DIMITRA[1]: AN INTELLIGENT DECISION SUPPORT SYSTEM FOR AGRICULTURAL PRODUCTS DEVELOPMENT DECISIONS

N. F. MATSATSINIS, Y. SISKOS

Technical University of Crete, Decision Support Systems Laboratory
University Campus, 73100, Chania, Crete, Greece
Email: nikos@dias.ergasya.tuc.gr

ABSTRACT

The paper presents an intelligent decision support system named DIMITRA for agricultural products development decisions. The system acts as a consultant for marketers providing visual support to enhance understanding and overcome their lack of expertise. The databases of the system result from consumers surveys. The system's model base encompasses statistical analysis, preference analysis, and consumer choice models. DIMITRA incorporates the following knowledge bases, in order to support marketing decision makers in the various stages of the product development process: selection of data analysis method, selection of market formula simulation, and evaluation of the financial status of enterprises. The system allows the decision makers to identify and examine the existing and potential market shares, formulate the appropriate communication and penetration strategies based on consumer attitudes and beliefs, adjust production according to the product's demand and, determine the most promising markets for the agricultural co-operatives and the agribusiness firms.

INTRODUCTION

Agricultural marketing differs from common marketing strategies with respect to product's attributes and natural characteristics, price determination, promotion, advertising and finally, distribution (transport-storage) procedures. Only in the last decade, research methodologies that were developed and utilized in behavioral sciences, economics, statistics and computer-related areas, have started having an impact on agricultural marketing.

The development of new products has a high cost, but even higher is the cost of the consequences of a possible failure. The importance of successful development of new products for the viability of enterprises has been pointed out by many experts in this field (Nylen, 1990; Urban and Hauser, 1993; Kotler, 1994). Earlier systems for decision support in marketing were developed by Little (1979, 1990), Van Bruggen (1992) and others. Their aim was to increase the effectiveness of managers, with the support of suitable scientific tools during the different phases of the decision making process (Simon, 1960; Sprague and Carlson, 1982). Another approach in the development of decision support systems in marketing has emerged with the adoption of Artificial Intelligence techniques. Artificial Intelligence techniques used for DSS development vary depending on the nature and the specific characteristics of each project (application field). The beginning of the application of artificial intelligence techniques in marketing can be traced back to the middle '80s. Those early systems combined quality and quantitative data manipulation, by use of several marketing models. Intelligent Decision Support Systems in marketing (IMkDSS's) soon became very powerful tools for marketing managers and up to now several intelligent systems have been developed (Wierenga and Van Bruggen, 2000; Matsatsinis and Siskos, 2001). The rapid evolution of Artificial Intelligence techniques along with the various approaches used in their integration in IMkDSS development created several sub-categories of those systems that can be classified in the following categories (Matsatsinis and Siskos, 2001): Intelligent Multicriteria Decision Support

[1] This research has been carried out with financial support from the Commission of the European Communities, Agricultural and Fisheries (FAIR) specific RTD programme, CT–095-0844.

Systems, Rouhg Set DSS, Case-based DSS, Knowledge based systems or Expert Systems, hybrid intelligent decision support systems, agent-based, artificial neural nets and neuro-fuzzy. All these approaches use different information technology techniques (Intelligent Decision Support Systems, Management Expert Systems, etc.) to implement their methodologies.
The simulation of the strategy of product penetration is a complex distributed decision-making task, involving several actors belonging to different levels of responsibility and having complementary functionalities within an organization. Several methodologies have been proposed in Marketing Decision-Making literature, presenting different approaches in order to support product development process (Kotler, 1994; Liberatore and Stylianou, 1995; Van Bruggen, 1992; Wierenga, 1992). In this framework, an original consumer-based methodology for agricultural products development is proposed by (Matsatsinis and Siskos, 1999).

CONSUMER-BASED METHODOLOGY FOR PRODUCTS' DEVELOPMENT

To support the product development process an original consumer-based methodology is proposed (Fig. 1). It is based on the use of different models for data analysis, multicriteria analysis and brand choice.
During the market survey, every consumer expresses his evaluations of a set of reference products involved in the survey, on the base of a group of criteria. Finally, he is requested to rank the products according to the order of preference. The collection of this kind of data requires the design and use of a specific questionnaire (Matsatsinis and Siskos, 1999).
The initial phase of this methodology aims to acquire a general picture of the particular survey. This is followed by the use of data analysis models in order to determine consumer and market features. This task is called "Market Segmentation". Market trends are identified through this approach. Concurrently, the multicriteria method UTASTAR (Jacquet-Lagrèze and Siskos, 1982; Siskos and Yannacopoulos, 1985) is applied to the multicriteria consumer preferences, in order to determine the criteria explaining each of the consumer's choices. This method assesses a utility function $u(\underline{g})$, which is as consistent as possible with the consumer ranking, where $\underline{g} = (g_1, g_2, ..., g_n)$ is the vector of the criteria on which the products are evaluated. The consumer's utility function is assumed to be additive: $u(\underline{g}) = p_1u_1(g_1)+p_2u_2(g_2)+...+p_nu_n(g_n)$, *where* $u_i(g_i)$ is the assessed marginal utility of the criterion g_i, normalized between 0 and 1, and p_i is a weighting factor of the *i-th* criterion, the sum of weights being equal to one: $\sum_{i=1}^{n} p_i = 1$.
The UTASTAR method assesses for each consumer separately his utility function, which is as consistent as possible with his rank order of the products used; the relative importance of the criteria is then derived from this utility model. This preference disaggregation analysis is called "Criteria Analysis". The use of models of consumer personal choice allows the market simulation and the calculation of the market shares of the competitive products taking part in the survey. This aims at the selection of the most suitable model approach, as close as possible to the real market shares ("Brand Choice Task"). The next step concerns the design of the new product by simulating its introduction into the market using the multicriteria evaluations. It is followed by the application of alternative scenarios. With the help of the selected brand choice model, the market simulation and the calculation of the new market shares to be expected, after the introduction of the new project, are performed. This process involves "Scenario Generation and Complex Scenario Generation". Based on the results of the scenarios' application, the choice of the most appropriate penetration strategy for the new product is accomplished. This is the main task and is called "Penetration strategy selection".
The methodology is realized through the development of an intelligent decision support system. Into the various stages of the proposed methodologies several forecasting, data analysis, multicriteria analysis, and brand choice models are used. In addition to these analytical models,

three partial expert systems have been integrated into the DSS, which by their intervention into the various stages of the process, aid the decision maker to:

- Choose the most appropriate data analysis method.
- Choose a suitable brand choice model
- Assess the financial situation of the companies, whose products are considered in the market surveys.

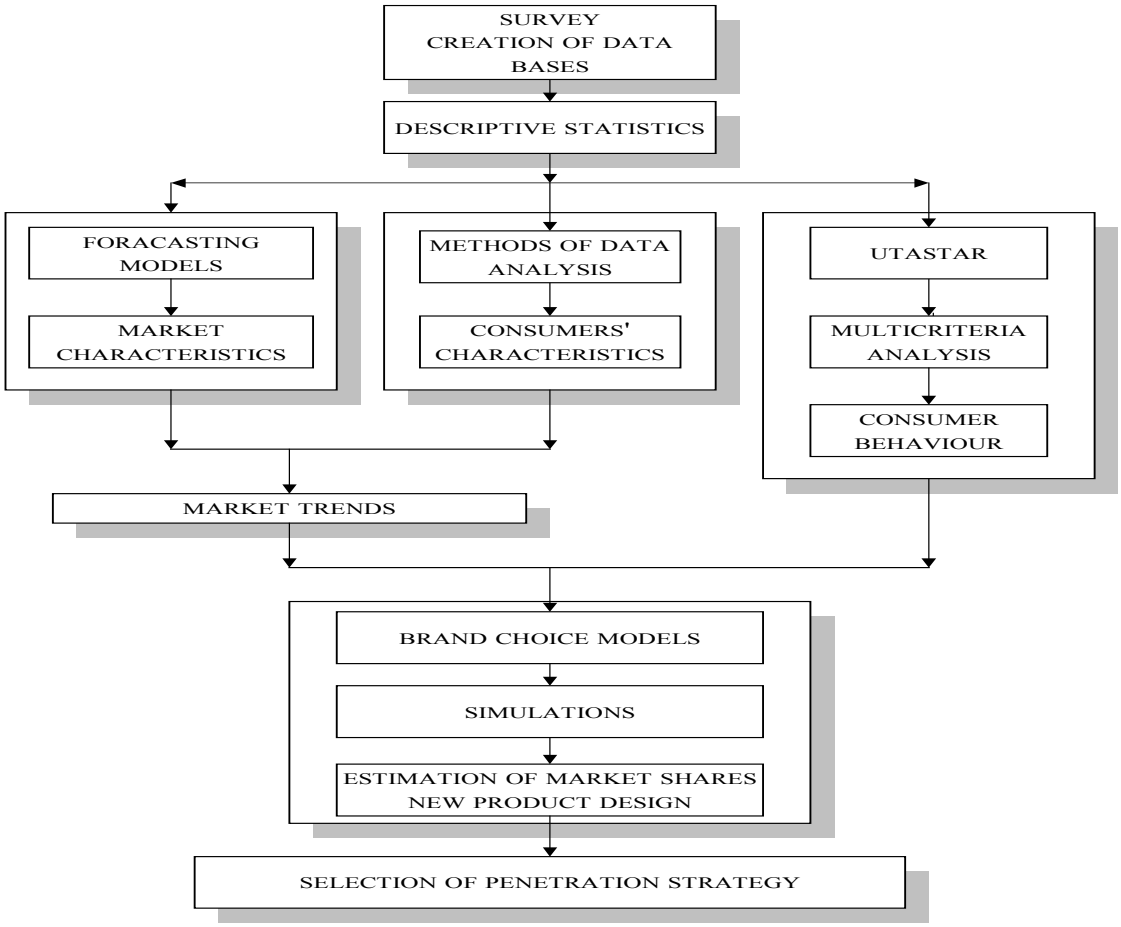


FIGURE 1. Methodological flowchart (Matsatsinis and Siskos, 1999)

CONSUMER'S BEHAVIOUR ANALYSIS

Consumer behaviour analysis is accomplished utilizing multicriteria preference analysis for each consumer separately in combination with data analysis methods and techniques concerning consumer profiles in general. Through this analysis the user is informed about the determinant criteria of market behavior and market segmentation by criterion or by a combination of criteria. As stated earlier, the consumer selection policy can be expressed by means of a set of reference products which the consumer, either has or can rank through simple questionnaires, familiar decision making situations, and so on. The UTASTAR model is applied on the consumer data preference set.

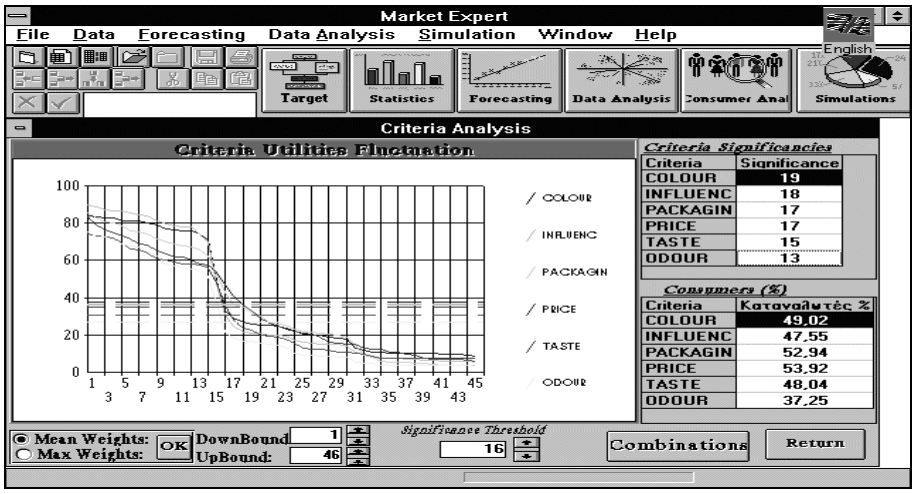


FIGURE 2. Criteria analysis

Preference disaggregation analysis using the UTASTAR model allows the study of the criteria that appear to determine each consumer preferences; a criterion is considered to be determinant when its estimated mean weight overcomes a threshold of about 16%**.** Figure 2 shows the graphical presentation of the fluctuation of the criteria utilities in relation to the percentage of consumers. The main criteria explaining consumer behavior are displayed on the right part of the screen.

SIMULATING THE NEW PRODUCT

One of the tools used for planning, development, and monitoring of products is market simulations. Market simulations are conducted with the help of consumer personal choice models offered by the system. Market simulations can be thought as "what-if" analysis. The decision maker is able to modify the values of the criteria and observe the impact of this change in the market shares. Thus, the decision maker is able to determine the features of the new product that will lead to higher market shares. Figure 3 presents the system's window of simulations together with the window of the expert system suggestions for the selection of the most suitable model of consumer choice.

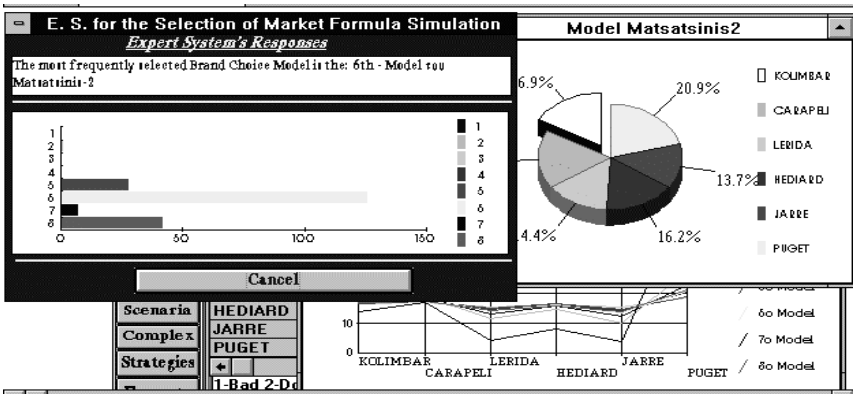


FIGURE 3. Simulations and Market shares estimation

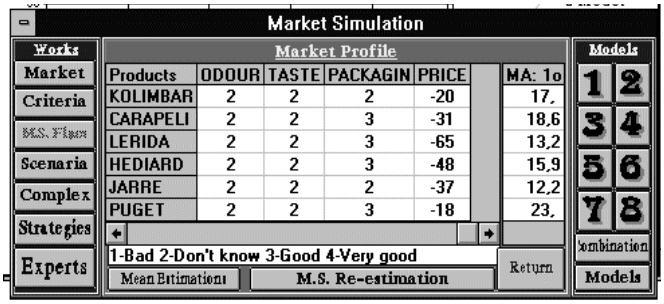
In DIMITRA, the control, choice, and execution of all the simulation tasks is carried out with the help of a simple control window presented in Figure 4.

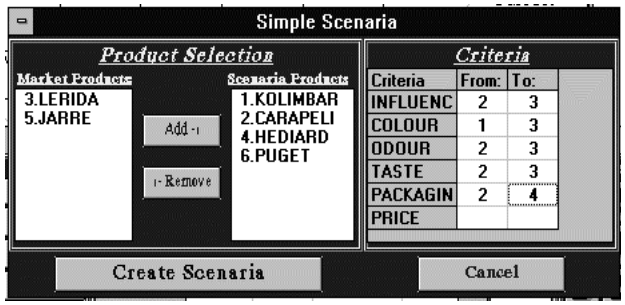
At the center of the window the decision maker sees the multicriteria matrix, which contains the mean values of the consumers' evaluations. The estimated market shares, according to the selected model, are presented to the right of the multicriteria matrix, and at the right end of the window the decision maker can find and select one of the available brand choice models (1-8). By pressing the appropriate command button (MS Re-estimation), the system performs the re-estimation of the market shares, according to the new figures inserted in the multicriteria matrix. With market simulations the system attempts to give an appropriate answer to the decision maker's "what – if"

questions: What market shares shall be obtained if the characteristics of the products are to be changed and take the values found in the multicriteria table ("what-if" analysis).

FIGURE 4. Control window of market simulation tasks FIGURE 5. Formation of simple scenarios.

With simple scenarios (Figure 5 and 6) the decision maker is able to examine the shares of the market's products when the values of the criteria vary between specific bounds, set by the decision-





maker. The order in which the multicriteria evaluations of the criteria vary is determined by which extent each criterion plays determinant role in the consumer's decisions. At the right end of the window the decision maker sees all the available scenarios along with the corresponding combination of the criteria

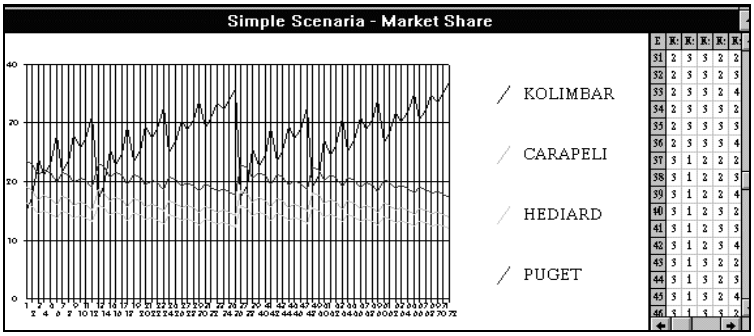


FIGURE 6. Market shares estimated by simple scenarios

Simple scenarios, attempt to aid the decision-maker to trace and select subsequent scenarios that will be examined more exhaustively. One option is to select those scenarios that give almost equal market shares, but their implementation is cost is much more low. He also may fully reject scenarios that give very small market shares or scenarios that give satisfactory shares but are associated with very high implementation cost.

After the completion of the examination of simple scenarios the decision-maker has determined the composition of the "market" and has selected the possible development scenarios of the new product. The process continues with the selection of an independent criterion (the price of the product) and the determination of the bounds in which this criterion will vary. Then the decision maker determines the alternative strategies that wishes to examine when the value of the independent criterion varies between the specified bounds. In the final stage of the application of strategies, the scenarios are introduced and the fluctuations of market shares in relation to the price are examined. At the same time, the decision maker has the opportunity to take into consideration the evaluations of experts on distribution and promotion channels of the enterprises participating in the market survey. A new module, for channels evaluation, has encompassed in the system. DIMITRA is able, with the cooperation of the decision maker, to evaluate the alternatives distribution and promotion channels of the brands under consideration. In order to evaluate the alternative channels the system uses the UTA II (Siskos, 1980), multicriteria method. Finally, the decision maker selects the strategy that the enterprise will adopt for planning, development, and market penetration of the product.

CONCLUSIONS

Effectiveness of DIMITRA can be evaluated through the success of the new products developed by it. Thus, a positive element is the fact that the market behaviour can also be monitored after the introduction of the new product in the market, so that the necessary corrective interventions in the product characteristics can be applied wherever and whenever is necessary.

The next step is the necessity of evaluating the satisfaction of consumers after the purchase and use of the developed product in order to measure the success of the determined strategy. Consequently, the model base of the system should also include qualitative models of consumer satisfaction.

Other factors, which have to be taken into account during the next phases of the development of the system, are the additional consumer brand choice models incorporation in order to support the different stages of the products life cycle. One of the extensions of the system is oriented towards the development of a new expert system, which will select the most appropriate consumer brand choice model by taking into the product life cycle, and the objectives of the decision maker.

REFERENCES

Jacquet-Lagrèze, E. and Siskos, J. (1982) Assessing a set of additive utility functions for multicriteria decision making: The UTA method, *European Journal of Operational Research*, no. 10, pp. 151-164.

Kotler, P. (1994) Marketing management: Analysis, planning, implementation and control, 8th ed., Prentice-Hall, London.

Liberatore, M.J., Stylianou, A.C. (1995) Expert Support Systems for New Product Development Decision Making: A modeling framework and applications, *Management Science,* vol. 41, pp. 1296-1315.

Little, J.D.C. (1979) Decision Support Systems for marketing managers, *Journal of Marketing*, no. 43, pp. 9-26.

Little, J.D.C. (1990) Information technology in marketing, *Working Paper*, Sloan School of Management, MIT.

Matsatsinis, N.F. and Siskos, Y. (1999) MARKEX: An intelligent decision support system for product development decisions, *European Journal of Operational Research*, vol. 113, no. 2, pp. 336-354.

Matsatsinis, N.F., Siskos, Y. (2001) Intelligent Support Systems for Marketing Decisions, Kluwer (forthcoming).

Nylen, D.W. (1990) Marketing decision-making handbook, Prentice-Hall Inc, New Jersey.

Simon, H. (1960) The new science of management decision, Harper and Row, New York.

Siskos, Y. (1980) Comment modéliser les préférences au moyen de fonctions d'utilité additives, *RAIRO Recherche Opérationnelle,* no. 14, pp. 53-82.

Siskos, J. and Yannacopoulos, D. (1985) UTASTAR: An ordinal regression method for building additive value functions, *Investigaçao Operational*, vol. 5, no. 1, pp. 39-53.

Sprague, R.H and Carlson, E.D. (1982) Building effective decision support systems, Prentice-Hall, Englewood Cliffs, N. J.

Urban, G.L. and Hauser, J.R. (1993) Design and marketing of new products (2nd ed.), New Jersey: Prentice Hall.

Van Bruggen, G.H. (1992) Performance effects of a marketing decision support system: A laboratory experiment, in: *Proceedings of the 21st Annual Conference of the European Marketing Academy*, AARHUS.

Wierenga, B. (1992) Knowledge-based systems in marketing: Purpose, Performance, Perceptions and Perspectives, *Working Paper 112*, Rotterdam School of Management, Erasmus University.

Wierenga, B., Van Bruggen, G.H. (2000) Marketing Management Support Systems: Principles, Tools and Implementation, Kluwer Academic Publishing, Boston, MA.