pretends to be, a proof of concept. Further research is needed to create a truly realistic and understandable business game.

Future research should unfold in three different directions: improve-

ment of the interface and of the informative character of the game, expansion of the model to the modeling of other areas such as production and human resources and finally the evaluation of more research experiments with participants with an academic background from the areas of management and economics.

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