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Operational Research in a Developing Country: The Example of Jordan

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Much interest has been expressed in recent years in the problem of applying operational research in less developed countries. This paper examines the problems and possibilities of developing an interest in operational research in one such country, the Hashemite Kingdom of Jordan.

Key words: developing countries, Jordan, philosophy of OR

INTRODUCTION

Operational research is a western science. Its origins may stem from the wartime experiences of the allied military effort, but the roots go far deeper. Behind the practical developments which have been characteristic of OR in the post-war era, there is an underlying social philosophy which has permitted scientific management and analytical decision-making to flourish. This creed has several facets which are not shared by all societies, and in consequence the ideas of OR may not transfer readily from western nations to others. With improved international communications, and especially the availability of cheap computer programs to apply OR *techniques*, there is a need for management scientists to proceed with caution in less developed countries. It is easy to prescribe a simple technique whilst failing to diagnose a deeper, more serious, problem in management.

Management science flourishes on the twin foundations of measurement of the past and present, and planning for the future (especially for alternative futures). Implicit in this are commitments to each one. There must be a readiness to take measurements, to make them accurately, and to record them for analysis and use. The widespread acceptance of databases as being good and desirable is an instance of this. On the other hand there must be a willingness to make plans for the future in an atmosphere where discussion and comparisons can take place and decisions be made on the basis of reasoning. Coupled with this is the acceptance of the need to take time over the planning process as an essential part of the manager's task.

Such foundations are not universal. Measurement may be unreliable or non-existent, and suggestions that it should be done receive derisive treatment. Analysis and experimentation may be revolutionary ways of looking at an enterprise. Planning for the future carries the implication that one can change things by deliberate effort. To some people this runs counter to social and/or religious beliefs which are deep-rooted. The problems are most evident in less developed countries, and this paper considers the example of the Hashemite Kingdom of Jordan (usually referred to as Jordan).

In the last decade there has been a large increase in the literature concerned with the place and practice of operational research in developing countries. Kemball-Cook and Wright[1] presented a survey which considered the contribution of OR to development and the extent of the influence of published work. Luck and Walsham[2] drew together some published material, and the *Journal of the OR Society* has published a special issue[3] devoted to the subject. Throughout this extant literature, it is possible to determine a common thread of 'appropriateness' To be successful in any application, operational research must be appropriate to the problem, to the decision-makers and to the environment (which includes the culture). Thus it is not enough to transplant a solution to a problem across national boundaries; the reasoning and analysis which produced the model which led to the solution must be re-examined in the light of the new circumstances. This applies whatever the national boundaries may be.

JORDAN'S ECONOMY

There are many factors which make the Jordanian economy an unusual one. The nation was created after the post-First World War Anglo-French mandates over the middle-eastern area. Since 1952, when King Hussein's reign started, the country has been ruled benevolently and with an active economy. The 1967 Arab–Israel war seriously affected this, as Israel annexed the west-bank territories. This deprived Jordan of its agriculture and industry, and of the important tourist centres of Jerusalem and other Christian sites, and created a large influx of refugees. The tension in the Middle East has had other consequences for Jordan. Civil war in the Lebanon has led to Amman, the capital, being selected as the regional centre for organizations which had been based in Beirut. Fighting between Iraq and Iran to the east has brought more shipping to the seaport of Aqaba (the country's only access to the sea) and more road transport to Iraq through the deserts of eastern Jordan. The oil-rich residents of Saudi Arabia and the Gulf States come to Jordan as tourists, escaping the worst of the summer's oppressive heat and stimulating the economy.

The country has few national resources. Much of the land area is arid desert, damaged by millennia of over-grazing and other effects of human habitation. Jordan is the world's third largest producer of potash, and this industry is steadily developing, both in the volume of output and in the range of products produced. Exploration for oil continues, but reserves are small. Water for agriculture and consumption is very scarce, and its availability depends on fluctuating winter rainfall.

The industrial base of manufacturing is limited. Apart from the potash industry, there is a large cement company, a petroleum refinery with associated chemical plants, and smaller factories for the domestic requirements for food, clothing, cigarettes and other products.

The economy flourishes as a result of two unusual features: first are the subsidies, grants and loans received from other countries, both neighbours and in the west; second are the remittances received from the quarter of a million Jordanians working overseas, principally in the Gulf region and its oil industry. In consequence, the nation has a buoyant economy.

The visitor to Amman will be struck both by the frenzy of construction work that is one manifestation of this boom, and by the roads filled with new, expensive cars, which is another. Less apparent, but more relevant to the economy, is the over-large percentage of the workforce employed in the service sector, in public and private. About 55–60% is so employed, a figure which would be difficult to sustain in the absence of the funds from individuals and governments abroad. In spite of appearances, there is poverty where the wealth created by development has made little impact on some parts of the society.

MANAGEMENT

Management in Jordan is typical of that in an Arab country. It is affected by the culture and way of life, and so is different in several respects from that of western countries. In a recent study, Al-Faleh[4] identified several characteristics of Jordanian management, including:

(i) the importance of status over ability,
(ii) a rigid hierarchy,
(iii) the strength of kinship ties in decision-making,
(iv) reactive management.

These are reinforced by the more general findings of Muna[5] in a wider study of Arab management. His work emphasized that many executives favour a consultative style of management, with rare delegation.

There are changes, with increased western influence on the style of management. This arises in four ways:

(i) exposure of practising managers to training courses in Jordan, organized either internally (in a limited number of cases) or externally by one of the several Amman-based management centres;

(ii) education overseas, principally in the USA and Europe, leading to a steady flow of academically qualified MBAs (or higher) into the economy;
(iii) international trade, with executives from overseas being based in Amman, and Jordanian managers travelling on business abroad;
(iv) the increased use of computers as business tools, using software developed in the west for western-style management problems.

In spite of such influences, the objectives of managers have not necessarily changed very much. Economic growth does not appear to be a driving force in industrial development. It should be remembered that (as in many developing countries) industrialization has been very rapid and very recent; there has not been the equivalent of a gradual industrial revolution, with its consequent gradual change of outlook among managers. Many enterprises are less than a generation away from an agricultural economy in which trading was characterized by the bazaar merchant and his attitudes. These have not been completely lost in such a short time. Quick, high profits, small-scale production and short-term gain are unspoken objectives. Investment in the future is rare, and savings are generally spent on displays of wealth (such as cars, housing and jewelry—the last echoing the Bedouin tradition of gold ornamentation). A small amount of trading takes place on the Amman Stock Market. But generally, it is left to the government and to external funding to lay the foundations for future economic security.

Planning for the future is, consequently, not an integral part of managerial style. Although lip-service is paid to the idea in public, in practice the social pressure of "Insh 'Allah" (if God is willing) takes over. It can be justified by reference to the uncertain future of the country in the midst of the turmoil of the Middle East. But such justification is often a veneer over a desire to conform to norms of social and religious behaviour.

THE PLACE OF OPERATIONAL RESEARCH IN JORDAN

Scientific analysis of business enterprises is often oriented towards planning for the future, and trying to isolate the best decisions. In a society such as Jordan, this is revolutionary. "It implies that somehow one can alter his environment through conscious action. To Jordanian society in general such an attitude is still unfavourable, and, in some cases, it is considered dangerous and heretical."[6] (Although this was written in 1970, it is still valid.)

Operational research methods in the west have been classified as predictive or optimizing. (See, for instance, Buffa and Dyer.[7]) Predictive models allow decision-makers to explore the future and answer questions of the nature "What happens if...?" Optimizing models seek to determine the best set of decisions for a given problem. Predictive models include simulation models, forecasting techniques and queue models. Optimizing models include mathematical programming, scheduling methods and rules for inventory management. It is accepted that this classification is not a rigid one; predictive models may be optimized and optimizing models used to give predictions.

With the nature of management in Jordan, it appears that predictive models will be of more use than optimization tools. They do not remove the decision-taking responsibility from the manager, but act to provide extra information. Sagasti,[8] writing in the context of development in South America, has made similar comments about the pitfalls of an over-emphasis on techniques of optimization.

But even predictive models can only be used in an environment which accepts their use. In Jordan, as elsewhere, the characteristics of the business environment must include:

(1) having a commitment to efficiency;
(2) being aware of the need for taking and recording measurements;
(3) having a desire to plan for the future;
(4) having a known choice of practicable decisions.

In organizations where these are at present, there is scope for modelling. All are generally present in business in developed countries, but may not be there in a less developed country, as the following illustrates.

(1) Efficiency

Al-Faleh[4] indicated that efficiency is not the first goal of all Jordanian management. More important may be the desire to provide jobs for kith and kin. Some jobs may be perpetuated through the unwillingness of some workers to lower themselves to perform a task which is considered beneath their perceived class or status. In addition to inefficient use of manpower, machinery may not be used efficiently, through ignorance, lack of trained operators or the lack of supplementary equipment.

(2) Measurements and records

The need for measurements and comprehensive sets of data is recognized throughout industrial economies, either through the needs of governments or for accountability to employees and investors. It is, nonetheless, not such a great priority among less industrialized societies. Data collection when the results are not of immediate practical benefit may be regarded as a pointless exercise. Even when figures are collected, they may not be recorded in a consistent way, so that thorough analysis may be impossible. Lack of numeracy may make statistical data more prone to error, and may lead to false truth being given to the data. In Jordan, publicly collected data is of increasingly good quality. Statisticians from both the Department of Statistics and the Royal Scientific Society acknowledge the past inadequacies of national data, and are taking pains to improve this. Other bodies are following their example. (Lest western management scientists become complacent, it is noteworthy that many of their own studies have been delayed by insufficient data!)

(3) Planning

Planning for the future is not necessarily part of the philosophy of managers in developing countries. In part this may be due to those reasons quoted earlier, where socio-religious beliefs run counter to such plans. In part it may be due to the pace of economic development. "Tomorrow may be quite different—how can we plan for it?" And in part it may be due to the uncertainty of political and social structures. In Jordan, the past decade has been one of relative stability, but the uncertain future over the Palestinian issue has its effects on business planning.

(4) Choosing between alternatives

In order that decision-making may have any meaning, there must be a choice of alternatives which is recognized and accepted by those within the management structure. In some such situations, the existence of choice may not be perceived by those who carry responsibility. Thus the organization will not be able to develop as fully as would otherwise be possible. Reasons for such failure to recognize choice are numerous: self-imposed restrictions, ignorance and conservatism are common to problems in both developed and developing nations.

At present, very little operational research has been implemented in Jordan. Scheduling tools such as critical path analysis and PERT are used in several sectors of the economy, and are useful there. But these tools are not being used as predictive in any sense. Several studies have been completed using Jordanian data as examples,[9,10] but these have not been put into practice, owing, it appears, to resistance to the idea of modelling. Some models are in use in the water authority, concerned with the management and development of the supply of water to Amman. Similar models are being used to plan for telecommunications systems. Some applications of OR techniques have been carried out within the two important manufacturing industries of the country, potash and cement. Stock-control methods are in common use in several manufacturing industries; the problems of long lead-times on imports are severe and render textbook assumptions about predictability of supply invalid.

As a result of a national survey of villages to establish a database relating to rural development, there is scope for location–allocation studies of public and private facilities. Consideration of this has highlighted a problem which is by no means confined to Jordan among developing countries. Solutions to planning problems must be politically acceptable; each region within the country must have the sense that it is receiving the same treatment as others. This applies even if the needs of different parts of the country are not the same, whether through earlier inequalities of funding

or through the natural variation of climate, settlement patterns and communications. The location–allocation models in use (Iowa State University[11]) allow both optimization and predictive roles. The optimal location of a facility can be found, and compared with a politically desired solution which is predicted to be inferior on a purely numerical scale.

Beyond these few areas of application, there would appear to be scope for further OR studies, both to help in particular industries and to demonstrate the value of modelling for other problems. In the next section, some suitable project areas are outlined. These ideas were put forward by Jordanian colleagues in the civil service and in education; they were discussed within the context of future collaborative work within the country. To implement them will require commitment of time and resources by the end-user and the work of well-trained operational research staff, either as new employees or as external consultants. Some of the work could be seen as the work of a university researcher; at present the constraints of the higher education system on teaching time and study for higher degrees (usually undertaken in a western nation) will make such a solution difficult.

POSSIBLE JORDANIAN OR PROJECTS

(1) Water resource modelling

The water authority has already used some network models, and hydrological models of rivers and groundwater have been constructed. The demand for water is rising steadily, and the amount available is limited and variable from year to year. Study of options for the future requires comparison between the costs and the benefits, and the complexity of the management of an integrated scheme necessitates the use of models to thoroughly assess the consequences of each choice.

(2) Higher education planning

"Jordan's most important resource is in its people" is a claim often quoted by leaders. Currently 25,000 students attend the two non-military universities (Jordan and Yarmouk), and a comparable number study overseas. Concern has been expressed about the paucity of vocationally relevant courses, and the difficulty of retaining qualified personnel as faculty members. With increased demand for university education, there is an evident need for an assessment of the potential options for developing higher education in the future.

(3) Electricity supply planning

There has been considerable expansion over the past decade in the availability of electric power to the population of Jordan. This has happened at the same time as a rise in per-capita power consumption. Such increase in availability and demand is typical of that in many developing countries. There is a clear pointer to the need for assessment of decisions concerning the future growth in generating capacity and the distribution system.

(4) Banking industry

In developing countries, a very small fraction of the population uses banks; cash is used for most transactions, and money is channelled into tangible assets and durable goods, rather than saved as deposits and investments. Banking facilities are confined to the large centres of population, and their development there may be quite rapid, matching that seen in developed countries (e.g. electronic funds transfer, cash cards). Although education can help encourage more use of banking facilities, the banks need to assess development plans, using suitable models. As a developing international finance centre, there is scope for financial models to be used as guides for investment.

(5) Simulation models in transport

(*a*) *Aqaba port.* Aqaba, as the only Jordanian outlet to the oceans, is especially important for the nation's economy. There is only limited space available for physical expansion, and thus increases in the tonnage handled will have to follow from better use of the existing berths and

quayside facilities. It would seem that, in this instance, a suitable simulation model of the port's operation (or even of part of it), developed to allow interaction in planning, would allow sensible decisions about development to be made.

(*b*) *Railway freight*. Much of the potash traded through Aqaba is shipped by rail, and this tonnage is being steadily expanded. Plans to transport a range of other goods by rail have been proposed. A simulation model of the loading/unloading of rail freight, and of the use of the railway lines into Aqaba, would allow sensible operating strategies to be evaluated, and indicate bottlenecks which could occur in the future, in sufficient time for them to be overcome.

(*c*) *Traffic intersections*. Car ownership in Jordan, as in many developing countries, is increasing very rapidly. In rush hours, this leads to congestion at many intersections, and Draconian measures have had to be taken to alleviate this. Western transport planners have regularly used models to compare traffic management schemes; and such would undoubtedly have a place in Jordan, to identify future problem areas and allow for improvements to be made before the traffic problems become desperate.

WHERE OR CANNOT BE APPLIED EASILY

In stating the conditions for potential OR studies, it is implicit that there will be areas of society where the methodology cannot be used, or where its potential is small. These apply both to developed and to less developed countries, but the latter have distinct problems. These may be due to management, or to data, or to difficulties of evaluating the outcome of decisions, or some combination of these.

Two industries which are important to many developing countries do not lend themselves readily to OR studies. Agriculture is important for its contribution to the economy. However, it is notable for being fragmented, and frequently run by less well-educated people. Outside community-managed enterprises, OR has little scope. Some obvious exceptions may spring to mind; OR can help with feasibility studies of new plant, or with scheduling deliveries and collection of agricultural products. But there is little that OR can contribute directly to the improvement of national agriculture unless there is centralized control. In agriculture, the needs of managers are more basic than the 'sophistication' of OR. A team from the British Overseas Trade Board in 1986 "stressed the need for improving quality control and packaging" if Jordanian agriculture wished to break into the West European market.[12]

Tourism also makes a noticeable contribution to the economies of many less developed countries. Data are not often reliable on the effect of decisions related to tourism, and the problems of improving the revenue from internal and external tourism is more concerned with long-term strategies of marketing, education and facility improvement than with simple decision-making with measurable consequences.

A restraint on OR studies which may be noticeable in smaller countries is the need to consider the long-term security of the state. The decisions being analysed may have a value which is not negligible in the context of the national GDP. The analysis should therefore proceed with extreme caution, with such a restraint in mind. Few pieces of OR work in developed countries can have such an effect on national security (here the word 'security' is being used in its widest sense, to include security of food supplies, financial security of the government, security of transport, as well as military security).

THE PLACE OF OR EDUCATION

An increasing number of students are being exposed to the ideas of operational research at both graduate and undergraduate level. Both the civilian Jordanian universities include courses in their business administration and mathematics degrees which are available to those majoring in other subjects.

The nature of these courses is to produce generalists, not specialists, and so there are very few people well-versed in a wide range of OR methodology. The need is to increasse the number of such people, and to develop some kind of unit which could carry out some of the studies described in the previous section. Several of these would be sensible as doctoral work, for a student with

a reasonable grasp of OR principles and practice. This would also lead to closer involvement of universities in practical problems of the nation.

Coursework in OR must reflect the differences between the western culture and that of the country. Some of these differences have been described earlier. There are others. Traditionally, an OR group in industry has a wide consultancy brief, and does not fit easily into a niche in a management hierarchy. Al-Faleh[4] has described Jordanian management as hierarchical, and a group with freedom to move within a pyramid, both horizontally and vertically, will not readily be accepted. A second difference is in the examples used in textbooks. These are often based on western industries, which may be at best inappropriate and at worst misleading (in the sense that they may imply that OR is *only* suited to those industries), and such enterprises may not exist in the developing country. In such circumstances the teacher must seek out appropriate examples from the experiences of the students to replace or supplement the textbooks. Some of the case studies presented in the western literature[2,3] are valuable here, but an observer in a developing country will readily find simple illustrations of decision-making with which to demonstrate that OR is appropriate. (The author found many such examples in Jordan: one class considered the objectives of the highway authority in selecting roads to form a major diversion; another looked at the decisions implicit in selecting the siting and number of radar speed traps.)

Computers are being introduced into some OR courses, and software for modelling is becoming cheap and easily available. One danger of this proliferation is the emphasis on optimization methods such as linear programming, where predictive methods may be more suitable. A second danger is in the assumption inherent in such software that data are totally accurate (this latter caution should be heeded by all users, not just those in a less developed country). There is scope for using microcomputers as part of the process of OR education, but with caution. Western ideas cannot be immediately copied to a developing country.

Education in OR, especially in a country such as Jordan, will have a different nature from that which is widespread in other subjects. OR is not a subject which can be learned. It is an approach to a wide class of problems, and one which requires thought in its application. For this reason it will demand a measure of dedication, by both teacher and student, which may exceed that for other courses.

SOME RECOMMENDATIONS

In any less developed country, there are many opportunities for modelling for scientific analysis of decisions. Only a small number of people will be involved in this, and it is advantageous if they can be linked together, to co-operate in the OR process. So a first step in developing OR in any less developed country will be to collect information on those who have a practical interest in the subject, with a view to exchanging ideas. This would make a useful student project. The general principles outlined earlier can be used to identify suitable enterprises for further modelling, and all are possible university-based studies.

In addition there are many one-off projects which can be identified within organizations by those with a basic idea of what it is possible for OR to achieve, even if others take over for the study itself. Thus managers need to be made aware of what is suitable, and to know who, for instance in universities, is able to follow up the problem wisely and well.

Given such conditions, OR can develop in less developed countries, and can contribute to their development.

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REFERENCES

1. D. Kemball-Cook and D. J. Wright (1981) The search for appropriate OR: a review of operational research in developing countries. *J. Opl Res. Soc.* **32,** 1021–1037.

2. G. M. LUCK and G. WALSHAM (Eds) (1982) *Selected Readings in Operational Research for Developing Countries.* Operational Research Society, Birmingham.
3. OR in developing countries. *J. Opl Res. Soc.* **37,** No. 2, 1986.
4. M. AL-FALEH (1987) Cultural influences on Arab management development: a case study of Jordan. *J. Mgmt Dev.* In press.
5. F. MUNA (1980) *The Arab Executive.* Macmillan, London.
6. K. M. MOGHRABI (1970) A plan for university business education in Jordan. Ph.D. thesis, Texas Tech University.
7. E. S. BUFFA and J. S. DYER (1978) *Essentials of Management Science/Operational Research.* Wiley, New York.
8. F. R. SAGASTI (1976) Thoughts on the use (and abuse) of OR/MS in the planning and management of development. *Opl Res. Q.* **27,** 937–948. (Reprinted in Luck and Walsham.[2])
9. J. M. TIEN and K. EL-TELL (1984) A quasihierarchical location–allocation model for primary health care planning. *IEEE Trans. Syst. Man Cybernet.* **14,** 373–380.
10. A. O. HUSHAN (1981) Analysis of Jordan petroleum refinery production procedures. M.Sc. thesis, Maths Department, University of Jordan.
11. Iowa State University Geography Department (1982) Location–allocation for small computers. Iowa State University.
12. S. TARBISH (1986) Jordan plans for high-tech growth. *The Middle East* **140,** 46–47.