EMPIRICALLY EXAMINING COMPLEXITY IN CARBON FOOTPRINT BUSINESS PROCESS

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Abstract

The major objective of this paper is to analyse some of the conceptual (or theoretical) and methodological (or empirical) contributions that Agent Based Simulation and Complexity Theory can make to the management scientists in their Business Process related research; through the critical analysis of the extant literature on these topics. This article also throws some light on using Complexity as the Base Theory. Through this article, avenues for further management research using these tools and methodology are suggested.

Keywords: Agent Based Modelling, Simulation, Carbon Footprint, Business Process, Complexity Theory, Research Method

INTRODUCTION

It is appreciated that simulation is the third way of doing science besides inductive reasoning (or induction) and deductive reasoning (or deduction) (Macal and North, 2005). Several instances of diverse sciences where Simulation is so widely used are mentioned hereafter. Simulation is still rarely used by management researchers, particularly those who study business and other systems as social rather than technical or mechanical entities (Berends and Romme, 1999).
Complexity theory research has allowed for new insights into many phenomena and for the development of new manners of discussing issues, regarding management and organizations (M. Lissack, 1999). Henry J. Coleman, Jr. (1999) pointed out that Complexity theory views organizations as “complex adaptive systems” that co-evolve with the environment through the self-organizing behaviour of agents navigating “fitness landscapes” (Kauffman, 1995) of market opportunities and competitive dynamics. Changing external and internal “attractors” influence the process of adaptation by agents (Kauffman, 1995; Morgan, 1996; Stacey, 1996).

The thematic objectives of this article are: to provide a forum to critically discuss Simulation as a research method in Business and Management; to look into Complexity Theory, its concepts and approaches and how can it be used as a Base Theory to empirically examine the complex business process of Carbon Footprint; and to discuss how simple models and their simple rules can still achieve complex results.

1. **TOOLS AND METHODOLOGY FOR BUSINESS AND MANAGEMENT RESEARCH**

Researchers need to assess, verify and decide what tools and methodologies are appropriate for one’s own research. The conclusions and the end results of the research very much depend upon this assessment and the decision. It is critically discussed herein, research method, base theory concepts and tools used by the researchers in Business and Management.
1.1 Simulation as a Research Method in Business and Management

Simulation is used as a research method by various disciplines as diverse as for example, Anthropology to simulate archaeological data to explain the growth or decline of civilizations; Biology to model bacterial behaviour and interaction; Cognitive Science to develop models on emotion, cognition and social behaviour; Economics to model people’s economic behaviour and so on (Macal and North, 2005). However, Simulation is used rarely in Management research. “The main reasons for the low status of simulation research in management studies are: the emphasis on academic specialization rather than craftsmanship, the complicated systems rather than complex systems viewpoint, and the paradigm of the empirical sciences rather than design sciences which prevails in management studies” (P. Berends and G. Romme, 1999).

Among the different approaches of Simulation i.e., Discrete Event Simulation, System Dynamics Simulation and Agent Based Simulation (ABS), ABS is associated with the assumption that the systems are built bottom-up as against top-down approach of Systems Dynamics. This is the reason why ABS is selected as the approach of Simulation for the modelling and simulation for the purposes of this article.

1.2 Agent Based Simulation

Agent-based Modeling and Simulation (ABMS) is a new modeling paradigm and is one of the most exciting practical developments in modeling since the invention of relational databases (North and Macal, in press). The independent systems of today’s world, their inherent complexity and a large number of growing interdependencies among them make our world hugely complex, for example, the effects of globalization and deregulation on the business and industry. Some systems are too
complex to be modelled let alone to be understood not because the rules are complex and in fact in most cases, simple rules result into complex behaviour of these systems, e.g., the effect of the notion of perfect markets becoming obsolete on economic systems. Therefore, ABS is the right tool to replace the inadequate and inappropriate modelling tools in today’s more complex systems and research.

1.3 Complexity – Theory, Concepts and Approaches

Complexity theory has captured the attention of the scientific community to the extent where its proponents tout it as a dominant scientific trend. Geographers and environmental, human and regional planners have applied the theory to topics ranging from cultural transmissions and economic growth to the braiding of rivers. It is necessary to move beyond all this, critically examine the nature of complexity research in management studies. The value of complexity exists in the eye of its beholder. For some, it is merely a passing fad, for others an interesting complement so accepted conceptual frameworks. Identical findings or phenomena can lead to radically different interpretations. How far can we extend the epistemological corollaries of algorithmic complexity? Does deterministic complexity allow or prevent prediction and control of complex systems? Does aggregate complexity support the role of individuality and creativity or does it point to biological determinism in human affairs?

2. EMPIRICALLY EXAMINING COMPLEXITY IN BUSINESS PROCESS

For our proposed research of how the Information Systems can help the Business account for and control carbon emissions, the need arose for the selection of an appropriate base theory and a research method to empirically test the theory, resulting
in the combination of the Complexity theory and Simulation. An attempt is made hereunder, through the following diagram, to summarise our proposed research area and the proposed research methodology.

**Figure 1 – Proposed Research Approach – Research Area, Base Theory and the Research Method**

The diagram herein depicts the Accounting Research and the Information Systems and Business Process Research as the two pillars over the foundation of the Accounting Standards and Practices. In addition, the Complexity Theory as the base theory and Agent Based Model and Simulation as a method to test the theory empirically help complete the foundation for the research area. The top end objective is shown as the roof of the diagram, i.e., how the Accounting Information Systems, being the Complex Adaptive Systems as they are, can help in the Carbon Emissions accounting and control.
2.1 Carbon Footprint as a Business Process

Our attempt is to introduce the process in brief in order to help visualise building the right Agent Based Model for this business process. Carbon Footprint is defined as under: Carbon Trust (2007):

"… a methodology to estimate the total emission of greenhouse gases (GHG) in carbon equivalents from a product across its life cycle from the production of raw material used in its manufacture, to disposal of the finished product (excluding in-use emissions).

"… a technique for identifying and measuring the individual greenhouse gas emissions from each activity within a supply chain process step and the framework for attributing these to each output product (we [The Carbon Trust] will refer to this as the product’s ‘carbon footprint’)."

The task of calculating carbon footprints can be approached methodologically from two different directions: bottom-up, based on Process Analysis (PA) or top-down, based on Environmental Input-Output (EIO) analysis. Herein an attempt is made to use the first mentioned approach of the Process Analysis. To date carbon footprints have been established for countries and sub-national regions (SEI and WWF 2007), institutions such as schools (GAP et al. 2006), products (Carbon Trust 2006), businesses and investment funds (Trucost 2006).

2.2 Using Complexity as the Base Theory

Management researchers’ work offers both the theoretical dimensions and empirical knowledge necessary to conduct complexity research. Key issues surrounding complexity include: i) the need to understand better the different kinds of complexity theory; ii) provision of data and techniques amenable to complexity research; iii)
proper interpretation of complexity theory, especially with regard to human systems; iv) exploration of the ontological and epistemological corollaries of complexity.

Although there are different complexity theory interpretations, a number of common concepts are observable. These include the concepts we are using in this study: sensitivity to initial conditions, the presence of disequilibrium and feedback processes, all of which interact to produce novel forms of order. These concepts form the theoretical basis for our study. We have highlighted the fact that complexity theory is relatively untested in social systems. Parkhe (1993) argues that the development of theory should follow a research route which begins with exploratory research.

2.3 Complexity and Simulation do complement each other

Following Axtell & Epstein (1994 p.28) the problem of coping with complexity via Agent Based Modelling or Simulation is that the experiments would be of little interest “if we cannot understand these artificial complex systems any better than we understand the real ones.” Therefore, to understand and for others to understand our work, simple but robust guidelines have to be followed.

2.4 Validation of Agent Based Models and Simulation

As Axelrod (1997a, p. 211) notes, attention to the quality of a simulation model is important throughout the research enterprise. Debugging a program is always a difficult task and we can never be sure of producing completely error free code. Nevertheless, we can look for some "alarm" signals that can alert us to the presence of bugs. The credibility of the model is enhanced through proper validation of the model. Within the Multi-Agent Simulation (MAS) community (Axel, 2000) it is also widely recognized that one weakness of MAS is the impossibility of establishing a
mathematical proof of the obtained results. However, the use of several techniques and methods may enhance the credibility of MAS.

CONCLUSION

The idea of using of the Complexity Theory in the research of Complex Adaptive System of Carbon Footprint business process is not only exciting but it also provides an opportunity to complement the benefits of Simulation with that of Complexity Theory. Management Researchers are therefore encouraged to learn the appropriate computer skills in order to be able to use the Computer Simulation in order to achieve the desired results. On the other hand, if this is really an issue on the side of resources, the Management Researchers no doubt have several other methods to adopt, a prominent example being Action Research even for the likes of the proposed research referred to in this article.
REFERENCES


