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MARKEX: An intelligent decision support system for product development decisions

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Abstract

A new methodology for the development of new products and an intelligent DSS, named MARKEX, which is an implementation of this methodology, are presented in this paper. The system acts as a consultant for marketers, providing visual support to enhance understanding and to overcome lack of expertise. The databases of the system are the results of consumer surveys, as well as financial information of the enterprises involved in the decision making process. The system's model base encompasses statistical analysis, preference analysis, and consumer choice models. MARKEX incorporates partial knowledge bases to support decision makers in different stages of the product development process.

Keywords: Intelligent decision support systems; Data analysis; Consumer behaviour; Product development

1. Introduction

The importance of successful development of new products for the viability of enterprises has been pointed out by many experts in this field (Booz et al., 1971, 1982; Wind et al., 1990; Nylen, 1990; Urban and Hauser, 1993; Kotler, 1994). The development of new products has a high cost, but even higher are the costs of the consequences of a possible failure (Crawford, 1979; Association of National Advertisers, 1984; Urban and Hauser, 1993).

The present situation of the world market forces the decision makers to become more competitive through better decision making (Kotler, 1994). The need for adequate information (Schewe and Smith, 1980) makes it necessary for enterprises on the one side to create a suitable infrastructure for information collection through market research programmes, and, on the other side, to develop suitable software tools (Cox and Good, 1967). The expected benefits do not concern so much cost reduction and improvement of enterprise effectiveness, but rather improvement of strategies.

Earlier systems for decision support in marketing were developed by Little (1979, 1990), Van Bruggen (1992), Kotler (1994) and others; their aim is 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

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support systems in marketing has emerged with the adoption of Artificial Intelligence techniques. A number of expert systems in marketing has been reported: STATPATH (Portier and Lai, 1983), REX (Pregibon and Gale, 1984; Gale, 1986a), STUDENT (Gale, 1986b), MUSE (Dambroise and Massotte, 1986, 1987), PROMOTER (Abraham and Lodisch, 1987), INNOVATOR (Ram and Ram, 1988), DANEX (Böckenholt et al., 1988, 1989), NEGOTEX (Rangaswamy et al., 1989), ADCAD (Burke et al., 1990), PROMOTION ADVISOR and PROMOTION DETECTIVE (McCann and Gallagher, 1990; McCann et al., 1990), INFER (Rangaswamy et al., 1991), STRATEX (Borch and Hartvigsen, 1991), COMSTRAT (Moutinho et al., 1992), DMAS (Liberatore and Stylianou, 1993, 1995). The enumeration of the existing systems is a difficult job, since it is hardly possible to gather information on already working systems or on systems, which are designed and developed for enterprises. Thus, only systems made known by international bibliography are available for study. An attempt to catalogue these reported expert marketing systems has been attempted by Wierenga (1992) and Matsatsinis (1995).

The study of these systems, from the view point of new product development, showed that most of those developed up to the present are still at the stage of prototype, their knowledge bases are limited and, as a rule, they cover only single phases of the development procedure. Another problem is the fact that the evaluation of correct functioning is usually carried out under laboratory conditions and by the researchers, who themselves designed the systems. Also, most of the earlier developed systems exhibit significant shortcomings in handling qualitative data. These facts brought up the idea to form initially a consumer-based methodology to support the development of new products and subsequently a system to apply this methodology.

A first attempt consisted of the development of a new methodology for market analysis and for the design of new products, proposed by Siskos and Matsatsinis (1993), based on the study of consumer behaviour. This methodology was realised in the form of a decision support system and has already been successfully applied to a series of real market research projects and agricultural product development (Nikolaidis et al., 1993; Siskos and Matsatsinis, 1993; Baourakis et al., 1993a, b, 1995a, 1996; Matsatsinis et al., 1995; Siskos et al., 1995a, b). The mathematical models of this system offer assistance for the handling of quantitative as well as qualitative data.

The conclusions resulting from these applications, the requirements of the decision makers in the field of marketing, and the demands of the present market led us to the planning and development of a new Intelligent Decision Support System (named Market Expert – MARKEX), based on expert knowledge, aiming to help decision makers to solve specific problems.

The proposed methodology for the development of new products is developed in Section 2. Section 3 outlines the structure of the system and Section 4 presents some output of the system through a real world application. The final section of the paper, includes conclusions and new research orientations.

2. Methodological issues

Siskos and Matsatsinis (1993) proposed an original consumer-based methodology (Fig. 1), to support the product development process in enterprises. During the market survey, every consumer expresses his evaluations of a set of reference products involved in the research, 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 a specific questionnaire.

Its initial phase consists of acquiring a general aspect of the results of the survey with the help of descriptive statistics. This is followed by the use of data analysis models to determine consumer characteristics. 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 (see also Hauser and Urban, 1977, 1979; Eliashberg, 1980; Lilien et al., 1992; Urban and Hauser, 1993; Siskos et al., 1995a, b). The use of brand choice models (see Manrai, 1995) allows the market simu-

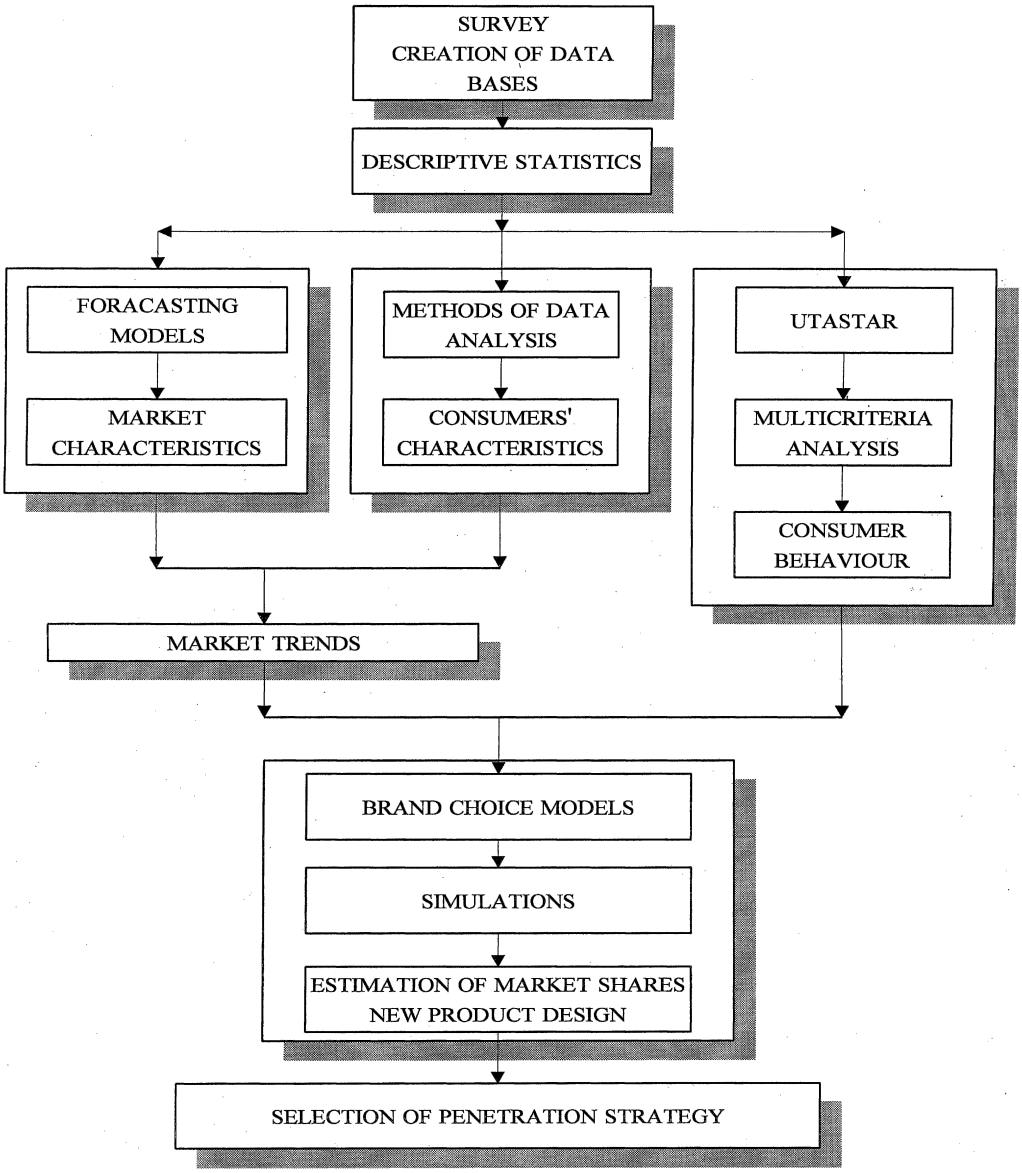

Fig. 1. Methodological flowchart of MARKEX.

lation and the calculation of the market shares of the competitive products taking part in the survey (Siskos and Matsatsinis, 1993), aiming at the selection of the most suitable model approach, as far as possible, to the real market shares. The next step concerns the design of the new product by the introduction of the decision makers' multicriteria estimations. This is followed by the application of alternative scenarios. Again with the help of the appropriate brand choice model, which is selected directly by the user or proposed by the expert system, the market simulation and the calculation of the new market shares to be expected after the introduction of the new product are performed. Based on the results of the scenarios' application, the decision of the most appropriate penetration strategy for the new product is made.

In the present version of the MARKEX system, the above methodology remains the same. However, the system exhibits some new features in order to meet some additional requirements of the procedure (Fig. 1) and to better support the product development process (Nylen, 1990; Urban and Hauser, 1993; Kotler, 1994). In this version the model base of the system has been improved and extended with the modification of the existing models and the addition of new ones. The realisation of the methodology and its application during the different phases of this process are based on the use of different models for forecasting, data analysis, multicriteria analysis and branch choice. The second, and perhaps the most important new feature of the presented new version, is the addition of the expert systems. Now, MARKEX employs three partial expert systems, which support the decision maker in all the steps of the original methodology.

3. Structure of the system MARKEX

The overall structure of the system is presented in Fig. 2, while Fig. 3 presents the data flow diagram of the knowledge-based decision support system. MARKEX merges partial knowledge-based expert systems (E.S.) as independent subsystems in the decision support system (DSS). These subsystems are described below, while the next paragraph outlines the MARKEX system.

3.1. Interface subsystem

This subsystem allows the communication of the user with all the other subsystems. Its rational planning, the simple handling, the clearness of its messages, and the possibilities of graphical presentations of its results are some of the system's characteristics. The Windows environment and the Professional edition of Visual Basic v.3 used for the system development offer a friendly environment for the end-users. The use of the keyboard has been limited to a few necessary jobs because most of them are carried out with the "mouse". The user is able to communicate with the available expert systems in a number of different ways as described below (Section 3.4).

3.2. Databases management subsystem

This subsystem allows the systematic storage, request, retrieval and maintenance of all the available data. Almost all of these operations are performed in the background without the involvement of the user in the tedious details of data handling. The databases used in this system are parts of the database management system.

The role of the subsystem includes the following:

- creating the databases required by the different parts of the system like
  - Product sales data,
  - Financial data of enterprises,
  - Questions,
  - Answers,
  - Data analyses,
  - Frequencies,
  - Multicriteria evaluations, and
  - Consumer utilities.
- informing the databases used by the system, by adding, changing, and deleting entries,
- offering the possibility for the creation of specific filters, registers, and the creation of multicriteria evaluation tables,
- offering the possibility for the creation of specific filters for consumer selection and questions under certain conditions.

The data obtained from the answers are entered and processed with the help of a worksheet similar to those of the different business programmes already existing. All files, except the question files, are ASCII files so that they can also be used by other programmes and vice versa. The filters are one of the most powerful tools of the system, since they offer the users the possibility to select any desirable combination of data for processing. The multicriteria evaluation tables are created by the answer files with the help of specific filters and registers, thus allowing the re-definition of their contents (Fig. 4).

3.3. Model base management subsystem

The model base of MARKEX has been improved compared to the base proposed by Siskos and Matsatsinis (1993) with the addition of fore-

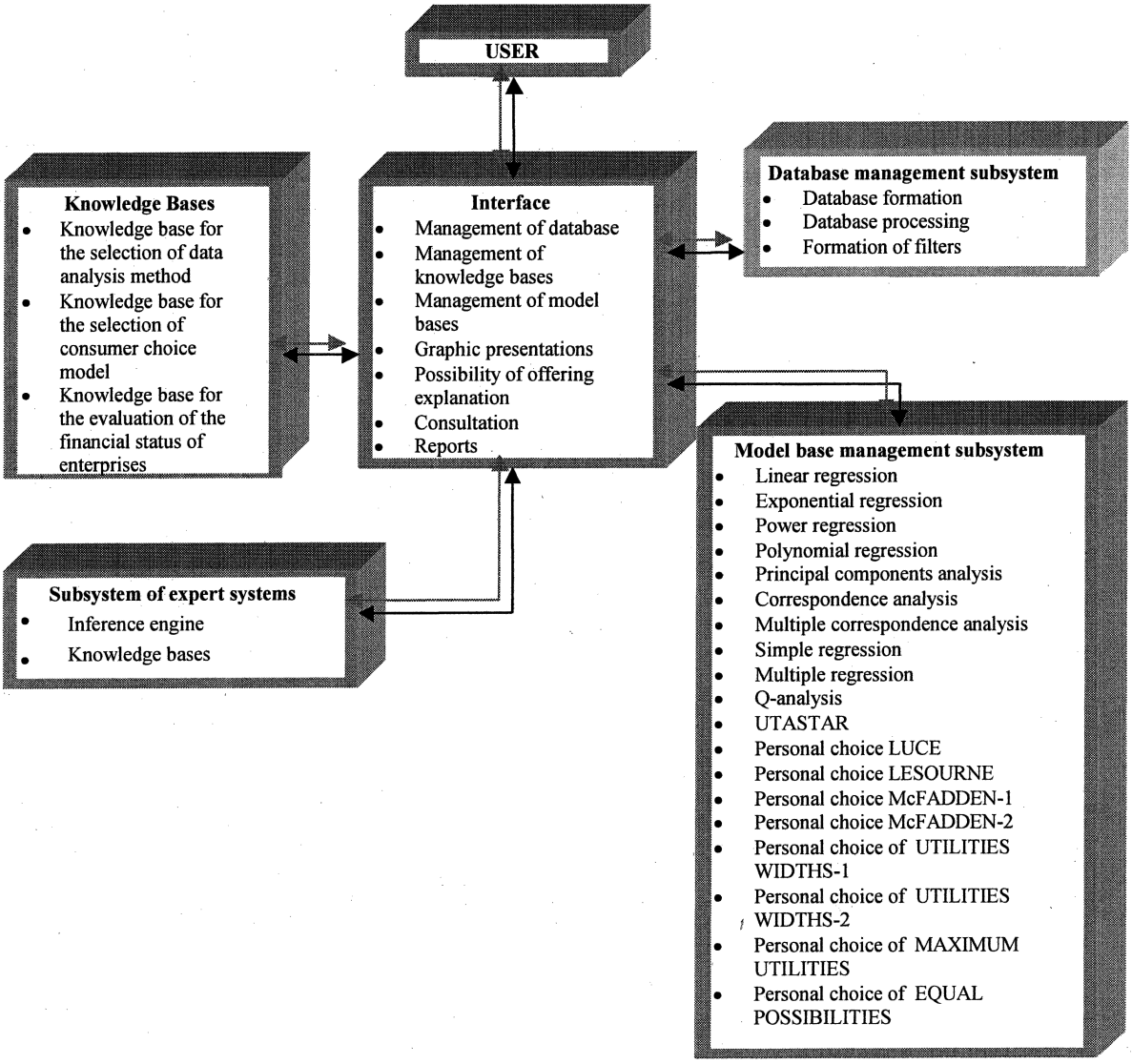

Fig. 2. Elements of MARKEX.

casting models (Fig. 1) and new models of consumer choice (see Appendix A).

3.4. Subsystems of expert systems

As already mentioned, the system incorporates three partial Expert Systems functioning independently of each other. The communication of the expert systems with the part of application where they are used is realised through the communication subsystem (Fig. 5).

The communication subsystem of MARKEX, as far as the Expert Systems are concerned, is composed of three different subsystems, one for every expert system. Each of them has a different way of presenting itself to the user. The communication subsystem for the selection of the data

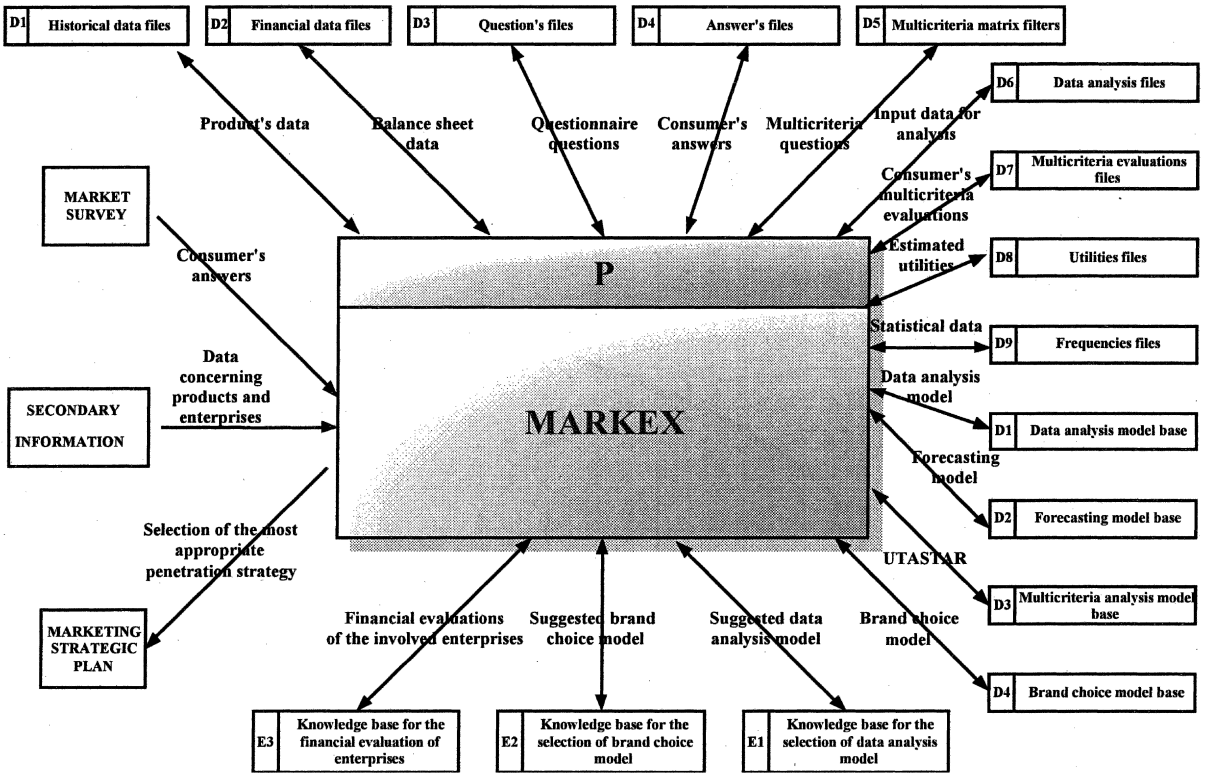

Fig. 3. Data flow diagram of the intelligent decision support system.

analysis system is the most obvious one and interacts with the user, requesting information, then presenting alternative answers, and finally proposing the suitable data analysis model.

The communication subsystem for the selection of the brand choice model presents itself only by showing on the screen the graphic illustration of the results of the application of the proposed model. The user is informed of this "proposal" by the simultaneous appearance on the screen of the market shares according to the proposed model and an auxiliary presentation giving further information on the selection.

Finally, the third subsystem which handles the estimation of the financial situation of the enterprise will appear adding its own estimations on the financial situation of the enterprises participating with their products in the "Market", which are added to the data of the existing multicriteria table (Siskos and Matsatsinis, 1993). The multicriteria table is created separately for each consumer consisting of the individual criteria evaluations and of the corresponding product ranking.

Communication of these subsystems with the inference engine for conclusion drawing is achieved through the channels' input–output which can transfer orders, facts, proposals, answers, and messages.

Knowledge bases come into contact with the inference engine drawing which can start searching either forwards or backwards, depending on the desired result. The necessary data required from the single knowledge bases are taken from corresponding databases.

For the construction of the knowledge bases, initially all available information has been collected from the international bibliography as well as from experts of every sector. Then it has been codified according to the requirements and the possibilities of the kernel M4 used for the devel-

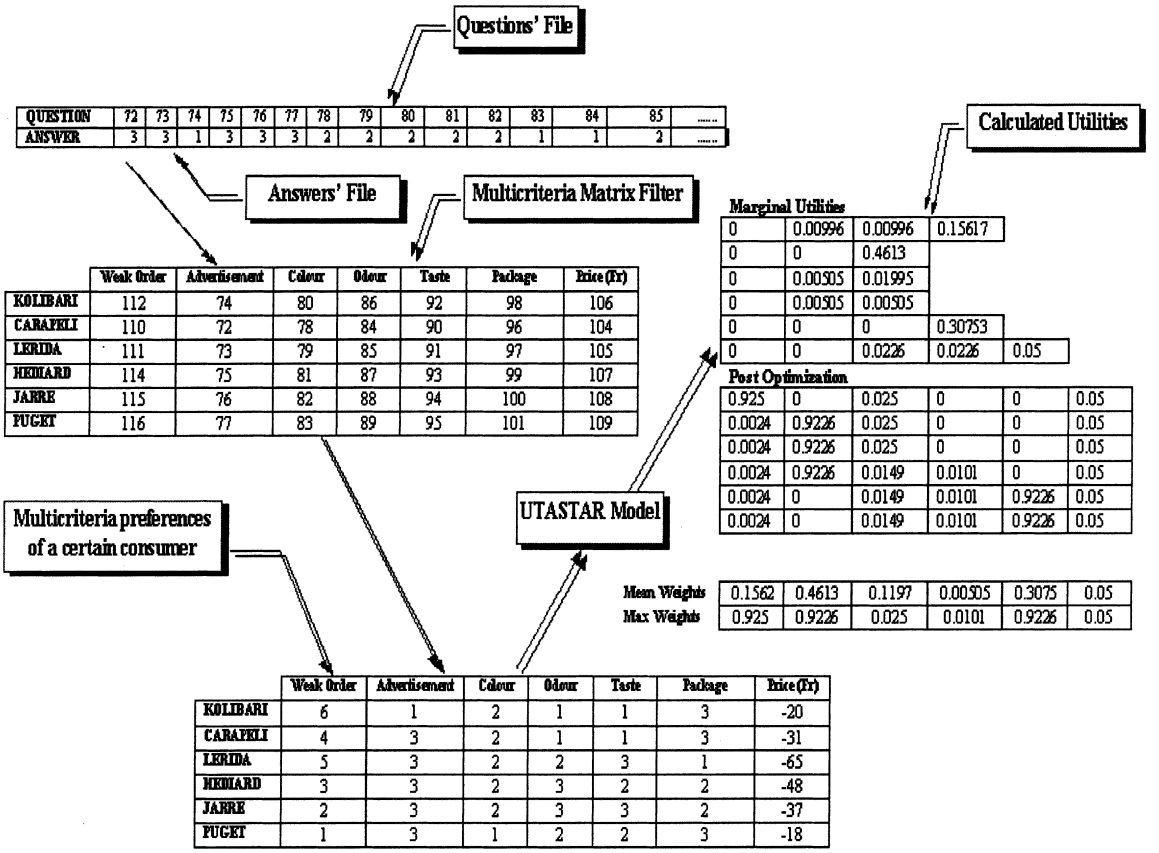

Fig. 4. Calculation of utilities.

opment of the expert system (Cimflex Teknowledge, 1993). This has been followed by the monitoring of the rational development of the following knowledge bases:

- selection of data analysis method,
- selection of consumer choice model, and
- evaluation of the financial status of enterprises.

The acquired knowledge from different experts is stored in the form of rules which are created, for the sake of economy, by the use of the operators AND, OR and NOT (Fig. 6). The development-codification of the knowledge bases includes rules, facts, meta-facts, propositions, and variables (Cimflex Teknowledge, 1993). A short presentation of the knowledge bases used by the system is presented below.

3.4.1. Knowledge base for the selection of data analysis method

The assumptions required for the proper function of the data analysis methods, the different objectives of analyses achieved by each of these methods, as well as the ignorance of the functional details of these methods on behalf of the user-decision maker in the field of marketing, led to the development of an expert system for the selection of the most suitable data analysis method for every data set. The selection of the method depends on two factors; the objectives of the analysis itself according to the decision maker (Table 1) and the number and type of the data used (Table 2).

The knowledge base was developed by using information acquired from specialised interna-

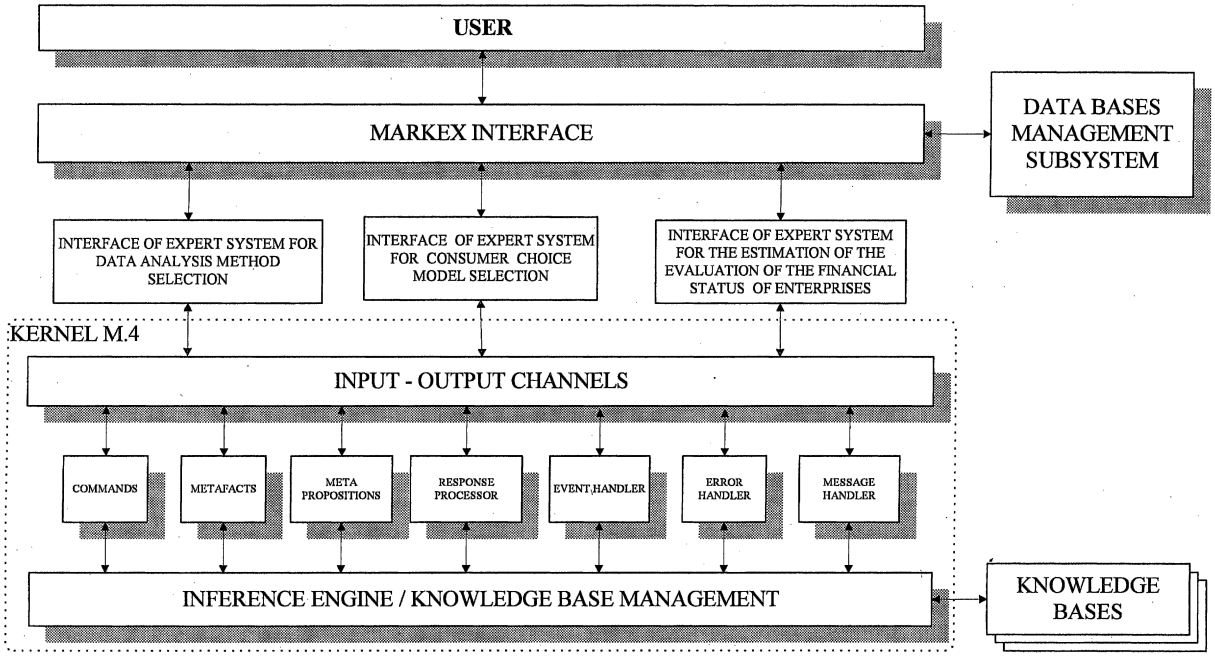

Fig. 5. Structure of the connection MARKEX – Kernel M.4.

tional bibliography (Bouroche, 1977; Lagarde, 1983; Lebart et al., 1984; SAS/STAT, 1990), as well as by the knowledge of experts in the field of data analysis methodology. It is actually composed of 165 rules.

During a work programme, the decision maker selects a database for analysis. This action determines the type of data that he desires to analyse. Subsequently, the user has to determine the objective of analysis (Table 1). Every objective is approached best by specific methods of data analysis.

Data selected by the user determine the type of data to be analysed. Additionally, the selection of the suitable method is also influenced by the number and the type of the chosen variables. Table 1 presents the objectives out of which the user has to choose one for examination. Table 2 enumerates the general requirements for the application of data analysis methods, and Fig. 7 displays a sample rule from the knowledge base.

rule-47: ***if*** target-data-anal = 1 ***and***
nb-of-var = NVar ***and***
NVar > 2 ***and***
NVar <= 7 ***and***
type-of-data = 3 ***and***
not (transform =5 ***or*** transform =6)
then data-anal = 'Impossible'.

Fig. 6. General form of rules.

3.4.2. Knowledge base for the selection of consumer choice model

The aim of all brand choice models is to find out the preferences of the consumer as far as the products of the "market" are concerned. The de-

Table 1
Codification of data analysis objectives

No	Analysis objective
1	Examination of similarities – dissimilarities among variables.
2	Examination of similarities – dissimilarities among consumers.
3	Investigation of relation between variables and consumers.
4	Investigation of intensity relations among variables.
5	Examination of potential grouping of variables.
6	Examination of potential grouping of consumers.
7	Determination of sizes.

Table 2
General requirements for the application of data analysis method

IF	Number of variables IS	AND number of dependent variables IS	AND type of dependent variables IS	AND number of independent variables IS	AND type of independent variables IS	THEN data analysis method IS
	>2	0	–	–	Quantity	Principal components analysis
	=2	0	–	–	Quality OR Order	Correspondence analysis
	>2	0	–	–	Quality OR Order	Multi-correspondence analysis
	=2	1	Quantity	=1	Quantity	Simple regression
	>2	1	Quantity	>1	Quantity	Multiple regression
	>2	0	–	–	Binary	Q-Analysis
	⩾1	0	–	–	Quality OR Order	Descriptive statistic

rule-88: ***if*** Objective of Analysis ***is*** Investigation of relation variables-consumers ***and***
Number of Variables ***is*** > 2 ***and***
Number of Dependent Variables ***is*** 0 ***and***
Type of Independent Variables ***is*** Quantity
then data analysis method ***is*** 'Principal Components Analysis (Correlations)'.

Fig. 7. Sample rule from the knowledge base for the selection of the most appropriate data analysis model.

termination and selection of the most appropriate model depends on two factors. The first one is the width of utilities allocated by the consumers of the segment (delta = Umax − Umin for each consumer). The second is the type of distribution of these utilities, which is determined by the estimation of kirtosis and symmetria parameters. The width and the type of distribution of utilities contain the information on how the consumer confronts this specific market. Thus, the consumer expresses through the width the possibility or the impossibility to differentiate between the products, whereas the distribution of the utilities within this range expresses his specific preferences for each of these products. The study of these characteristics results in the determination of different types of consumer behaviour. For these different types of consumer behaviour, different choice models are applied. The selection of the most appropriate model for every case depends on the experience acquired from the application of these models to real problems and on the specific characteristics of the models themselves. It is expressed in the form of rules taking into account these factors. The knowledge base of the present expert system uses 35 rules, one of them being presented in Fig. 8.

3.4.3. Knowledge base for the evaluation of the financial status of enterprises

The attempt of the decision maker to select the most suitable strategy of penetration of the product to be developed, requires knowledge of the financial position of the enterprises participating in the survey. Having established this knowledge, the decision maker can examine the different scenarios with greater confidence for his final decision. Financial problems constitute a very complex field, since many factors have to be taken into account and there is no precisely structured procedure for making these decisions. Financial ratios (Table 3) are used in order to estimate the strong and weak points of an enterprise. Financial analysis usually reveals the competitive position of the enterprise within its branch and generally within a specific economy structure. This information is essential for the determination of the marketing strategy to be followed. However, the estimation of the financial position of enterprises requires special knowledge,

rule-21: ***if*** delta >= 0.6 ***and***
Symmetria <= 0.25 ***and***
Symmetria >= -0.25 ***and***
Kirtosis <= 0.5 ***and***
Kirtosis >= -0.5
then Formula of Consumer Choice Model ***is*** 'Width of Utilities-2".

Fig. 8. Selection of consumer choice model knowledge base.

which the normal user of MARKEX usually does not have. It was tried to satisfy this need of decision makers in the field of marketing by developing an expert system for the estimation of the financial status of enterprises (Matsatsinis, 1995; Matsatsimis, 1997). Many other researchers have also attempted to develop similar systems (see Mui and McCarthy, 1987; Sena and Smith, 1987). However, this is the first time that the estimations of such a system are introduced in a multicriteria table and are taken into account for the estimation of marketing strategies. Knowledge bases that have been developed and used in MARKEX are described below.

Table 3
The financial ratios and the qualitative criteria of the system

Code	
Effectiveness Ratios	
A1	Profits pro Interest Rates and Taxes / Total of Assets
A2	Net Profits after Taxes / Own Capitals
A3	Mixed Profits / Total of Assets
A4	Net Profits / Mixed Profits
Solvency ratios	
B1	Short term obligations / Total of Liabilities
B2	Total of obligations / Total of Assets
B3	Long-term obligations / (Long-term obligations + Own capital)
B4	Circulating assets / Short-term obligations
B5	(Circulating assets − stocks) / Short-term obligations
B6	Stocks × 365 / Cost of sales
B7	(customers + Bills to be cashed) × 365 / Total of net sales
Managerial performance ratios	
C1	Financial expenses / Sales
C2	General and administrative expenses / Sales
C3	(Claims) × 365 / Yearly sales
C4	(Accounts to be paid) × 365 / Purchase of raw and secondary material
Qualitative criteria	
D1	Administrative experience of managers
D2	Position of the enterprise in the market
D3	Technological structure of the enterprise
D4	Organisation
D5	Specific competitive advantages of the enterprise
D6	Flexibility of the market.

For the correct function of the system, a database with financial data has to be created from the balance sheets and the commercial accounts of the enterprises taking part in the research. Thus, if the system has to express its opinion on the status of an enterprise, it retrieves the necessary information from the suitable database in the form of ratios used to express its estimation.

In the expert system proposed, the adopted classification of financial ratios is based primarily on the methodology developed by Courtis (1978). According to this methodology, the ratios are divided into three basic categories: effectiveness, management proficiency, and solvency. Further qualitative criteria for the estimation of enterprises have been added to these ratios (Table 3).

In the framework of monitoring the knowledge bases, consisting of a total of 1590 rules, continuous comparisons were carried out among the estimations of experts (financial analysers) based on the values calculated by the ratios, and the results given by the system.

4. Implementation for agricultural products development

MARKEX, in its initial form, was developed and operated as a decision support system. In the form of a traditional DSS, it was used in different studies, like development of a new flour product for a flourmill enterprise in Crete, Greece (Siskos and Matsatsinis, 1993), market research on Cretan olive oil in the market of Athens (Baourakis et al., 1995a),

market research on Cretan wine in the market of Athens (Siskos et al., 1995b), market research on Cretan olive oil in the German market (Matsatsinis et al., 1995), and market research on Cretan olive oil in the French market (Baourakis et al., 1996).

This was followed by the presentation of the Intelligent DSS system in a practical application for the development of a new product of extra virgin olive oil designed for the French market.

The first step involved the formation of all the necessary databases. Three sources of data were used. Primary data from the properly codified questionnaires, relevant secondary information about products' sales, total size of the market in sales and money terms and, finally, available financial data which are necessary to estimate the situation of the enterprises participating in the survey.

4.1. Trends of the market

The study of the trends of general market characteristics like volume of sales of the products in quantity and money terms is based on the forecasting models of the system. With the help of these models, trends of market development are examined and the sales of the products are predicted.

With the selection – by the user – of the data to be analysed, the first expert system's screen will appear. It offers the possibility to select between the use of the E.S. and the deviation of the advisory procedure (Fig. 9).

The screen of the E.S. has three main regions through which it communicates with the decision maker. The region in the middle shows the questions of the system to the user, while the region below shows the possible choices of answers for the decision maker. The above region is used by the E.S. to give its final suggestions or explanations to the decision maker, who can accept its viewpoint or go ahead directly to the choice of the analysis method.

Fig. 10 shows on the topside the possibilities of the graphic presentation of the results and on the down side the possibilities of magnifying parts of the graphic presentation for a more detailed study of particular cases. In the first screen, the results of the selected data analysis method are shown.

4.2. Analysis of consumer behaviour

Through this analysis the user is informed about the determinant criteria of market behaviour and market segmentation by criterion or by a combination of criteria.

The main screen for criteria analysis is presented in Fig. 11. It shows the graphical presentation of fluctuation of the criteria utilities in relation to the percentage of consumers. The main criteria explaining consumer behaviour are displayed on the right part of the screen. For instance, the product's price was the most significant criterion for 53.92% of the consumers, while packaging was in the second place with 52.94%; criteria such as colour, influence, taste and, to a smaller extent, odour of the product, were closely rated.

Criteria analysis is operational after the formation of the corresponding utility file. Utility files are created by the application of the UTASTAR method to the multicriteria tables supplied by each consumer through the market survey. The results of the UTASTAR method are the global utilities allocated from every consumer to each product, the marginal utilities of every criterion and the weights (measure of relative significance) of each criterion. For the estimation of the significance of each criterion the user can select between mean and max criteria weights (for example Fig. 11 displays numbers which are estimated taking into account the mean weights of each criterion).

4.3. Market shares – Simulations

Through all the analysis made so far (descriptive statistics, data analysis and analysis of consumer behaviour) the decision maker is able to determine some features which can help him to partition the market in segments with some special interest. The effectiveness of the segments is monitored and segments to be studied are chosen accordingly (Nylen, 1990; Kotler, 1994). If no segment meets the conditions of effectiveness, then the whole market is regarded as one segment. However, if there are several segments, each one is studied separately in the framework of the analysis of the product under development and of the

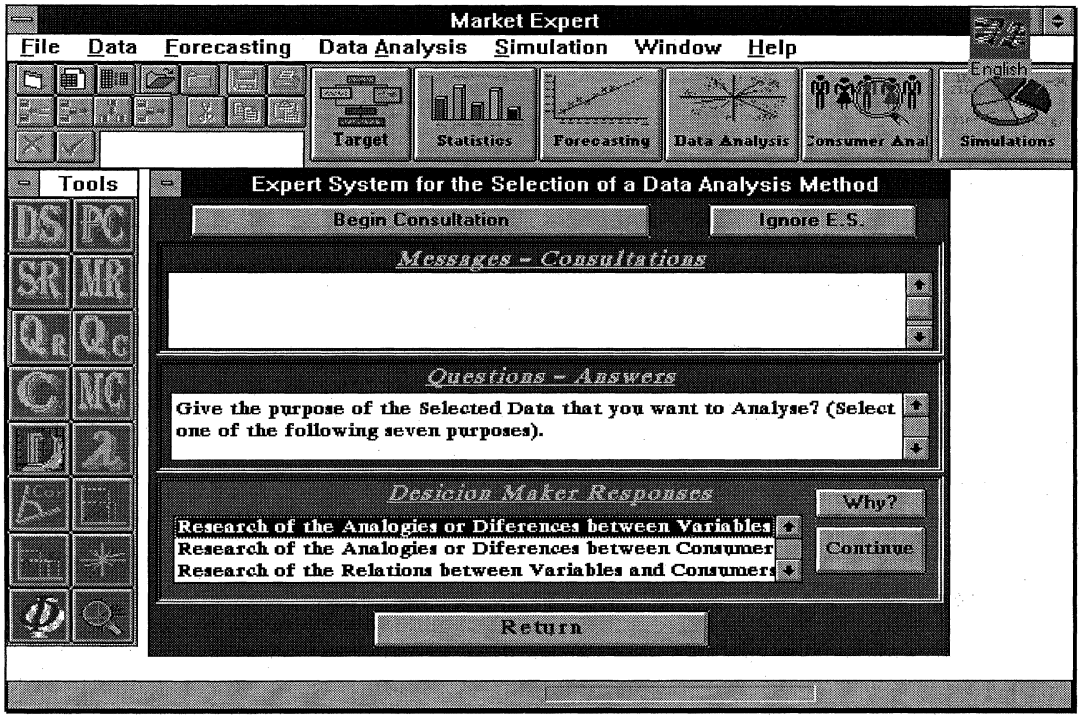

Fig. 9. Expert system for the selection of data analysis method.

analysis of the competitors, in order to detect the competitive advantages of the market products through the calculation of the market shares, the placement of products, the detection of the main competitors, and the determination of the features of the new products.

One of the tools used for planning, development, and monitoring of products is market simulations with the help of models of consumer personal choice offered by the system (Appendix A). 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 a better market share. Fig. 12 presents the screen of simulation together with the screen of the expert system suggestions for the selection of the most suitable model of consumer choice.

In Fig. 13, the table with multicriteria evaluations and the control panel for market simulations are presented.

For every product of the market research, the market shares and their fluctuations, as well as the utilities of the criterion are given according to the calculations from the total of the models of the system (Fig. 14).

The results from the application of the scenario arise from the repeated simulations and are presented in Fig. 15. It can be observed that the change in the market shares of the product to be studied shows a declining tendency as the price of the product rises. The trend of the decline changes from 31 to 42 Fr.; it is also noteworthy that mainly another gains the market shares lost by one product, whereas an unimportant percentage is distributed between the other two products.

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 (Fig. 15). 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. At this point, the third expert

system will intervene and will insert its estimations concerning the financial status of the enterprises. Then the utilities of the products are recalculated and the market shares are re-estimated according to the selected strategies. The results of the application of strategies are presented in Fig. 16.

Finally, the decision maker selects, with the help of the above results, the strategy that the enterprise will adopt for planning, development, and market penetration of the product.

5. Conclusions

In the framework of the present paper a new intelligent decision support system in marketing (MARKEX) was analysed, planned, developed, and applied. This system achieves a prototype methodology for the development of new products.

Examining MARKEX as a software system, one can observe that it is user-friendly, with graphic possibilities, able to carry out different jobs

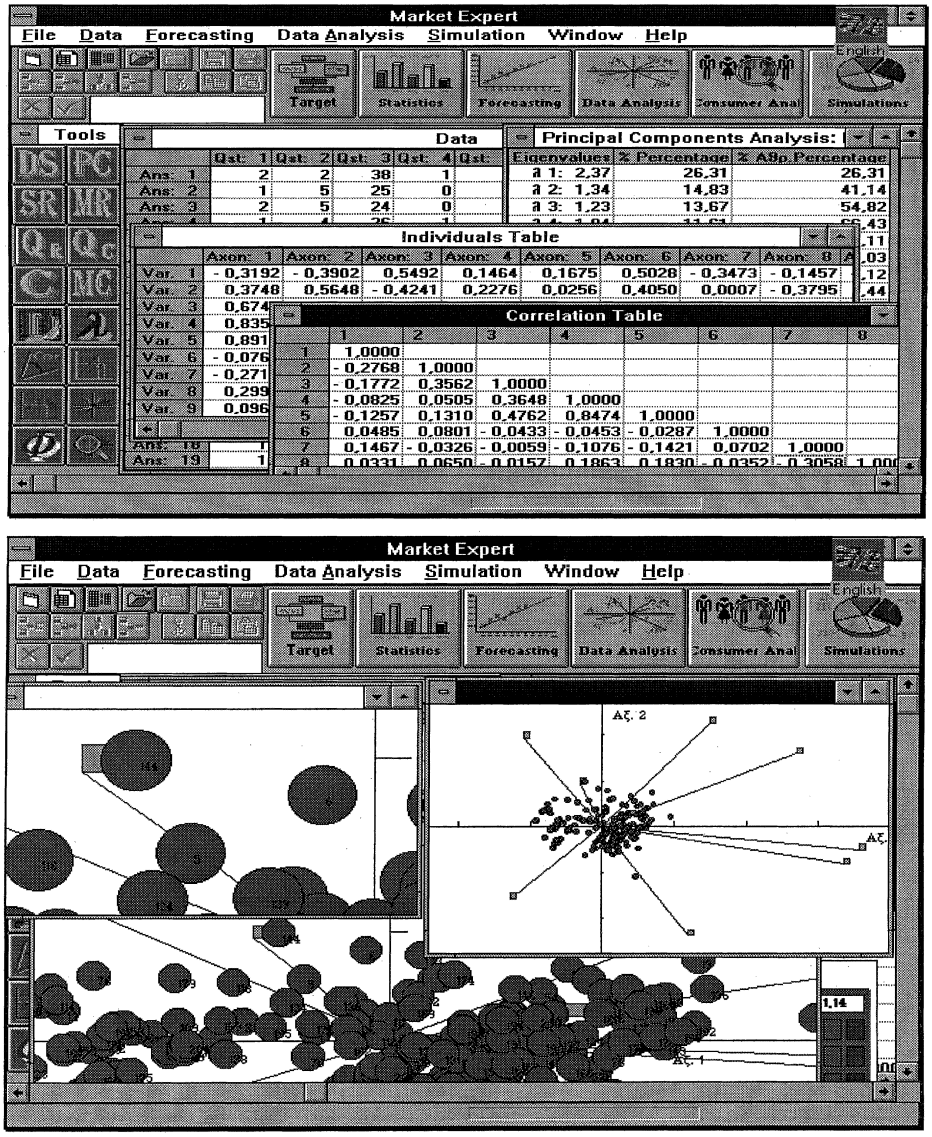

Fig. 10. Data and graphic representation of the analysis results.

at the same time, as well as to offer a large model base. It can be installed very easily in any computer and it works in the Windows environment. The speed of the computer plays a role in the solution of the linear programs, in the re-estimation of the utilities where all the consumers will participate, and in the presentation of the different modes requiring the handling of a large volume of data. Based on the experience acquired by the user, the following proposals can be put forward for future research activities and improvements of the present system.

A weakness of the models used is the lack of the parameter of time, thus it excludes the observation of the development of market shares as a function of time. Therefore, an attempt has to be made to develop either new models, or a new methodology taking into account the parameter of time, too.

The selection of the appropriate brand choice model is based on the idea of the correlation of the width of utility allocated by the consumers of a specific segment with the type of distribution of these utilities. The consumer through the multicriteria table expresses implicitly his preferences for the examined products. Then by the application of the UTASTAR method in the multicriteria table of each consumer the system calculates the utility of each product. It is assumed that through the width of the utilities each consumer expresses his/her possibility or impossibility to decide for or against one product. The distribution of the utilities within this range expresses his or her specific preferences for each of the examined products. The study of these results leads to the determination of different types of consumer behaviour, which was combined with a different model of choice. This idea, in spite of the fact that it gave positive results up to present, has to be studied more thoroughly and has to be extended also to the study of the behaviour of choice models.

The model finally selected for the representation – simulation of the behaviour of a "Market" gives market shares of the products which cannot be absolutely identified with known market shares. This is a factor of uncertainty and increases the possibilities of errors for different cases. Thus, the subject has to be approached again, either by introducing acceptable divergence limits or by using methods for uncertainty management.

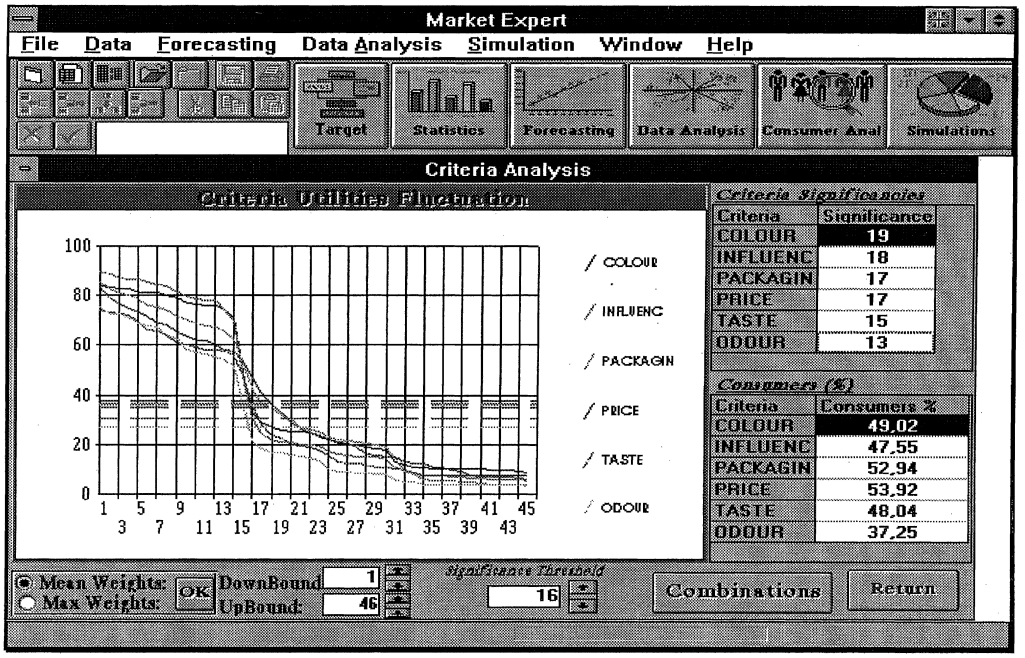

Fig. 11. Criteria analysis with utilisation of the average weight of criteria.

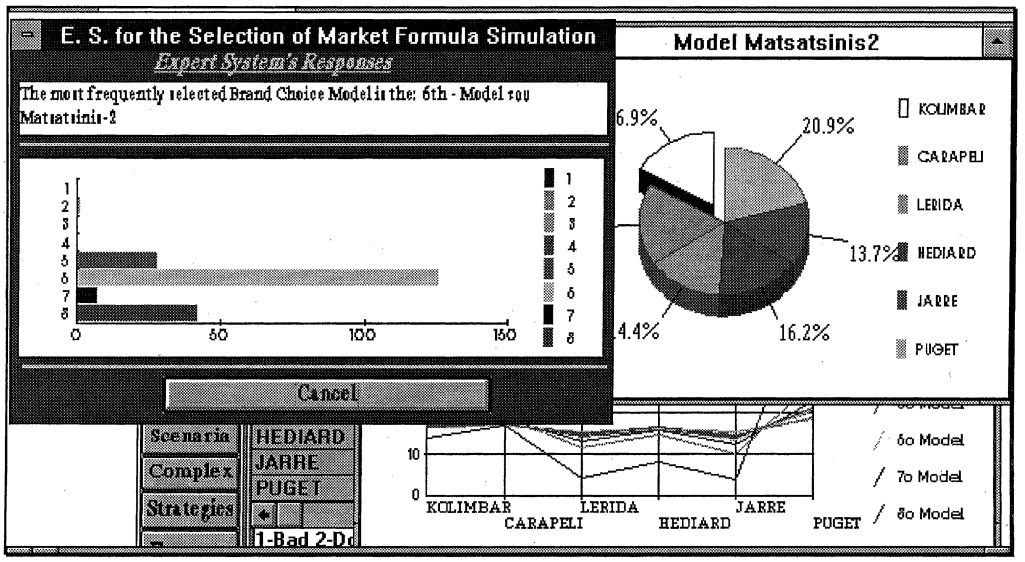

Fig. 12. Expert system for the selection of market formula simulation.

Problems resulting from the lack of experts and/or the high cost of their work can be solved in a satisfactory way by incorporating the suitable expert systems (interpretation of the results of data analyses, correlation of the results from data analyses and criteria).

Effectiveness of MARKEX 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

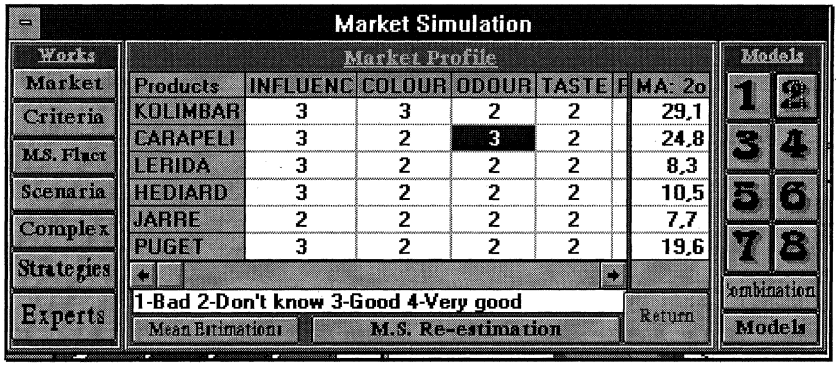

Fig. 13. Multicriteria table and control panel for market simulation.

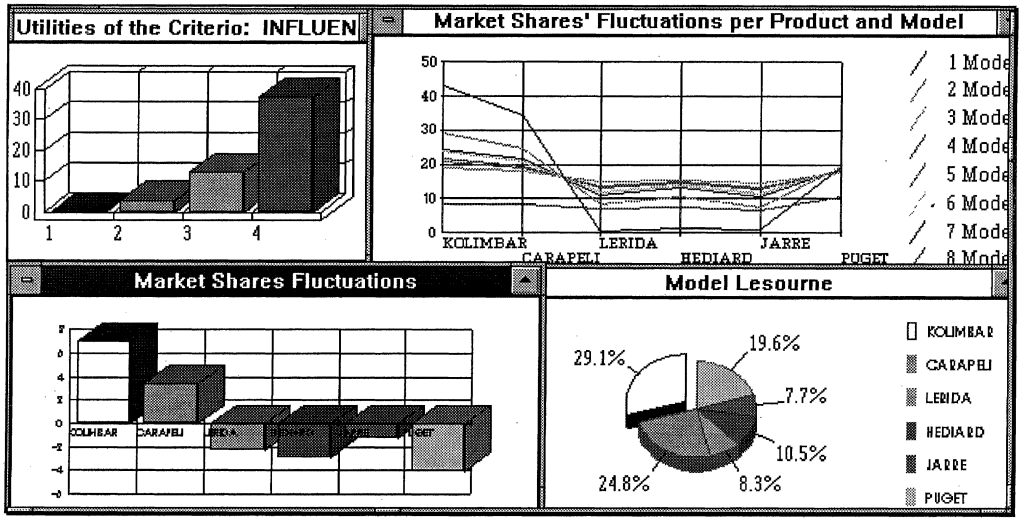

Fig. 14. Market simulations results.

of MARKEX are the distribution channels and the policy of product promotion to be followed. One of the extensions of the system is oriented towards the development of a new expert system which will direct sales to specific markets, by taking into account the existing channels, the demands of the different markets, the prices in these markets, transport means and costs, as well as the long-term strategic aims of enterprises.

For further reading

Roy, 1985; Roy and Bouyssou, 1993; Silk and Urban, 1978; Siskos, 1982

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Appendix A. Models of personal consumer choice

The probability $P_{ij}(C)$ that consumer **i** will select product **j** from a series of products C is expressed by the following models:

Models of consumer personal choice	Formula
Luce (1959, 1977)	$P_{ij}(C) = \frac{U_{ij}}{\sum_{k\in C} U_{ik}}$
Lesourne (1977)	$P_{ij}(C) = \frac{U_{ij}^2}{\sum_{k\in C} U_{ik}^2}$
Multinomial model McFadden-1 (McFadden, 1970, 1976, 1980, 1991)	$P_{ij}(C) = \frac{e^{U_{ij}}}{\sum_{k\in C} e^{U\,k}}$
Slightly reinforced McFadden-2	$P_{ij}(C) = \frac{e^{2Uj}}{\sum_{k\in C} e^{2Uik}}$
Width of utilities-1	$P_{ij}(C) = \frac{U_{ij}^{U_{\max}-U_{\min}}}{\sum_{k\in C} U_{ik}^{U_{\max}-U_{\min}}}$
Width of utilities-2	$P_{ij}(C) = \frac{e^{2(U_{i\ \max}-U_{i\ \min})}}{\sum_{k\in C} e^{2(U_{i\ \max}-U_{i\ \min})}}$
Maximum of utilities	$P_{ij}(j\|C) = \begin{cases} \frac{1}{m} & \text{where } U_{i\ \max} \geqslant U_{ij} \geqslant U_{i\ \max} - \varepsilon_i \\ 0 & \text{otherwise} \end{cases}$ with $\varepsilon_i = \frac{\delta_i}{n-1}$, where $\delta_i = U_{i\ \max} - U_{i\ \min}$
Equal probabilities	$P_j = \frac{1}{m}$ where $U_{i,\max} - U_{i,\min} \leqslant 0.1$

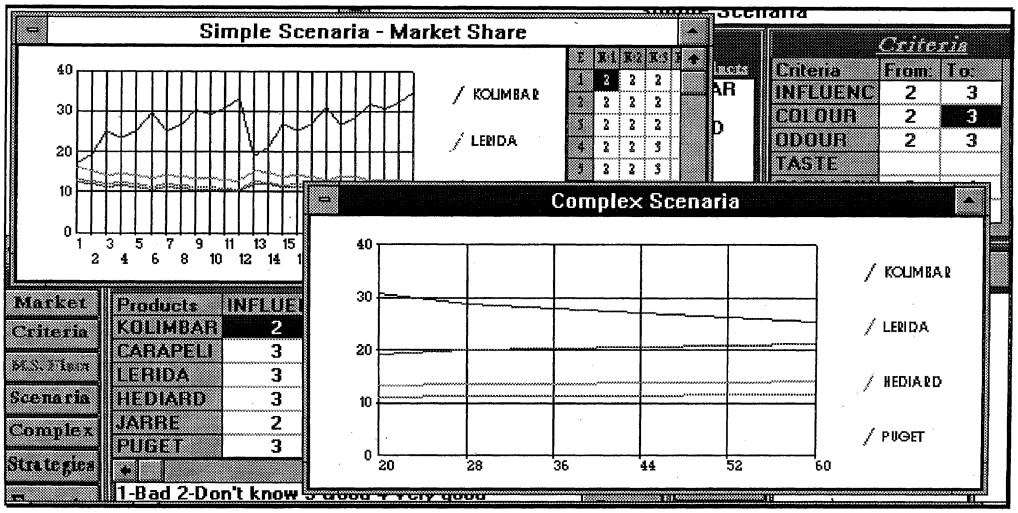

Fig. 15. Results from the application of scenarios.

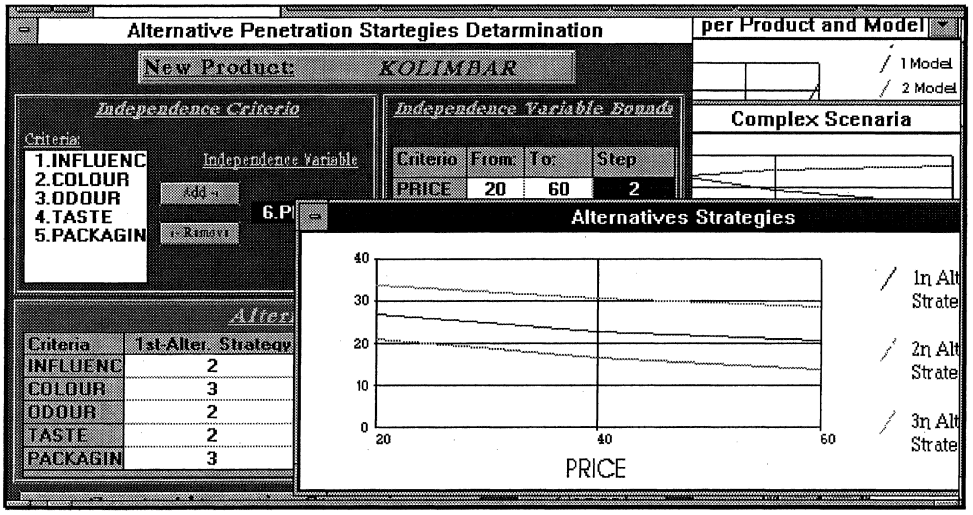

Fig. 16. Market shares variations according to price fluctuations.

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