VIRTUAL MARKETS: THE APPLICATION OF AGENT-BASED MODELING TO MARKETING SCIENCE

by

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Certification of Authorship and Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree except as fully acknowledged within the text. I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Roger A. Parker, UTS ID # [redacted] 26 September 2010

Dedication

To Anita. Without her love and encouragement, this dissertation would not exist. And, quite literally, neither would I.

Abstract

Advances in any science ultimately depend on the creation of instruments that can create observations from which theories can be hypothesized and tested. This dissertation proposes that significant advances in marketing science can be realized with the engagement of the advanced computational science technique of agent-based modeling. To support this proposition, the methodology is examined from first principles to concrete implementation. The ontological and epistemological bases for agent-based modeling are developed, and the evolutionary science paradigm as it applies to marketing (for which the method is most useful), is reinforced with extensive analysis of evolved universal human behaviors, especially behavior relevant to marketing. The concept of the narrative framework is then posited. The primary property of the framework is the central role of choice as an expression of value and resource allocation. This framework then explicates the notion of virtual market, and a appropriate definition of agent derived. The computing requirements and skills needed to actually building a virtual market are also proscribed. Then a detailed, operational example of a virtual market is laid out. Called AirVM, it portrays the dynamics of the market for passenger air travel by simulating the product definition and ticket purchasing process for every passenger travelling on every regularly scheduled commercial flight in the world over a week time period – over 40,000,000 passengers flying on thousands of flights, offered by hundreds of carriers. The synthetic populations of passengers (customers) and airlines (sellers) have empirically-derived distributions of salient properties, called incidence distributions, which are described in detail with empirical data to support their formulation and parameter estimation. The computing logic and samples of the interface are presented, and the system critiqued using appropriate agent-based modeling criteria. The major contributions of the research are the verification of the ontological suitability of agent-based modeling to marketing science, the empirical confirmation of the evolutionary basis for marketing behavior, the conceptual structure for construction of agent-based models in market research, and the proscription of how to construct a virtual market, illustrated with a detailed example. There are also several contributions to the airline passenger industry that emerge from the work. Finally, the dissertation contributes another example of the application of the technique to the burgeoning literature on agent-based modeling.

Acknowledgements

Of central importance in the conduct of this research are my supervisors from the UTS Faculty of Business. Paul Wang has had to suffer with the seemingly interminable delays as I worked at a full time job and meandered down myriad pathways leading to this final work. He is to be commended for his patience. Siggi Gudergan, who came late this particular party, has shown interest in the work since the beginning, and I am very pleased that he was able to formally participate. Louise Young, who has now moved on from UTS, was of invaluable assistance early on in the development of the concepts that are developed here. The other individual at UTS who deserves special recognition is Jordan Louviere, who first introduced me to Discrete Choice Modeling and had a foundational impact on the results of this effort.

The work reported in this thesis is, in part, the result of a research project into passenger behavior that I was responsible for while I was engaged as the Senior Marketing Scientist for the Marketing Department of Boeing Commercial Airplanes in 2002. I was privileged to assemble a research team of top class individual from around the world to work on better understanding why passengers bought airplane tickets. Many advances were made in our understanding of airline passenger behavior that are now being adopted by the broader airline community, and many of the contributions generated by that team contribute to and are discussed in this work. Cheri Jones, my manager at the outset at Boeing, had the foresight and courage to let me assemble and support the team. Richard Lonsdale (who taught me about airlines), Fred Ervin and Zhengjie (John) Zhang (who were programming masters) were my close Boeing colleagues during the entire adventure of the next six years.

Among those prominent in the effort were Jordan Louviere, who taught me choice theory, Richard Carson, then Chair of the Department of Economics at University of California San Diego, and Joel Watson, also at UCSD, who tutored me in economics and worked with me on the passenger OD demand model, and David Bunch, at University of California, Ervine, who estimated the first passenger itinerary choice model. From the University of Warsaw, Poland, the team from their Institute of Computational Mathematics led by Marek Niezgodka and with the help of Wojciech Wislicki, Jan Radomski, Kristoff Nowinski, and Andzrej Slodownik worked to developed advanced concepts of airline network analysis. DeAnn Julius, then on the

Monetary Advisory Board of the Bank of England and now the Chairwoman of the Royal Institute of Foreign Affairs in London, helped me understand the problems and difficulties of the modern airline industry, and how technology could be brought to bear on those problems. Moshe Ben-Akiva from MIT and his student Joan Walker, now at the University of California at Berkeley, contributed to the mixed logit model that is now the pag choice model described here. Frank Koppelmann, from Northwestern, and Laurie Garrow at Georgia Tech, and her student Dan Illiescu, worked with me on many aspects of the application of discrete choice modeling to the airline industry. Dan, in particular, developed his PhD dissertation on the ticket cancellation model discussed here based on my recommendations regarding approach and data.

Finally, I owe my two friends and business associates, Nick Lanyon in London and David Perroud of M1nd-Set SA in Geneva, a continuing debt of gratitude for the forbearance and encouragement during the process of writing the thesis itself over the last two years. They have contributed much in wisdom and experience, even though they would not admit it.

A final comment on the personal point of reference from which this analysis is created. I maintain, as explained in the body of the work, that all analyses are conditional on a reference narrative which sets the framework for the motivation, method and logic of the work. Most doctoral theses are scholarly examinations of topic of interest to their creator, often crafted as launching pads for their careers in the field of their choice. And they serve that purpose admirably, establishing the worth of the individual in the context of his or her reference narrative and that of others who share similar narratives. This is not exactly the case for me. Rather, this effort is a milepost in what has already been a rather long journey. As I write this I am in my mid-sixties, and have been working with computers and mathematical models of social phenomena for over four decades. I have been engaged in the development of models of such disparate subjects as consumer movement patterns in shopping districts, recreational area utilization, racial desegregation of public schools, vehicle reliability inspection programs, and (obviously) global air passenger demand. I have developed and implemented literally hundreds of consumer survey research designs and analyses. This long experience colors the approach and reasoning supporting this work, and it is my hope the reader finds that those hues enhance its value beyond simple research and reporting of results.

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