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Marketing Intelligent Systems for consumer behaviour modelling by a descriptive induction approach based on Genetic Fuzzy Systems

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ABSTRACT

In its introduction this paper discusses why marketing professionals do not make satisfactory use of the marketing models posed by academics in their studies. The main body of this research is characterised by the proposal of a brand new and complete methodology for knowledge discovery in databases (KDD), to be applied in marketing causal modelling and with utilities to be used as a marketing management decision support tool. Such methodology is based on Genetic Fuzzy Systems, a specific hybridization of artificial intelligence methods, highly suited to the research problem we face. The use of KDD methodologies based on intelligent systems like this can be considered as an avant-garde evolution, exponent nowadays of the so-called knowledge-based Marketing Management Support Systems; we name them as Marketing Intelligent Systems. The most important questions to the KDD process–i.e. pre-processing; machine learning and post-processing–are discussed in depth and solved. After its theoretical presentation, we empirically experiment with it, using a consumer behaviour model of reference. In this part of the paper, we try to offer an overall perspective of how it works. The valuation of its performance and utility is very positive.

1. Introduction

Firms operate in markets that are increasingly "turbulent" and "volatile." How to deal with this turbulence and survive in these hypercompetitive conditions has become a strategic question (Agarwal, Shankar, & Tiwari, 2007; Christopher, 2000). Consequently, the idea of the achievement and support of a sustainable competitive advantage gave rise, in the nineties, to another focused on its continuous development (D'Aveni, 1994), which is more realistic these days. One of the main implications of this reformed strategic approach is a search for new suitable market opportunities. Of course, such opportunities need to be correctly identified and addressed by firms. This premise justifies the transcendental relevance recently given to the creation and management of knowledge about markets (Drejer, 2004). In this vein, the marketing function of companies and, most especially, their Marketing Management Support Systems (MkMSS) plays a notable role in this task, as they must contribute to the reduction of the uncertainty related to the firms' markets of reference. As we know, this question does not only imply having access to good marketing databases. On the contrary, the key question is having the necessary level of knowledge to take the right decisions (Campbell, 2003; Lin, Su, & Chien, 2006). The analytical capabilities of MkMSS are more critical than ever to provide this support to marketing managers' decision making, in order to give useful and valuable information about market behaviour. Specifically, we highlight the following: models and methods of analysis.

It is expected that MkMSS will improve their performance in the near future, taking advantage of the synergies caused by the integration of modelling estimation techniques based on classic econometrics with new methods and systems based on artificial intelligence (Gatignon, 2000; Van Bruggen & Wierenga, 2000). The adoption of these new methods represents a worthwhile opportunity to improve the efficiency of the marketing managers' decision making and consequently, if well applied, the accuracy of marketing strategies (Li, Kinman, Duan, & Edwards, 2000).

The paper we present here focuses on the exploration and analysis of the suitability of certain brand new methods based on knowledge discovery in databases (KDD) to be applied in marketing modelling. Specifically, our main aim is twofold: first, we aim to make a modest contribution to the methods used in consumer behaviour modelling. In any case, this is the marketing field we have focused on to develop and experiment our methodology, though it also applies to marketing causal modelling, in general, as well as to other Science and Social Sciences fields that work with similar causal models.

We propose a complete knowledge discovery methodology, whose main questions are shown in this paper, to extract useful patterns of information with a descriptive rule induction approach based on Genetic Fuzzy Systems; this is a novel hybridization of methods belonging to the field of artificial intelligence, highly appropriate for the marketing problem we face. With this purpose, we have had to

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give solutions, adapted from our academic field, to the diverse questions related to the main stages of the KDD process; i.e. data preparation, data mining, and knowledge interpretation. Moreover, an important characteristic of our methodology is that it has been designed under the base there is a causal model of reference; a consumer behaviour model in our case. In other words, the knowledge discovery process is guided by a prior theoretic structure that defines the elements (variables) of the model. Hence, this machine learning approach is not only interesting for practitioners, but also for academic researchers' purposes.

To address these questions, the paper is structured as follows. Section 2 reflects on the suitability of evolving our marketing modelling methods towards a growing importation and use of artificial intelligence methods to support professional and academic marketing problems. Section 3 presents an overview and justification of the artificial intelligence tools employed (fuzzy rules, genetic algorithms, etc.). Section 4 illustrates with some examples the behaviour of the proposed KDD tools. Section 5 shows the methodological proposal in detail. Next, in Section 6 we experiment with the methodology, show some significant results and dedicate a brief closing part to illustrate both the intrinsic and complementary advantages of our fuzzy modelling-based method. Section 7 discusses the main contributions of our research, reflecting on the academic and managerial implications. Finally, in Section 8 we comment on some research limitations and opportunities (our future research agenda).

2. Background and starting reflections

Is there a gap between what marketing modellers offer and what marketing managers demand? If marketing modelling had got to a stage of maturity, as Leeflang and Wittink (2000) argue, one would expect to find a significant use of academic models among marketing practitioners. Notwithstanding, it seems that marketing managers rarely apply them (Roberts, 2000; Wind and Lilien, 1993; Winer, 2000). It is essential that we academics meditate on this. Maybe, the answer is much less complex than we would primarily expect.

We think that the efforts of marketing academics are not productive in terms of the managerial applications of their models. This is not due to deficiencies in the theoretic aspects that support the models' structure, but due to a lack of involvement by not offering useful methods of analysis that allow the models' users (marketing managers) to "play" with these models to support their decisions. This is what has guided our research, hence the gist of this paper.

The academics may be too focused on testing hypotheses and validating models and theories without paying enough attention to what our "customers"–the marketing managers, users of our scientific production–need. Indeed, marketing modellers cannot afford to fall into marketing myopia! In this regard, we should not forget that the main purpose of our research efforts ought to be the contribution to the development of our field, and this necessarily implies looking after the practical applicability of our models, too.

Therefore, how can we strengthen the utility of our models to achieve a better explanation of markets, thus better matching them to marketing managers' needs? Research efforts can be addressed to the improvement of three main areas of interest in marketing modelling (Roberts, 2000): theoretic aspects defining the models; understanding of managers' (users) needs, hence the framework of application of models; and refinement of the statistical tools (i.e. techniques and methods in general) applied to estimate the models. The pursuit of these improvement guidelines is not too distant from what Little (1970, p. B-483) asked of researchers a few decades ago when building models to support marketing managers' decision making:

> Although the results of using a model may sometimes be personal to the manager […] the researcher still has the responsibilities of a scientist in that he should offer the manager the best information he can for making the model conform to reality in structure, parameterization, and behaviour.

Consequently, it seems clear that modellers should be driven by the requirements of models users (i.e. demand-side), instead of by a supply-side orientation (Gatignon, 2000). This practice is expected to improve the use of the academic models among the practitioners (Roberts, 2000). In this sense, a firm focused on consumption markets with access not only to more representative models of real systems being modelled but also to more powerful methods of analysis to extract knowledge from huge databases and able to simulate with models ought to improve its competitiveness and competitive advantage (Van Bruggen & Wierenga, 2000). This is a premise that has significantly conditioned the evolution of MkMSS from the early 80s, specifically with the appearance of the Marketing Decision Support Systems, until now (Li et al., 2000; Talvinen, 1995; Wierenga & Van Bruggen, 1997, 2000).

The late 80s saw the increasing use of diverse methods from Computer Science and Artificial Intelligence to the detriment of those from the Operational Research and, especially, the econometrics and statistics fields. This tendency has increasingly intensified in the last two decades (Bucklin, Lehmann, & Little, 1998; Eliashberg & Lilien, 1993; Leeflang & Wittink, 2000; Leeflang, Wittink, Wedel, & Naert, 2000; Li, Davies, Edwards, Kinman, & Duan, 2002).

This evolution in the methods used in marketing modelling has not been accidental. In this sense, Lilien, Kotler, and Moorthy (1992) noted that this tendency was to be expected as modellers and users needed techniques that were more flexible, powerful and robust, capable of providing greater and improved information with respect to the real systems being modelled. Of course, this implies a greater adaptation to both the characteristics of current databases–i.e. huge, imprecise, with data gathered in formats of a different nature (numerical, categorical, linguistic, etc.)–and the type of decision problems to be supported by such models. Under these circumstances, it seems an evolution of the marketing modelling methods towards systems based on artificial intelligence is only logical (Shim et al., 2002; Wedel, Kamakura, & Böckenholt, 2000), which justifies the growing predominance of the knowledge-based MkMSS in the last two decades (Wierenga & Van Bruggen, 2000).

In sum, MkMSS clearly tend to be based on knowledge discovery methods that make use of diverse artificial intelligence methods to be applied during the machine learning process; e.g.: evolutionary algorithms, fuzzy logic, artificial neural networks, rules induction, decision trees, etc. Specifically, it is expected that the use of artificial intelligent methods in the MkMSS framework will evolve towards the use of intelligent systems based on the hybridization of these techniques (Carlsson & Turban, 2002; Shim et al., 2002). We like to call them as Marketing Intelligent Systems. It might be the inexorable fate of marketing modelling methods. This fact, which is more evident from a professional perspective–i.e. under the framework of application of the MkMSS–, has still to take hold in academic studies.

3. Knowledge extraction based on fuzzy rules and genetic algorithms

3.1. The KDD process

In general terms, KDD is a recent research field belonging to artificial intelligence whose main aim is the identification of new, potentially useful, and understandable patterns in data (Fayyad, Piatesky-Shapiro, Smyth, & Uthurusamy, 1996). Furthermore, KDD implies the development of a process compounded by several stages that allow the conversion of low-level data into high-level knowledge (Mitra, 2002). Though KDD is synthetically viewed as a three-stage process–i.e. pre-processing, data mining and post-processing–(Freitas, 2002), we believe that, for our academic field, it is more interesting to present it within a wider structure. Specifically, we prefer the following five-stage process