Operations research/management science in the United Arab Emirates

Current status and future diffusion and challenge

Darwish Abdulrahman Yousef

*Department of Business Administration, College of Business and Economics,
United Arab Emirates University, Al-Ain, United Arab Emirates*

Abstract

Purpose – The purpose of this paper is to present results of a survey that investigates levels of awareness and usage of Operations Research (OR)/Management Science (MS) in industrial and service organizations in the United Arab Emirates (UAE).

Design/methodology/approach – A sample of 450 individuals at different management levels were co-opted and descriptive statistical analyses were employed.

Findings – Results reveal that the majority of the respondents are aware of OR/MS and use it to some extent. Results also showed that the most common OR/MS techniques are: decision analysis, cost benefit analysis, computer simulation, financial modeling, and risk analysis. The most common application areas are: project evaluation, sales analysis, manpower planning, accounting procedures, and stock control.

Research limitations/implications – This study like any other study has some limitations. First, the sample size is somewhat small, and therefore this might limit the generalization of the results of this study. Second, this study is confined to medium sized and large organizations and in turn it excluded small organizations. This might also affect the generalization of the results. Finally, this study is confined to certain emirates and in turn it might not provide clear picture of OR/MS awareness and use in the UAE as a whole.

Practical implications – The findings of this study have some implications for both practitioners and researchers. For decision makers (practitioners) they will be aware of the type of problems being solved using OR/MS techniques and type of OR/MS techniques being used to solve those problems. Furthermore, decision makers will be aware of the barriers to the wide use of OR/MS techniques. This will help them identify means of overcoming those barriers. For researchers/academicians, they will be aware of OR/MS techniques which are widely used in the country and consequently, more emphasis will be placed on those techniques.

Originality/value – Due to lack of recent survey type studies in the Arab countries in general and in the UAE in particular, this study is the first which provides a comprehensive picture of the status of OR/MS in the UAE at the present time.

Keywords Operational research, Management science, United Arab Emirates, Developing countries

Paper type Research paper

Introduction

Operations Research – also known as Operational Research (OR) or Management Science (MS) – was first introduced in the western world during the Second World War, and since then it has flourished and widespread in almost all aspects of life. This might be as a result of the awareness of the significance of OR/MS for improving the efficiency of decision-making and problem solving process. OR/MS is especially

significant to developing countries where lack of resources is the norm and every possible improvement to efficiency is needed due to relative shortage of resources and/or shortage of human capital. However, although OR/MS was introduced in a number of developing or newly industrialized countries since the mid-fifties, the status of OR/MS in these countries is not up to expectation due to a number of problems and obstacles such as insufficient qualified OR personnel, lack of accurate data, lack of management support, etc.

An extensive literature review of previous research revealed lack of surveys with regard to OR/MS awareness, levels of usage, techniques used, application areas, and other related issue in the Arab world in general and in the UAE in particular, except the surveys carried out by Kemp and Yousef (1995) and Yousef (2000) in the UAE. Therefore, the present study aims at exploring the present status of OR/MS in the UAE in terms of awareness of OR/MS, sources of acquiring knowledge in OR/MS, willingness to learn OR/MS, degree of OR/MS usage, techniques used, application areas, perceived benefits of using OR/MS.

The paper is organized as follows: next section presents a review of literature, and then the next section describes the methodology, followed by the results, and finally the conclusion.

Literature review
Literature review reveals lack of surveys in the Arab World except those carried out by Kemp and Yousef (1995) and Yousef (2000) in the United Arab Emirates (UAE). However, a number of authors have addressed OR/MS in the Arab countries from either a conceptual perspective or an empirical perspective. Bazaraa and Bouzaher (1981) formulated a multi-regional single time period linear goal programming model for agricultural planning in Egypt. In Egypt also, Elshafei (1982) presented a number of case studies carried out at the OR Centre of the Institute of National Planning.

Saaty (1982) reported the application of OR approach to tackle transportation problem in Sudan, whereas Farhat (1986) applied linear programming to an Iraqi state farm. On the other hand, Smith (1987) looked at the possibilities for OR practice and education in the Hashemite Kingdom of Jordan, and Babes and Sarma (1991) investigated health centre queues in Algeria. Khorshid (1993) considered fisheries in Kuwait, while Al-Faraj (1993) developed a panning model for determining the location and size of fixed traffic center (FTC) through two stages. In the first stage, the optimal regional sites of traffic patrol units (TPU) are determined using a goal integer linear programming approach. Based on the results of the model at the first stage and other relevant data, the second stage determines the location and size of the FTC using a binary integer linear programming technique. The model has been used to determine the regional sites of TPU and the FTC for the Dammam Metropolitan, Saudi Arabia utilizing historical data. Abu-Taleb and Mareschal (1995) described the application of the PROMETHEE V multicriteria method to evaluate and select from a variety of potentially feasible water resources development options, so that the allocation of limited funds to alternative development projects and programs can proceed in the most efficient manner. The procedure was tested using data from Jordan.

In a study in the UAE, Badri (1996) formulated a multiobjective zero-one course scheduling model and tested the model using data from the UAE University.

Al-Shamari (1999a) used a modified model of data envelopment analysis (DEA) to evaluate the operation efficiency of a sample of 55 manufacturing organiz0ations in Jordan. Likewise, Al-Shammari (1999b) measured and evaluated the productive efficiency of health-care organizations (hospitals) in Jordan using a multicriteria (DEA) methodology. Using similar technique, (DEA), Zaibe and Dharmapala (1999) analyzed horticultural growers' technical efficiency for a sample of farmers in the Batinah region of Oman.

In another study in the UAE, Badri *et al.* (2000) used the path analytical model to study the effects of environment variables such as government laws and political consideration on the choice of operations strategy and performance for a sample of UAE manufacturers. The paper by Bolat (2000) addressed the problem of assigning arriving fights to the available gates at an airport using a mixed-binary mathematical model with a quadratic function for minimizing the variance of idle times at the gates. The procedure was tested using real life data obtained from the Saudi Arabian Airlines.

Saber and Ghosh (2001) addressed the problem of assigning undergraduate students to academic major areas at a Middle Eastern business school using linear programming which maximizes the overall value of the assignments to the students and the academic units concerned. Zaibet *et al.* (2004) investigated socio-economic changes in Jabal Akhdar, Oman, and assessed their impact on economic performance using the concept of technical efficiency for a sample of 43 farmers producing goats. DEA based on the Charnes-Cooper-Rhodes (CCR) and Banker-Charnes-Cooper (BCC) models was used to derive technical efficiency measures and Banker-Thrall model was used to compute returns-to-scale (RTS) intervals. Then the two-stage ordinary least square (OLS) method was used to determine the influential inputs.

In a study in Kuwait, Al-Sharrah *et al.* (2006) presented the application of multi-objective optimization tools for planning of a mixed-integer model of a petrochemical industry to arrive at a small set of good solutions out of the Pareto optimal solutions. Their proposed procedure has been applied to the petrochemical industry in Kuwait. In another study in Kuwait, Al-Yakoob, and Sherali (2006) constructed mathematical programming models for assigning faculty members to classes taking into account certain specialized central policies at Kuwait University. The procedure was tested using a number of case studies related to the Department of Mathematics and Computer Science at Kuwait University. Similarly, Al-Yakoob, and Sherali (2007) formulated a mathematical programming model that assigns offered classes to time-slots and addresses gender issues by defining appropriate surrogate constraints along with objective penalty terms. Their model was tested using a number of case studies related to Kuwait University.

Mostafa (2007a) used DEA to evaluate the relative efficiency of GCC banks; Mostafa (2007b) also used DEA method to evaluate the relative efficiency of Arab banks. Furthermore, Mostafa (2007c) used production frontier analysis to measure the relative market efficiency of 62 listed companies in Egypt. Mostafa (2009) also investigated the efficiency of top Arab banks using two quantitative methodologies, namely DEA and neural networks. By the same token, Mostafa (2007b) used DEA method to evaluate the relative efficiency of Arab banks. Alardhi and Labib (2008) developed zero-one integer linear programming model to tackle preventive maintenance scheduling of cogeneration plants, which produce both electric power and desalinated water. To test the model,

a scheduling of preventive maintenance task for Kuwait cogeneration plants is investigated. The study by Emrouznejad and Anouze (2008) aimed to benchmark the top Arab banks using DEA technique and to compare the results with that of recently published studies.

Methodology

Sample and data collection

The Chamber of Commerce and Industry in each emirate produces a list of all industrial and business organizations operating in that emirate. From these lists, a random sample of 150 organizations in the emirates of Abu Dhabi (including the city of Al-Ain), Dubai, Sharjah and Ras Al-Khaimah was drawn. Then a random sample of 450 individuals at different management levels in these organizations was selected and personally administered questionnaires were distributed by the author and his assistants. Of the four hundred fifty questionnaires distributed, only two hundred twenty five questionnaires were returned, resulting in a 50 per cent response rate. Of the returned questionnaires, only one hundred eighty six questionnaires were usable. The questionnaire was administered in English. The main characteristics of the sample are presented in Table I.

Measures

A questionnaire was designed by the researcher to assess the awareness and usage of (OR)/(MS) in the UAE. The questionnaire consists of three parts:

(1) Part one consists of questions regarding the extent of awareness of OR/MS, willingness to learn it if not currently aware of it, the reasons for not willing to learn it, the sources of acquiring knowledge in OR/MS, the extent of using OR/MS, OR techniques being used and the areas of application of these techniques, the benefits of using it, and the length of time it has been used.

(2) Part two was directed to those who are currently not using it although they are aware of it asking them about the reasons for not using it, are they planning to use in the future and if not, what are the reasons for not planning to use it in the future.

(3) Finally, Part three consists of general information both about the organization and the individual completing the questionnaire.

The questionnaire was revised by number of experts and number of changes that have been introduced based on their recommendations.

Analysis

Since, this study is an exploratory type, descriptive statistics including means, standard deviations, frequencies and crosstabs were used. These types of statistical analysis suit the purpose of this study.

Results

OR/MS awareness

The survey conducted revealed that of 186 respondents, 137 are aware of OR/MS, while 49 are not. Table II shows the degree of awareness in OR/MS.

Characteristics	Frequency	Per cent
Respondents age		
Less than 30 years	78	42
30-45 years	71	38
Over 45 years	37	20
Gender		
Male	157	84
Female	29	16
Nationality		
UAE	83	44
Arab	55	30
Non-Arab	48	26
Organisation's activity type		
Manufacturing	30[a]	16
Service	112	60
Both	44	24
Organisation ownership		
Public	57	31
Private	88	47
Joint	41	22
Educational level		
Less than university degree	13	7
University degree	141	76
Postgraduate	32	17
Number of years in current position		
Less than five years	107	58
Five-ten years	54	29
Over ten years	24	13
Number of years in current organization		
Less than five years	63	34
Five-ten years	65	35
Over ten years	58	31
Organisation age		
Less than five years	30	16
Five-ten years	67	36
Over ten years	89	48
Organisation size		
Less than 50 employees	33	18
50-100 employees	37	20
Over 100 employees	116	62

Note: [a]Number of respondents

Table I.
The main characteristics
of the sample

Levels of awareness	Frequency	Per cent
Not at all	48	26
Slightly	47	25
Moderately	38	20
More than moderately	38	20
Extremely	15	8
Total	186	100

Table II.
Levels of awareness
in OR/MS

Table II indicates that 48 percent of the respondents are moderately or more than moderately aware of OR/MS. This might indicate that OR/MS is gaining acceptance in the UAE organizations and in turn might increase the level of usage of OR/MS.

Sources of acquiring OR/MS knowledge
Table III presents the main sources of acquiring OR/MS knowledge.

The survey revealed the following sources of acquiring OR/MS knowledge: taking courses in OR/MS was mentioned 88 times (about 47 per cent), training in OR/MS mentioned 69 times (37 per cent), use of OR/MS mentioned 84 times (45 per cent), and reading books and journals mentioned 76 times (41 per cent).

Willingness to learn OR/MS
Table IV shows the willingness of those who are currently not aware of OR/MS to learn about OR/MS.

About 59 percent of those who are currently not aware of OR/MS are willing to learn about it. This, undoubtedly, is a positive attitude which might lead to wide acceptance and use of OR/MS in the future.

OR/MS usage
Under this heading a number of topics are examined: degree of use, techniques used, application areas, advantages of using OR/MS techniques as perceived by users, and length of time OR/MS techniques have been used.

Degree of use. Table V shows the degree of OR/MS use in the organizations in the UAE.

Source of acquiring OR knowledge	Frequency	Per cent
Through taking courses	88	47
Through training	69	37
Through reading books & journals	76	41
Through practice	84	45

Table III.
Main sources of acquiring OR/MS knowledge

Willingness to learn OR/MS	Frequency	Per cent
Yes	29	59
No	20	41
Total	49	100

Table IV.
Willingness to learn OR/MS

Degree of use	Frequency	Per cent
Not at all	35	25
Slightly	31	22
Moderately	32	23
More than moderately	25	18
Extremely	15	12
Total	138	100

Table V.
Degree of use of OR/MS techniques

This table indicates that 75 percent of the users use OR/MS slightly or more. This might lead to the conclusion that the level of OR/MS usage in the UAE is reasonably high.

Techniques used. Table VI lists techniques being used. This table indicates that the five most popular OR/MS techniques in the UAE are: decision analysis, cost benefit analysis, computer simulation, financial modeling, and risk analysis in that order.

This might due mainly to the relative simplicity of these techniques, and probably because most of these techniques derive their data input directly from the accounting system. Furthermore, the environment also plays a significant role in the choice of the techniques. For example, Clayson (1980, p. 294) argued that ". . . it is the nature of the local problem-environment that determines what OR techniques are relevant . . .", and Papoulias (1984, p. 584) stressed that "the OR methodology and the OR techniques used must fit the needs of the society and the economy in the context of which they are going to be utilized".

These results differ from those of Kemp and Yousef (1995) who found that the most popular techniques in the UAE are: inventory theory, forecasting models, cost benefit analysis, linear programming and decision theory, and those of Yousef (2000) who found that the most popular OR/MS techniques in the UAE are: cost benefit analysis, statistical analysis, forecasting models, linear programming, computer simulation, and

Techniques	Mean	SD	Rank
Decision analysis	5.10	1.92	1
Cost-benefit analysis	4.92	1.91	2
Computer simulation	4.89	2.06	3
Financial modeling	4.87	1.87	4
Risk analysis	4.86	1.96	5
Decision tree	4.86	2.13	5
Statistical analysis	4.74	2.03	7
Inventory theory	4.60	1.92	8
Multi-attribute decision-making	4.52	2.12	9
Scenario analysis	4.41	2.04	10
Goal programming	4.21	2.09	11
Transportation models	4.20	1.87	12
Minimal spanning tree	4.19	2.11	13
Shortest route technique	4.15	2.18	14
Integer programming	4.09	1.95	15
Assignment models	4.09	1.99	15
Linear programming	3.95	1.98	17
Mixed integer programming	3.98	1.93	18
Maximum flow	3.97	2.08	19
Markovian decision process	3.90	1.97	20
Monte Carlo method	3.85	2.04	21
PERT	3.80	1.92	22
CPM	3.73	1.93	23
Dynamic programming	3.76	1.94	24
Queuing theory	3.72	2.04	25
Reliability models	3.65	2.03	26
Non-linear programming	3.62	1.94	27
Fuzzy theory	3.57	1.96	28
Game theory	3.56	1.96	29

Table VI.
OR/MS techniques being
used

decision analysis. Those differences might be due in part to the changes in the structure of the economy and in turn in the problems faced by the organizations and to the level of the country's development.

Application areas. Table VII lists areas of applications of OR/MS techniques reported by the respondents.

The most common application areas are: project evaluation, sales analysis, manpower planning, accounting procedures, and stock control in that order.

In order to remain competitive and hence to survive, organizations need to operate efficiently. All of these application areas are used to improve the efficiency of operation of the companies concerned. The other application areas also contribute to long and short-term efficiency to a greater or lesser extent.

This might lead one to believe that certain characteristics make some OR/MS techniques more likely to be adopted than others in the UAE. This may be explained by the fact that OR/MS users in developing countries and the UAE in particular have little knowledge and experience in OR/MS. Other contributory factors might be the lack of OR/MS training, and inadequate OR/MS education. However, the results of this study in this regard differ from those of Kemp and Yousef (1995) who found that the most common application areas in the UAE are: forecasting demand, profitability analysis, allocating resources, product mix, and stock control and those of Yousef (2000) who found the most common application areas in the UAE are: forecasting, quality control, project management, inventory management, and production scheduling.

Application area	Mean	SD	Rank
Project evaluation	5.33	1.90	1
Sales analysis	5.24	1.97	2
Manpower planning	5.17	2.02	3
Accounting procedures	5.15	2.02	4
Profitability analysis	5.13	2.02	5
Stock control	5.13	1.99	5
Project control	5.05	2.01	7
Supply planning	5.05	2.04	7
Production scheduling	5.02	2.05	9
Capital budgeting	5.00	2.10	10
Quality control	5.00	2.14	10
Quality control	5.00	2.14	10
Forecasting demand	4.97	2.09	13
Operation planning	4.93	2.09	14
Allocating resources	4.90	2.07	15
Price setting	4.88	2.10	16
Maintenance & repair	4.84	2.15	17
Locating warehouses	4.80	2.13	18
Investment appraisal	4.79	2.13	19
Assignment problems	4.76	2.20	20
Capacity planning	4.76	2.16	20
Distribution problem	4.75	2.06	22
Product design	4.68	2.67	23
Product mix problems	4.60	2.16	24
Plan location	4.57	2.24	25

Table VII.
Application areas
of the adopted OR/MS
techniques

Those differences might also be attributed also to the structure of the economy and level of the country's development.

Advantages of using OR/MS. Table VIII lists the advantages of using OR/MS as perceived by the users of OR/MS.

This table shows that the most common three advantages of using OR/MS as perceived by users are: increase efficiency, improve competitive advantage and improve productivity in that order.

Length of time OR/MS techniques are used. Table IX presents length of time OR/MS techniques are used.

As it is clear from Table VIII, about 63 percent of the respondents reported that they have been using OR/MS techniques for five years or more. This is another indication that OR/MS has gained wide acceptance in the UAE organizations.

OR/MS personnel

Those personnel who have knowledge in OR/MS were of different nationalities, academic backgrounds and age (47 per cent of those with OR/MS knowledge are UAE nationals). The survey also revealed that of those with knowledge in OR/MS, 76 per cent are graduates, and 18 per cent postgraduates, about 69 per cent are 30 years old or over. On the other hand, the users of OR/MS were also of different nationalities, academic backgrounds and age. About 48 per cent are UAE nationals, 84 per cent are graduates, 11 per cent are postgraduates, and 72 per cent are 30 years old or over.

Barriers to the widespread use of OR/MS techniques in the UAE organizations

It appears that there are a number of factors which prevent the widespread adoption of the use of OR/MS techniques in the UAE at present. About 25 per cent of the survey respondents are not currently using any form of OR/MS. Table X presents the reasons for not adopting the use of OR/MS.

The most common reasons for not using OR/MS as reported by those with knowledge in OR/MS are: doing well without OR/MS, not used by similar

Advantages	Mean	SD	Rank
Increase efficiency	6.02	1.13	1
Improve competitive advantage	5.94	1.28	2
Improve productivity	5.92	1.32	3
Improve profitability	5.89	1.30	4
Improve capacity utilization	5.82	1.32	5
Increase sales	5.80	1.53	6
Reduce costs	5.79	1.28	7

Table VIII.
Advantages of using OR/MS

Length of time	Frequency	Per cent
Less than five years	38	37
Five-ten years	42	41
Over ten years	23	22
Total	103	100

Table IX.
Length of time OR/MS techniques being used

organizations, lack of top management support, lack of data required to use OR/MS and do not believe in OR/MS.

The real barrier to the widespread use of OR/MS might be due to the basic lack of knowledge and scope of the discipline in the UAE, which makes it difficult for the organizations to decide whether they have applicable problems.

Conclusion

This survey covered a sample of industrial and service organizations in the UAE. The survey was mainly conducted by use of a questionnaire. This led to a very high response rate. The survey gives a view of OR/MS use and practice in the UAE at present. Results revealed that there is a quite high level of awareness of OR/MS and a reasonable level of usage.

One can conclude that OR/MS in the UAE is still in its infancy/formation stage but there are positive indications that it will become better understood and more widely used. Consequently, the future of OR/MS in the UAE is bright. The UAE follows an open door economic policy and this encourages the use of advanced tools and techniques as a means of achieving efficiency, so OR/MS techniques can provide the help needed in this respect.

This study has implications for both decision makers (managers) and academicians. For decision makers (managers) they will be aware of the type of problems being solved using OR/MS techniques and types of OR/MS techniques being used to solve those problems. Furthermore, decision makers (managers) will be aware of the barriers to the wide use of OR/MS approach. This will help them identify means of overcoming those barriers. For academicians, they will be aware of OR/MS techniques which are widely used in the country and consequently, they will place more emphasis on those techniques.

This study like any other study has a number of limitations. First, the sample size is somewhat small, and therefore this might limit the generalization of the results of this study. Second, this study is confined to medium sized and large organizations and in turn excluded small organizations. This might also affect the generalization of the results. Finally, this study is confined to certain emirates and in turn it might not provide clear picture of OR/MS awareness and use in the UAE as a whole.

A number of future studies suggest themselves. For example, an investigation of the impacts of a number of variables such as organization's size, nationality, level of technology, decision maker's background and nationality on the use of OR/MS is

Reasons	Mean	SD	Rank
Doing well without OR/MS	5.00	1.31	1
Not used by similar organizations	4.64	1.69	2
Lack of top management support	4.06	1.84	3
Lack of data required to use OR/MS	3.97	1.89	4
Do not believe in OR/MS	3.94	1.57	5
Lack of appropriate computerized OR software	3.92	1.38	6
Lack of OR/MS professionals	3.69	1.79	7
Too costly	3.64	1.50	8
Lack of financial resources	3.47	1.84	9

Table X.
Reasons for not using
OR/MS techniques

worthwhile. Furthermore, a comparison of the use of OR/MS in the UAE organizations with the use of OR/MS in GCC organizations is of interest.

References

Abu-Taleb, M.F. and Mareschal, B. (1995), "Water resources planning in the Middle East: application of the PROMETHEE V multicriteria method", *European Journal of Operational Research*, Vol. 81, pp. 500-11.

Alardhi, M. and Labib, A.W. (2008), "Preventive maintenance scheduling of multi-cogeneration plants using integer programming", *Journal of the Operational Research Society*, Vol. 59, pp. 503-9.

Al-Faraj, T.N., Alidi, A.S. and Al-Ibrahim, A.A. (1993), "A planning model for determining the optimal location and size of traffic centers: the case of dammam metropolitan, Saudi Arabia", *European Journal of Operational Research*, Vol. 66, pp. 272-8.

Al-Shamari, M. (1999a), "Optimization modelling for estimating relative efficiency with application to industrial companies", *European Journal of Operational Research*, Vol. 115, pp. 488-96.

Al-Shammari, M. (1999b), "A multi-criteria data envelopment analysis model for measuring the productive efficiency of hospitals", *International Journal of Operations & Production Management*, Vol. 19, pp. 879-90.

Al-Sharrah, G.K., Hankinson, G. and Elkamel, A. (2006), "Decision-making for petrochemical planning using multi-objective and strategic tools", *Chemical Engineering Research and Design*, Vol. 84, pp. 1019-30.

Al-Yakoob, S.M. and Sherali, H.D. (2006), "Mathematical programming models and algorithms for a class-faculty assignment problem", *European, Journal of Operational Research*, Vol. 173, pp. 488-507.

Al-Yakoob, S.M. and Sherali, H.D. (2007), "A mixed-integer programming approach to a class timetabling problem: a case study with gender policies and traffic considerations", *European Journal of Operational Research*, Vol. 180, pp. 1028-44.

Babes, M. and Sarma, G. (1991), "Out-patient queues at the Ibn-Rochd health centre", *Journal of the Operational Research Society*, Vol. 42, pp. 845-55.

Badri, M.A. (1996), "A two-stage multiobjective scheduling model for [faculty-course-time] assignments", *European Journal of Operational Research*, Vol. 94, pp. 16-28.

Badri, M.A., Davis, D. and Davis, D. (2000), "Operations strategy, environment uncertainty and performance: a path analytical model of industries in developing countries", *Omega*, Vol. 28, pp. 155-73.

Bazaraa, M. and Bouzaher, A. (1981), "A linear goal programming model for developing economies with an illustration from the agricultural sector in Egypt", *Management Science*, Vol. 27, pp. 396-412.

Bolat, A. (2000), "Procedures for providing robust gate assignments for arriving aircrafts", *European Journal of Operational Research*, Vol. 120, pp. 63-80.

Clayson, J.E. (1980), "How relevant is operational research to development? The case of Kenyan industry", *Journal of the Operational Research Society*, Vol. 31, pp. 293-9.

Elshafei, A.N. (1982), "OR in developing countries: some experience with applying OR Egypt national planning studies", in Luck, G.M. and Walsham, G. (Eds), *Selected Readings in Operational Research for Developing Countries*, the Operational Research Society, Birmingham, pp. 79-87.

Emrouznejad, A. and Anouze, A.L. (2008), "A note on the modeling the efficiency of top Arab banks", *Expert Systems with Applications* (in press).

Farhat, M.Y. (1986), "A linear programming analysis of an Iraqi state farm", Working Paper 86-3, Department of Economics and Management Science, University of Keele, Keele.

Kemp, B.J. and Yousef, D.A. (1995), "OR in practice: results of a survey in the United Arab Emirates", *European Journal of Operational Research*, Vol. 80, pp. 25-33.

Khorshid, M. (1993), "Fisheries development in Kuwait: an integer programming model", *European Journal of Operational Research*, Vol. 64, pp. 38-353.

Mostafa, M.M. (2007a), "Modeling the efficiency of GCC banks: a data envelopment analysis approach", *International Journal of Productivity and Performance Management*, Vol. 56, pp. 623-43.

Mostafa, M.M. (2007b), "Benchmarking top Arab banks' efficiency through efficient frontier analysis", *Industrial Management & Data Systems*, Vol. 107 No. 6, pp. 802-23.

Mostafa, M.M. (2007c), "Evaluating the competitive market efficiency of top listed companies in Egypt", *Journal of Economic Studies*, Vol. 34, pp. 430-52.

Mostafa, M.M. (2009), "Modeling the efficiency of top Arab banks: a DEA – neural network approach", *Expert Systems with Applications*, Vol. 36 No. 1, pp. 309-20.

Papoulias, D.B. (1984), "Operational research and socio-economic development", *Journal of the Operational Research Society*, Vol. 35, pp. 579-86.

Saaty, T.L. (1982), "The sudan transport study", in Luck, G.M. and Walsham, G. (Eds), *Selected Readings in Operational Research for Developing Countries*, the Operational Research Society, Birmingham, pp. 91-113.

Saber, H.M. and Ghosh, J.B. (2001), "Assigning students to academic majors", *Omega*, Vol. 29, pp. 513-23.

Smith, D.K. (1987), "Operational research in a developing country: the example of Jordan", *Journal of the Operational Research Society*, Vol. 38, pp. 577-84.

Yousef, D.A. (2000), "The impact of some factors on the awareness and usage of management science techniques in a developing country: an exploratory study", *Al Ta'awon Al Sina'e*, Vol. 20, pp. 3-24.

Zaibe, L. and Dharmapala, P.S. (1999), "Efficiency of government-supported horticulture: the case of Oman", *Agricultural Systems*, Vol. 62, pp. 159-68.

Zaibet, L., Dharmapala, P.S., Boughanmi, H., Mahgoub, O. and Al-Marshudi, A. (2004), "Social changes, economic performance and development: the case of goat production in Oman", *Small Ruminant Research*, Vol. 54, pp. 131-40.

Corresponding author

Darwish Abdulrahman Yousef can be contacted at: dayousef@uaeu.ac.ae

الناشر للاستشارات

www.man