

European Research Studies,
Volume XII, Issue (1-2) 2009

The Use of Management Science Techniques by Business
Organisations with Special Emphasis on the Use in Different
Functional Areas: Survey in Greek Companies

By

John G. Halikias¹

Abstract

This paper presents an ongoing survey project researching into the extent and nature of use of management science techniques by business organisations in Greece. The survey shows that the usage of MS-techniques in Greek companies is relatively high compared to other European countries. However, the usage of more advanced techniques is very low in Greek firms and the application of MS-techniques is concentrated on a few traditional techniques. The reason for the low degree of applicability of more advanced techniques seems to be the general lack of understanding for the importance of these techniques.

Keywords: Management Science, Operational Research, Quantitative Methods

1. Introduction

The major contributions that can be made to business efficiency and improved management decision-making through the application of quantitative techniques, as well as the extent of their use, have been well researched [Green et. al. (1977), Kathawala (1988), Naude et. al. (1991)]. There is extensive evidence that the application of such techniques has resulted in significant improvements in economic efficiency (particularly at the micro-economic level) and has led to improvements in decision-making in both profit and non-profit organisations. A number of professional journals provide details of “successful” applications of quantitative techniques to specific business problems [Bazzoli (1998), Vinent (1994)]. This is one of the major reasons why there has been a considerable expansion of the coverage of such topics throughout business programmes during the past years, both in undergraduate and postgraduate level.

Another equally important factor is the progress that has been achieved in the manufacture of powerful and cost-effective computers. This evolution in computers combined with the availability of relatively cheap and user-friendly

¹ *Athens University of Economics & Business
Department of Marketing and Communication
76 Patission Street, 104 34 Athens, Greece
e-mail: jgh@aub.gr*

software means that the various quantitative techniques, which used to be the prerogative of the Management Science / Operational Research (MS/OR) specialist, can now be used directly by the business executives or managers. It is often argued that this feature is one of the major contributory factors behind the upsurge of interest in such techniques.

In an effort to ascertain the extend of use of quantitative techniques by business organisations, a project was initiated with the creation of a research team based on Leeds Business School (UK), Aarhus School of Business (Denmark) and Athens University of Economics (Greece). The project operated under the name "European Management Science Survey" (EMSS), and throughout its course a number of Working Papers were published [Halikias et. al. (1990, 1991a, 1991b, 1992), Kristensen et. al. (1990)]. The team intended to examine cross-country differences and to investigate the use (or lack of use) of such techniques by business organisations with a view to identify the need for provision of management training in this area.

The initial focus was on business organisations in each of the countries initially involved, with prospects of gradually extending the research into all the major European countries and repeating the investigation in future years to establish time patterns. With this rationale, the Greek team repeated the survey twice. The first survey took place in 1996 and involved 53 companies [Halikias (1999)], and the second in 2002, which involved 67 Greek companies selected randomly from the ICAP directory. The results on the usage of management science techniques are presented in the next sections.

2. Methodology

The survey was conducted in the autumn of 2002 with the questionnaire, a covering letter and prepaid envelope being sent to the chief executive of each organisation. If no response had been received within three weeks a reminder letter was sent, together with a further copy of the questionnaire with another prepaid return envelope. The sample consisted of firms from the primary, manufacturing, retail and services sectors. For each sector, the firms were selected at random from the I.C.A.P. Hellas Directory. The sample was comprised of a total of 200 firms, from which a total of 69 completed questionnaires were received, which implies that a response rate of 34.5% was achieved. It should be pointed out that in the beginning of the survey, the response rate was very low and a lot of effort was spent into finding the proper executives to answer the questionnaires. As a result, the final sample data became available in the beginning of 2004. The after-the-selection stratification showed that all sectors of the economy are represented in the sample with proportions quite near to the population composition (see Table 1).

The questionnaire was designed to provide information concerning the extent and nature of usage of quantitative techniques in the organisation and their relevance in different functional areas. Also, attention was focused on the identification of obstacles, which prevent or hinder the development of use of such techniques in the business world. One of the questions related to a list of

quantitative techniques and the respondents were asked to identify which of the techniques they had heard of and which ones they used. In order to test the reliability of the answers, a dummy technique named “Dynamic Multivariate Optimisation” was included in the list. The companies that indicated awareness of this dummy technique, or that they indeed actually used it, were omitted from the analysis (only 2 such cases were found). A summary of the questionnaire is presented below. Table 1 shows the distribution of the sampled companies with respect to their size and activity.

The Questionnaire

- Q.1 What is the main activity of your organisation ?
- Q.2 How many full time employees does the organisation have?
- Q.3 Please indicate the description of your own department activities:
- Q.4 Are quantitative techniques applied in your organisation?
- Q.5 Indicate the main reasons for **not** applying quantitative techniques in your organisation.
- Q.6 Does your organisation have an internal OR unit ?
- Q.7 How useful do you think the OR unit is to your organisation as a whole?
- Q.8 Does your organisation make use of external OR services ?
- Q.9 How useful do you feel quantitative techniques are to your organisation ?
- Q.10 Indicate the main reasons for the application of quantitative techniques in your organisation.
- Q.11 How frequently does your organisation use quantitative techniques in each of the following areas ?
- Q.12 Please indicate whether each of the following techniques are known to your organisation and if so with which frequency they are applied (30 quantitative methods are listed).

Table 1. Activity and Size Distribution of Companies

Activity	Number of employees				Total
	< 200	200-499	500-999	>= 1000	
Primary sector		1	1	3	5
Manufacturing	11	8	8	3	30
Retail Sector	10		1	2	13
Services	6	4	1	8	19
Total	27	13	11	16	67

3. Results of Survey

This paragraph is mainly intended on showing the results of the survey concerning usage in business organisations of different size and type, the reasons for use/non-use of quantitative methods and the usefulness of the techniques. The results concerning the usage of different techniques and their application to the activities of the companies are also presented.

3.1 Results Concerning the Usage Depending on Main Activity and Size

One of the main purposes of this survey was to determine the use of MS-techniques in different types of business. It is demonstrated that the usage of MS-techniques is at its highest in companies of the primary sector and of services, while the usage within manufacturing sector shows the lowest usage (Table 2). At a later section, we will show which techniques have the highest usage in different types of business organisations.

With respect to the company size we observe the following. Most surveys on the usage of management science techniques show that the usage of these techniques increases as a function of company size. However, this fact is not underlined in our survey. Except for companies with more than 1000 employees (which participate in the sample with only 16 observations), the highest percentage of use of MS-techniques appears in the 200-499 employees group of companies, and the lowest in the 500-999 employees group (Table 2).

Table 2. Activity and Size Distribution of Companies
(Use of Quantitative Methods, Percentages)

Activity	Number of employees				Total
	< 200	200-499	500-999	>= 1000	
Primary sector		100.0%	0.0%	100.0%	80.0%
Manufacturing	63.6%	87.5%	62.5%	66.7%	70.0%
Retail Sector	70.0%		100.0%	100.0%	76.9%
Services	66.7%	100.0%	100.0%	75.0%	78.9%
Total	66.7%	92.3%	63.6%	81.3%	74.6%

3.2 Reasons for Not Using MS-Techniques

The reasons for usage and non-usage of techniques are of special interest and have been analysed by different foreign surveys [for an overview see Kristensen et. al. (1990)]. In 17 questionnaires (from a total of 67, i.e. 25.4%), it was indicated that the company did not use quantitative techniques in general. If a company did not use quantitative techniques, we asked different reasons for not using these techniques. The results are shown in Table 3. The most obvious reason for not using techniques is the lack of support from senior management,

but it is also of interest to notice that almost 36% of these companies stated that quantitative techniques are not considered to be relevant to the activities of the company.

Table 3. Reasons for not using Quantitative Techniques (Percentages, n=17)

Reasons	Yes	No
Lack of support from senior management	71.4%	28.6%
Insufficient training/education of staff	47.1%	52.9%
Bad record of OR specialists/advisers	15.4%	84.6%
Techniques not seen as relevant to activities	35.7%	64.3%
Lack of computing resources	0.0%	100.0%

3.3 Reasons for Using MS-Techniques

If we focus attention on the companies indicating general usage of quantitative techniques, the following reasons for usage are found (Table 4): It is important to notice that almost all the respondents considered the efficiency of quantitative methods to be a reason for using MS-techniques. This reason signals general belief and experience with the usage of quantitative methods. This reason for usage is followed by the availability of computer facilities, support from management, and the presence of skilled personnel, while good experiences with advisers appears to be of less importance.

Table 4. Reasons for use of Quantitative Techniques (Percentages, n=50)

Reasons	Yes	No
Support of senior management	73.2%	26.8%
Good record of OR specialists/advisers	41.7%	58.3%
Effectiveness of OR applications	98.0%	2.0%
Availability of trained staff	56.1%	43.9%
Availability of computing resources	79.1%	20.9%

Further analysis of the reasons for usage of MS-techniques shows that the support from management plays a dominant role in small companies, which makes it of special importance to induce managers in these companies that MS-techniques are relevant to company activities (for companies with less than 500 employees, support of management is considered as a reason for use of MS-techniques in 79.2% of the cases, whereas for companies with less than 200 employees in 92.9%). The recordings of reasons for not using MS-techniques in Table 3 support this suggestion. This again points to the educational background

of the managers in smaller Greek companies, a point that has to be further researched.

As for the usefulness of the techniques, it is important to notice that according to the results in Table 5, 49.1% of the companies which use MS-techniques believe that they are essential to their companies, while another 30.2% consider them as “very useful”. Only 20.8% of the respondents characterised them as just “useful” or “of little use”.

Table 5. How Useful the Quantitative Techniques are to your Company (Percentages, n=50)

Use	Percentage
No use	0,0%
Little use	1.9%
Useful	18.9%
Very useful	30.2%
Essential	49.1%
Total	100.0%

With respect to the use of external OR services, 19 companies (i.e. 28.4% of total sample or 38% of the companies which use MS-techniques) stated that they use outsourcing mainly from consulting companies. Finally, 21 companies (i.e. 42% of the companies which use MS-techniques) were found to have an internal OR unit. According to Table 6, the majority (73.9%) considers the OR unit as “essential”. None of them described the OR unit as “no use” or “of little use”.

Table 6. How Useful the OR Unit is to your Company (Percentages, n=21)

Use	Percentage
No use	0.0%
Little use	0.0%
Useful	8.7%
Very useful	17.4%
Essential	73.9%
Total	100.0%

3.4 Usage of Different MS - Techniques

The respondents were asked to consider an extensive list of specific quantitative techniques and to identify which they were familiar with and the extent of use of these techniques. The results on the level of familiarity and usage (measured as “occasionally” or “frequently” used) are shown in Table 8 (the results refer to all companies regardless of whether they considered themselves to be users of quantitative techniques or not).

Table 7 below shows the usage of the MS-techniques in general with respect to the various functions of the companies. Only the results from companies which considered themselves to be users of quantitative techniques are presented. A number of interesting points arise from this table. Forecasting, capital budgeting and corporate planning are the areas where quantitative techniques are mostly used (percentage of “frequently” used in more than 65% of the firms sampled). We also notice that the activities in which the techniques are “frequently” used in more than 50% of the cases are: market research, stock control, investment appraisal, and production scheduling.

Table 7. How Frequently do you Use Quantitative Techniques in each of the Following Activities (Percentages, n=50)

Activity	Never	Occasionally	Frequently*
Break even analysis	25.5%	27.7%	46.8%
Forecasting	5.8%	9.6%	84.6%
Market research	17.6%	21.6%	60.8%
Reliability	50.0%	18.2%	31.8%
Quality control	36.7%	18.4%	44.9%
Project management	40.0%	31.1%	28.9%
Stock control	23.5%	17.6%	58.8%
Investment appraisal	26.5%	18.4%	55.1%
Capital budgeting	13.5%	9.6%	76.9%
Production scheduling	39.6%	10.4%	50.0%
Corporate planning	14.0%	18.0%	68.0%

* Frequently means that the technique is used on a monthly basis or more frequently

Table 8. Knowledge and Use of Quantitative Techniques (Percentages, n=67)

Technique	Don't know of (%)	Know of and			Uses/Know of (%)
		Never used (%)	Occas. Used (%)	Freq. Used (%)	
Basic statistics (averages, etc.)	0.0	3.2	14.3	82.5	96.8
Analysis of variance	12.7	30.9	29.1	27.3	64.6
Hypothesis tests/Inference	21.6	35.3	25.5	17.6	55.0
Non-parametric methods	48.9	36.2	14.9	0.0	29.2
Regression/Econometric models	26.4	30.2	26.4	17.0	59.0
Smoothing /Moving Averages	34.6	19.2	19.2	26.9	70.6
Box-Jenkins models	66.0	21.3	12.8	0.0	37.5

Expert systems	57.4	27.7	10.6	4.3	35.0
Quality Control charts	16.4	30.9	21.8	30.9	63.0
Pareto charts	29.2	43.8	8.3	18.8	38.2
Cause-effect diagrams (Ishikawa)	49.0	26.5	6.1	18.4	48.0
Taguchi methods	74.5	21.3	4.3	0.0	16.8
Discriminant analysis	73.3	24.4	0.0	2.2	8.3
Factor analysis	39.6	41.7	12.5	6.3	31.1
Multidimensional scaling.	58.7	28.3	10.9	2.2	31.6
Log linear models	41.3	37.0	13.0	8.7	37.0
Correspondence analysis	54.3	37.0	6.5	2.2	19.0
Linear programming	25.9	38.9	14.8	20.4	47.5
Integer programming	40.0	46.0	4.0	10.0	23.3
Dynamic programming	38.5	36.5	13.5	11.5	40.7
Goal programming	35.2	29.6	11.1	24.1	54.3
Cluster analysis	44.7	31.9	4.3	19.1	42.3
Inventory/ stock control models	12.5	20.3	20.3	46.9	76.8
Simulation models	21.2	36.5	30.8	11.5	53.7
Network models	30.6	55.1	8.2	6.1	20.6
Project planning (CPM / PERT)	17.9	35.7	26.8	19.6	56.5
Queuing models	27.5	47.1	19.6	5.9	35.1
Decision analysis / Risk analysis	25.0	30.8	30.8	13.5	59.0
Game theory	30.6	57.1	12.2	0.0	17.6
Discounted Cash Flow analysis	16.4	23.6	16.4	43.6	71.8

Turning now to the results of Table 8 concerning the familiarity and usage of the quantitative techniques, we notice the following. Basic statistics, inventory / stock control models and discounted cash flow analysis are the most well-known and most used methods. A relatively high degree of usage is also found on ANOVA, smoothing methods / moving averages, and quality control / control charts. On the contrary, more advanced methods such as non-parametric methods, Box-Jenkins models, discriminant analysis, factor analysis and multidimensional scaling are not well known and only used at a very small scale (mostly occasionally).

With respect to the usage of the MS-techniques within the specific sectors of the economy, Table 9 reveals some important results. In the primary sector (which includes energy & mining) quality control and linear programming are the most used methods. In companies of the manufacturing sector, the most used

methods are basic statistics, inventory/stock control models, discounted cash flow analysis, and quality control charts.

Table 9. The Most Frequent Used Quantitative Techniques by Activity
(Percentage of Frequently Used > 40%)

Activity	Technique	Frequently used (%)
Primary Sector (n = 5)	Quality control/Control charts	66.7%
	Linear programming	60.0%
Manufacturing (n = 30)	Basic statistics (averages, dispersion)	89.7%
	Inventory/ stock control models	55.2%
	Discounted Cash Flow analysis	52.2%
	Quality control/Control charts	50.0%
Retail) (n = 13)	Basic statistics (averages, dispersion)	83.3%
	Inventory/ stock control models	69.2%
	Discounted Cash Flow analysis	41.7%
	Goal Programming	41.7%
	Cluster analysis	40.0%
Services (n = 19)	Basic statistics (averages, dispersion)	83.3%
	Discounted Cash Flow analysis	43.8%
	Smoothing methods/Moving Averages	41.0%
	Analysis of variance	40.0%

Basic statistics, inventory/stock control models, and discounted cash flow analysis are the most used techniques in the companies of the retail sector. The popularity of more advanced methods such as goal programming and cluster analysis is also noticed. Finally, companies of the tertiary sector (services) prefer quantitative techniques such as basic statistics, discounted cash flow analysis, smoothing methods / moving averages, and ANOVA.

3.5 Usage of Computer Software

Finally, looking at the particular computer software that is used to support the Management Science techniques, from Table 10 we observe the following. Spreadsheets is the most popular software among the users (45.9%). A relatively high degree of usage is also found on statistical software (23.5%). On the contrary, tailor-made software, databases and other business software have limited use at least as far as the support of quantitative methods is concerned.

Table 10. Use of Computer Software

Computer Software	Percentage Of use
Spreadsheets / Financial Analysis	45.9%
Statistical Software (SPSS, SAS, TSP, etc.)	23.5%
Tailored Made Software	17.6%
Data Bases	7.1%
Project Management & Other Business Software	5.9%
TOTAL	100.0%

4. Usage of MS Techniques: Further Analysis

Factor analysis of the questionnaire data on the usage of Management Science techniques (questions 11 & 12) was used to identify the dimensions associated with the main activities of the business organisations. Factor analysis has the ability to produce descriptive summaries of data matrices, which aid in detecting the presence of meaningful patterns among a set of variables. More specifically, we tried to identify patterns both for the activities where the quantitative techniques are used and for the knowledge and use of the techniques in general.

4.1. Use of Quantitative Techniques in Different Activities

In order to identify the main dimensions of the eleven activities listed in the questionnaire, as a first step, the principal factor solution was obtained using the varimax rotation for all the activities. Three significant factors (i.e with eigenvalues >1) emerged from the analysis, and all variables exhibited factor loadings greater than 0.500 in at least one factor. The principal factor matrix, obtained from the varimax rotation for the 11 activities, is shown in Table 11. To facilitate the identification of the factors, we have sorted the factor pattern matrix so that variables with high loadings on the same factor appear together. The factors displayed in Table 11 are ordered from left to right according to the proportion of total variance they explained. The factors are named to reflect the three operational dimensions of the business organisations as they were interpreted by the author.

The factor analysis shows that the three factors gave a satisfactory model explaining 65.5% of total variation. It is worthy to note that communalities are high in all variables indicating the significant contribution of all activities in the explanation of the variation in the usage of the techniques. A closer look at the

factors and the activities loadings on the factors, leads to the following conclusions.

Table 11. Use of Quantitative Techniques in Different Activities:
Factor Structure and Communalities

(Sorted Form of Rotated Factor Matrix)				
	Factor 1	Factor 2	Factor 3	Communi-
Activity	Management	Production	Operations	nalities
Forecasting	0.859	-0.117	0.111	0.764
Capital budgeting	0.793	0.151	0.283	0.731
Corporate planning	0.748	0.234	-0.249	0.676
Market research	0.705	-0.415	0.296	0.756
Investment appraisal	0.685	0.204	0.392	0.665
Project management	0.553	0.221	0.349	0.477
Production scheduling	0.054	0.870	0.046	0.762
Quality control	0.175	0.803	0.263	0.745
Reliability	0.332	-0.118	0.754	0.693
Break even analysis	0.174	0.258	0.648	0.517
Stock control	-0.075	0.399	0.504	0.419
Eigenvalue	4.151	1.978	1.075	7.204
Percent of total variance	37.7%	18.0%	9.8%	65.5%
Percent of common variance	57.6%	27.5%	14.9%	100.0%

The use of the quantitative techniques in the eleven activities appears to be concentrated in three main dimensions, as the factor analysis indicates. More specifically, the homogeneity among the activities of each factor, guided us to label them as factor 1: management, factor 2: production and factor 3: operations. The definition of each factor is given as follows:

Factor 1: Management. The use of the quantitative techniques in the general field of management concentrates on activities such as forecasting, capital budgeting, corporate planning, market research, investment appraisal, etc. These are the activities in which middle and upper management is involved in order to set up short-run and long-run planning of the company. It also appears that they cover all the main goals of the management, i.e. finance, marketing, investment, etc.

Factor 2: Production. The operational needs of production concentrate in few specific activities such as production scheduling and quality control. The techniques used are designed to support the production scheduling (inventory control, queuing models, etc.) and quality control (control charts, Pareto charts, etc.).

Factor 3: Operations. This factor shows efforts towards everyday operation of the company and includes a wide range of activities (reliability, break even analysis, and stock control). In other words, it includes the activities not covered by the other two factors (management and production).

4.2. Knowledge and Use of Quantitative Techniques

The analysis of patterns in the Usage of Management Science techniques was also performed by use of maximum likelihood factor analysis. It was found that 6 factors gave the most satisfactory model. The results of the factor analysis are shown in Table 12. All companies stating to be users of at least one method are included in the factor analysis leaving a sample of $n = 50$ companies. The factor analysis is based on usage of the individual techniques measured on the following scale: 1: don't know of, 2: know of and never used, 3: know of and occasionally used, and 4: know of and frequently used.

The factor analysis shows that these six factors explain 74% of total variation. The relatively high values of communalities indicate the significant contribution of all techniques in the explanation of variation in the usage of quantitative techniques. A closer look at the factors and the individual techniques loadings, lead to the following interpretation of the factors:

Factor 1: Use of Statistical Methods in Sales and Marketing. The first factor shows efforts towards forecasting of sales with use of techniques like regression, log-linear models, time series analysis, etc. We also notice techniques used in marketing such as discriminant analysis and non-parametric methods.

Factor 2: Use of O.R. Methods in Operations. This factor refers mainly to the usage of operations research techniques. The major O.R. techniques show high loadings on factor 2, and the factor obviously accounts for application in production and logistics. Network models were logical to be found in this factor.

Factor 3: General Use of MS Techniques in Production. This factor includes the major methods used in production quality control (Pareto charts, control charts, etc.). The factor also reveals a general applicability of statistical methods in production (ANOVA, simulation models, etc.).

Factor 4: General Use of Quantitative Techniques in Management. The factor reveals a general applicability of quantitative methods in management. High loadings are present in techniques such as stock control, basic statistics, and decision/risk analysis. It is logical that discounted cash flow analysis is found in this factor.

Factor 5: Use of Advanced Methods in Marketing. Two techniques, correspondence analysis and multidimensional scaling have high loads on this

factor. This signals what could be described as advanced marketing considerations. However, is not quite clear that cause-effect and expert systems appear in the same factor, though they are not irrelevant with special issues of marketing.

Table 12. Knowledge and Use of Quantitative Techniques: Factor Structure and Communalities

(Sorted form of the rotated factor matrix)							
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
Technique	Use in Sales & Marketing	Use of O.R. in Operations	General use in Production	General use in Management	Use of Advanced Methods in Marketing	Use in Quality Control	Communalities
Log linear models	0.834	0.036	0.112	0.061	0.169	-0.056	0.760
Regression models	0.731	0.221	0.333	0.038	0.083	0.320	0.806
Smoothing / MA	0.712	0.195	0.331	0.138	-0.274	0.242	0.850
Discriminant analysis	0.703	0.488	-0.030	0.017	-0.033	0.062	0.752
BJ models	0.609	-0.087	-0.013	0.023	0.462	0.394	0.834
Non-parametric methods	0.601	0.102	0.201	0.282	0.283	0.196	0.643
Integer programming	0.147	0.914	0.006	0.122	0.130	0.066	0.898
Linear programming	0.116	0.808	0.368	-0.024	-0.179	0.026	0.841
Dynamic programming	0.075	0.802	0.214	0.181	0.297	-0.068	0.844
Factor analysis	0.331	0.601	0.167	0.230	0.041	-0.031	0.680
Game theory	0.165	0.519	0.350	0.468	-0.174	0.271	0.802
Network models	0.505	0.518	0.412	0.251	-0.032	0.058	0.769
ANOVA	0.206	0.072	0.675	-0.006	0.077	0.158	0.704
Simulation models	0.221	0.322	0.658	0.436	-0.030	0.225	0.866
Queuing models	0.346	0.297	0.655	0.323	0.246	-0.231	0.855
Pareto charts	-0.149	-0.093	0.625	0.410	0.343	0.265	0.779
Quality control charts	0.085	0.382	0.615	0.163	0.177	0.315	0.710
CPM/PERT	0.277	0.319	0.584	0.106	0.184	-0.070	0.570
Stock control	-0.042	0.242	0.272	0.783	0.093	-0.080	0.786
Basic	0.305	-0.023	0.086	0.635	0.173	0.135	0.554

statistics							
Decision/risk analysis	0.255	0.244	0.189	0.630	0.186	-0.121	0.830
Goal programming	-0.249	0.404	0.113	0.543	0.411	0.012	0.823
Cluster analysis	0.042	0.020	0.057	0.535	0.501	0.134	0.658
Discounted cash flow anal.	0.488	0.309	0.087	0.534	-0.010	0.333	0.785
Cause-effect diagrams	-0.025	0.154	0.116	0.175	0.864	0.072	0.827
Multidimensional scaling	0.255	0.098	0.040	0.108	0.825	0.162	0.828
Expert systems	0.177	-0.028	0.134	0.135	0.760	0.113	0.685
Correspondence anal.	0.334	0.129	0.450	-0.006	0.616	-0.056	0.850
Taguchi methods	0.261	-0.026	0.126	0.040	0.153	0.850	0.839
Hypothesis tests	0.274	0.285	0.416	0.277	0.175	0.510	0.832
Eigenvalue	11.874	3.028	2.870	1.679	1.529	1.288	22.268
% of total variance	39.6%	10.1%	9.6%	5.6%	5.1%	4.1%	74.0%
% of common variance	53.5%	13.6%	12.9%	7.6%	6.9%	5.5%	100.0%

Factor 6: Use of Statistical Methods in Quality Control. Apart from factor 3, which refers to the general use of quantitative techniques in production and quality control, this factor includes Taguchi methods and hypotheses tests. This means that the last factor could be interpreted as a strictly quality control factor.

5. Conclusions

The usage of management science techniques in Greek companies is relatively high compared to other European countries (a survey of Danish, Scottish and UK companies [Kristensen et. al. (1993)] report an overall usage of 66%). However, the usage of more advanced techniques is very low in Greek firms and the application of MS-techniques is concentrated on a few traditional techniques, which are used mainly for forecasting purposes.

The survey also shows that there are major differences in the usage of MS-techniques depending on the type of business organisation and size of company. Another conclusion is that the main reasons for application of these techniques come from a belief and experience within the companies that MS-techniques are

efficient, computer facilities are present and their use is supported from management.

The reason for the low degree of applicability and lack of usefulness from more advanced techniques seem to be caused by a general lack of understanding of their importance and the applicability of results in decision making. These results mainly point towards more training and education in both well known and more advanced methods. Further research into those techniques, which have positive impact on company performance, is also worthwhile.

Finally, comparing the results of the present study with the ones of the earlier study in 1996, no significant differences were found. The usage of management science techniques in Greek companies practically remains the same (1996: 77%, 2002: 75%). Moreover, no differences are found in the use of quantitative techniques in the various sectors of the economy.

References

- 1) Bazzoli G.J. (1998), Getting at the Management of Care Within Managed Care, *Health Services Research*, (editorial), 32, no. 5.
- 2) Green T.B., Newson W.B. and Jones S.R. (1977), A Survey of the Application of Quantitative Techniques to Production/Operations Management in Large Corporations, *Academy of Management Journal*, Vol. 20.
- 3) Halikias J. (1999), The Use of Quantitative Techniques by Business Organizations in a Less Industrialized Country: The Case of Greece, *Integrating Technology and Human Decisions: Global Bridges into the 21st Century*, Conference Proceedings, 5th International Conference of the Decision Sciences Institute, (Athens).
- 4) Halikias J., Bourantas D., Jones C., Wisniewski M., Kristensen K. and Madsen H. (1990), The Use of Management Science Techniques in Europe: A Preliminary Report, *Operations Research Conference*, (Vienna).
- 5) Halikias J., Bourantas D., Jones C., Wisniewski M., Kristensen K. and Madsen H. (1991a), Use of Management Science Techniques with Special Emphasis on the Use of Statistical Methods in Marketing, *Marketing Thought Around The World*, Conference Proceedings XX EMAC Conference, Vol. I, (Dublin).
- 6) Halikias J., Bourantas D., Jones C., Wisniewski M., Kristensen K. and Madsen H. (1991b), Application of Statistical and Other Management Science Techniques in European Organizations, *Bulletin of the International Statistical Institute*, Vol. 2, 48th Session, (Cairo).
- 7) Halikias J., Bourantas D., Jones C., Wisniewski M., Kristensen K. and Madsen H. (1992), The Use of Management Science Techniques with Special Emphasis on the Use in Different Functional Areas: Some

Preliminary Results, *EMSS Working Paper No. 3, The Aarhus School of Business*.

- 8) Kathawala Y. (1988), Applications of Quantitative Techniques in Large and Small Organisations in the United States: An Empirical Analysis, *Journal of the Operations Research Society*, Vol. 39.
- 9) Kristensen K., Madsen H. and Ostergaard P. (1990), The Use of Management Science Techniques: An Overview, *EMSS Working Paper No. 1, The Aarhus School of Business*.
- 10) Kristensen K., Madsen H., Ostergaard P. and Wisniewski M. (1993), The Use of Quantitative Techniques by Business Organisations in Denmark, Scotland and the United Kingdom, *EMSS Working Paper No. 8, The Aarhus School of Business*.
- 11) Naude P., Stray S. and Wegner T. (1991), The Penetration of Quantitative Methods into Management Decision Making in the United Kingdom, *OMEGA*, Vol. 19.
- 12) Vinent G. (1994), Data Management: Executive Aid, *Executive Development*, (Bradford).