Multi-Agent Simulation and Management Practices

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INTRODUCTION

Intelligent agents offer a new and exciting way of understanding the world of work. Agent-based simulation (ABS), one way of using intelligent agents, carries great potential for progressing our understanding of management practices and how they link to retail performance. We have developed simulation models based on research by a multidisciplinary team of economists, work psychologists, and computer scientists. We will discuss our experiences of implementing these concepts working with a well-known retail department store.

There is no doubt that management practices are linked to the performance of an organisation (Reynolds, Howard, Dragun, Rosewell, & Ormerod, 2005; Wall & Wood, 2005). Best practices have been developed, but when it comes down to the actual application of these guidelines considerable ambiguity remains regarding their effectiveness within particular contexts (Siebers, Aickelin, Battisti, et al., 2008).

Most operational research (OR) methods can only be used as analysis tools once management practices have been implemented. Often they are not very useful for giving answers to speculative "what-if" questions, particularly when one is interested in the development of the system over time rather than just the state of the system at a certain point in time.

Simulation can be used to analyse the operation of dynamic and stochastic systems. ABS is particularly useful when complex interactions between system entities exist, such as autonomous decision making or negotiation. In an ABS model the researcher explicitly describes the decision process of simulated actors at the micro level. Structures emerge at the macro level as a result of the actions of the agents and their interactions with other agents and the environment.

We will show how ABS experiments can deal with testing and optimising management practices such as training, empowerment or teamwork. Hence, questions such as "will staff setting their own break times improve performance?" can be investigated.

BACKGROUND

Our current work examines the UK retail sector, but what we are learning about system modelling will be useful for modelling any complex system that involves many human interactions and where the actors work with some degree of autonomy.

The effects of socially embedded constructs, such as management practices, are inherently linked to their context. For many years social scientists have struggled to delineate the effect of management practices in order to reliably draw linkages to performance measures, and they continue to do so (e.g., Wall & Wood, 2005). The application of novel OR methods is necessary to reveal system-level effects of the introduction of specific management practices. This holds particularly when the focal interest is the development of the system over time, as in the real world.

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Existing Tools for Modelling the Impact of Management Practices

As a result of a literature review we have undertaken (Siebers, Aickelin, Celia, & Clegg, 2007) we found that only limited work has been conducted on developing models that allow investigation of the impact of management practices on retail performance. Most papers that investigate retail performance focus primarily on consumer behaviour and efficiency evaluation of firms with less emphasis on retail management practices (e.g., Keh, Chu, & Xu, 2006).

In terms of commercial software, we have found one example, ShopSim (Savannah Simulations, 2007), which provides a decision support tool for retail and shopping centre management. It evaluates the layout and design of a shopping centre. The software uses an agent-based approach, where behaviour of agents is driven by survey data. It is a good example of the form of output that we would expect our simulator to create. However, our tool will operate on a departmental level rather than on a shop level, and will investigate different kinds of management practices rather than a shopping centre layout. Furthermore, the input data will come from management and staff surveys in addition to customer surveys.

Choosing a Suitable Modelling Technique

When investigating the behaviour of complex systems the choice of an appropriate modelling technique is very important. In order to make the most suitable selection for our project, we reviewed the relevant literature spanning the fields of economics, social science, psychology, retail, marketing, OR, artificial intelligence, and computer science. Within these fields a wide variety of approaches is used which can be classified into three main categories: analytical approaches, heuristic approaches, and simulation. In many cases we found that combinations of these were used within a single model (Greasley, 2005; Schwaiger & Stahmer, 2003). From these approaches we identified simulation as best suiting our needs.

Simulation introduces the possibility of a new way of thinking about social and economic processes, based on ideas about the emergence of complex behaviour from relatively simple activities (Simon, 1996). Simulation allows clarification of a theory and investigation of its implications. While analytical models typically aim to explain correlations between variables measured at one single point in time, simulation models are concerned with the development of a system over time. Furthermore, analytical models usually work on a much higher level of abstraction than simulation models.

It is critical to define a simulation model using an appropriate level of abstraction. Csik (2003) states that on the one hand the number of free parameters should be kept as low as possible. On the other hand, too much abstraction and simplification might threaten the fit between reality and the scope of the simulation model. There are several different approaches to simulation, among them discrete event simulation (DES), system dynamics (SD), and ABS. The choice of the most suitable approach always depends on the issues to be investigated, the input data available, the level of analysis and the type of answers that are sought.

Agent-Based Simulation: Our Choice

Although computer simulation has been used widely since the 1960s, ABS only became popular in the early 1990s (Epstein & Axtell 1996). It is described by Jeffrey (2007) as a mindset as much as a technology: "It is the perfect way to view things and understand them by the behaviour of their smallest components." ABS can be used to study how micro level processes affect macro level outcomes. A complex system is represented by a collection of agents that are programmed to follow simple behavioural rules. Agents can interact with each other and with their environment to produce complex collective behavioural patterns. Macro behaviour is not explicitly simulated; it emerges from the micro-decisions of individual agents (Pourdehnad, Maani, & Sedehi, 2002). Agents have a number of core characteristics: autonomy, the ability to respond flexibly to their environment, and pro-activeness depending on internal and external motivations. They are designed to mimic the attributes and behaviours of their real-world counterparts. The simulation output may be potentially used for explanatory, exploratory, and predictive purposes (Twomey & Cadman, 2002). This approach offers a new opportunity to realistically and validly model organisational characters and their interactions, to allow a meaningful investigation of management practices. ABS remains a relatively new simulation technology and its principal application so far has been in academic research. With the availability of more sophisticated

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