Chapter 20
Modelling of Consumer Goods Markets:
An Agent-Based Computational Approach

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ABSTRACT

An agent-based behavioral model incorporating utility-based rational choice enhanced with psychological drivers is presented to study a typical consumer market. The psychological drivers incorporate purchase strategies of loyalty and change-of-pace, using agent-specific memory of past purchases. Attribute-specific preferences and prices drive the utility-based choice function. Transactions data is used to calibrate and test the model. Results indicate that prediction accuracy at both macro and micro levels can be significantly improved with the incorporation of purchase strategies. Moreover, increased agent memory does not improve predictions in the model beyond a threshold, indicating that consumer memory of past shopping instances is finite and recent purchase history is more relevant to current decision making than the distant past. The chapter illustrates the use of agent-based simulations to model changes or interventions in the market, such as new product introductions, for which no history exists.

INTRODUCTION

Consumer behavior as a field of study is highly interdisciplinary in its approach, and that is evident in the amount of literature on this topic in multiple fields of study – whether in economics, psychology, sociology, computer science or even applied mathematics. Correspondingly, the traditional methods of analysis used by researchers in this field are numerous, and they range from quantitative (statistical and regression based) to qualitative (surveys, interviews, ethnographic studies etc.). However, over the last few years, new studies are being increasingly seen in the literature, which use modern computational techniques based on computer simulations, data mining, big data analysis etc., which mirror the changes and technological progress in societies and markets the world over.

This chapter introduces one such method – agent based simulations, and links real world empirical data with models of behavior from multiple disciplines. Additionally, the chapter also provides an example of how such models can be used to "explore the future," with their ability to incorporate "what-if" scenario building techniques. This chapter is based on Sengupta and Glavin (2013) and Sengupta and Glavin (2010), and introduces the models and methods used in both, and extends them by illustrating how radical changes in the market (such as new product introductions) can be modeled robustly using computational methods.

Markets often exhibit noisy dynamics in the form of volatile movements in market shares (Jager, 2007). Frequent competitive interventions by manufacturers, such as introduction of new products, aggressive marketing policies such as multiple pricing and promotion strategies – is definitely one reason behind this widespread phenomenon (Ailawadi et. al., 2001; Blattenberg & Wisniewski, 1989). However, the presence of a wide variation in tastes and preferences amongst a reasonably large and demographically varied consumer population is also a key factor leading to the noisy character (Allenby & Rossi, 1998; Sengupta & Glavin, 2010; Sengupta & Glavin, 2012). Such markets do not lend themselves easily to traditional statistical and econometric analysis. Nor do markets where major interventions or events have occurred in the immediate past, which have moved these markets "out of equilibrium" (Reid & Brentani, 2004; Mathews, 2006), such as new product introductions, innovations etc. Additionally, the presence of potential non-linear interactions such as social networks, word-of-mouth influences etc. means that they may also exhibit a "complex" character – hence making traditional techniques further redundant. Not surprisingly, markets in general and consumer packaged goods (CPG) markets in particular, are increasingly being brought under the purview of "complex systems" analysis – whereby more modern "bottom up" methodologies such as agent based modelling are being used for analysis, inference and predictions (Gilbert et. al., 2007).

Systems which exhibit "emergent behavior" of some kind cannot be fully examined and analyzed by traditional "top-down" methodologies. Simulation based techniques – relying on agent based constructs – where constituents of the system (in this case, shoppers, firms etc.) are treated as individual modelling units (or agents) with the ability to follow independent rules of behavior and engagement have become increasingly popular and are widely advocated (Epstein & Axtell, 1996; Gilbert & Troitzsch, 2005; Tesfatsion, 2006). CPG markets have been extensively studied in the mainstream literature, but in spite of exhibiting many characteristics of a complex system, have only recently been brought within the purview of complex systems analysis (North et. al., 2009; Sengupta & Glavin, 2010; Rand & Rust, 2011). This paper builds a behavioral model of consumer choice, which is then incorporated within a multi-agent simulation framework to illustrate the accuracy and usefulness of such an approach in predicting market phenomena. It builds on earlier simpler models by the same authors, by incorporating crucial psychological factors into the choice model, modifying and extending the validation methodology and finally showing that both market and individual level predictions can be significantly improved by using enhanced choice models.

BACKGROUND

Our earlier work, specifically Sengupta and Glavin (2010) focused on developing a theoretical model of behavior, which took into account the heterogeneity in tastes within the consumer population and illustrated the link between this heterogeneity and the resultant volatility in overall market shares of brands and specific product characteristics. In order to carry out this analysis, the authors developed a rigorous methodology which focused on *out*

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