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THE CURRENT DEVELOPMENT IN THE METHODOLOGY AND APPLICATIONS OF OPERATIONS RESEARCH OBSTACLES AND PROSPECTS IN DEVELOPING COUNTRIES

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" بسم الله الرحمن الرحيم "

Introduction

Operations Research is a discipline that concerned with finding out about the real world and recommending actions to decision makers. The main purpose of operations research is to help decision makers, whether individuals or groups, whether concerned with business or social life, to make better decisions. When operations research began in the thirtieth in Europe, it was characterized by its approach: scientific, methodical, and interdisciplinary. Since the World War II, operations research has been increasingly used in the developed countries in different areas, industry, agriculture, service, trade and commerce, etc. Many real problems have been tackled and solved successfully by utilizing the powerful operations research techniques and significant productivity gains have been achieved by operations research applications.

However, applications of operations research in most developing countries have not been equally successful and not penetrated in any depth in the development planning process. However, the history of operations research strongly suggests that problems of developing countries which charactrize with resource limitations, conflicting criteria, and the need for accelerating the development process are eminently suitable for operations research applications. Even if the operations research applications in the developing countries have been unsatisfactory, it would be very wrong not to use the powerful tools and methodologies of operations research in the fullest possible ways to solve the development problems. Only we need to know the present status of the real problems and examine the conditions needed for successful applications of operations research techniques. It may be necessary to reassess and redefine the operations research's role in solving the important and critical problems facing developing countries in specific. In addition, it is necessary to overcome the barriers to the progress of operations research, such as, lack of data, lack of adequate operations research educational system, bureaucracy, inadequate technological and managerial infrastructure, etc.

It is true that the operations research in developing countries is done in a different context, than the advanced countries, and in a different social environment and it faces particular problems as the lack of experienced operational workers, lack of understanding on the part of managers, the lack of data, etc.,but these things should not by any means confine the developing countries. If operations research is viewed as a technology, then it should be investigated how to transfer that technology to the developing countries and how to adapt the successes of the operations research in the Western countries to the developing countries. It has become clear that the principles of the operations research discipline which have been established during the last forty years or so, mainly in the developed countries, have been transferring to the less developed countries without taking into account the different social and cultural context. To be successful in any application,operations research must be appropriate to the problem, to the decision-makers and to the environment which includes the culture. This it is not enough to transplant a solution to a problem across national boundries; the reasoning and analysis which produced the model which led to the solution must be re-examined in the light of the new circumstances.

However, despite of the lack of operations research progress in the developing countries, there is a consensus, which gives hope for the future, in the published work that operations research can be of considerable use in the development process. In the last two decades, there has been a large increase in the literature concerned with the practice of operations research in developing countries. The success of the operations research in any particular country will eventually rest on the nation of that country and its own effort.

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1. A WORLD VIEW OF OPERATIONS RESEARCH (O.R.)

1. A World View of O.R.

1.1. Development and Practising of O.R. in Developed Countries

The last thirty years have viewed a great growth of Operations Research (O.R.), particularly in the developed industrial nations of the world. Many problems have been encountered,some of which have been successfully resolved with the help of O.R. techniques while some still remain to be solved. The role of O.R. in solving some of the important and critical problems facing humanity has to be properly reassessed and redefined; one such critical problem is the development of the developing countries. Unfortunately, still the use of O.R. procedures to solve problems of development is at present minimal.

According to Abrams,[1] the history of application of O.R. dates back to antiquity. Intuitive application of knowledge of interaction of several components within a system could be found in various activities carried out in Ancient Egyptian Civilization. However, those applications were never formalized and put into wide use till the second quarter of the twentieth century. The first formal analysis and synthesis of systems using scientific method and mathematical techniques were implemented in tactical war problems during the world war II. Since the end of the war, the O.R. has been developed and practised in the Western and developed world, and this new discipline has been accepted and taught at most universities. In the beginning, O.R. methods have been used in industry and business in U.K. and U.S.A. Later, other developed countries of the west started using O.R. in industry and business.

The initiation phase of O.R. may be considered to be the period of fifties. In this phase, O.R. was applied to problems of production in steel, coal mining oil and chemical industries. Problems were of tactical nature in production planning and control, inventory, maintenance and reliability. Statistical methods, linear programming, simple queueing techniques, and simple models were the familiar methods used in this phase. The success rate of O.R. at this period was high because of the multi-disciplinary of O.R. teams, and thus satisfactory pay-offs were achieved in industries of developed countries and O.R. was thereby well established in this field. Because of the great success of O.R. in handling many of the pressing production problems in the manufacturing industries, gradually O.R. started to be used with great profit in areas of governmental decision-making, transport, health, management and so on. However, due to the lack of the large-scale computers in the early years, i.e., non-existence of huge core memories and relatively slow speed of calculations, only small and medium sized problems could be solved.

In the period of sixtieth, non-industrial problems in banking and finance, health, education, marketing and local government administration have been considered by many O.R. experts, furthermore, larger and more complex problems were being tackled with the help of the power of the relatively high speed third-generation computers. During this period, there was rapid growth of academic O.R., first in the U.S.A. and later in the U.K. and Europe, and there were numerous of theoretical researches in development of techniques, specially in U.S.A., and methodology of solution and many of sophisticated mathematical tools have been devised. Thus, more confidence was created and O.R. professionals started tackling more and more complex problems needing integration of various functional areas. Many combined models were built integrating various areas of management, and the integrative role of O.R. models was more and more appreciated in business organisations during the 1960s. Table 1. shows that the

Table 1.

Table 1. Data Based on Classification of Articales Published in:-

(i) Journal of Operational Research Society, Management Science, Operations Research, and OPSEARCH for the Period 1966-1975. (Source, Bandyopadhuay and Varde (17);

(ii) J. Of Operational Research Society, Management Science, Operations Research, and J. of Optimization theory and Application for the Period, 1976-1990.

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Theories.																									
1- Mathematical Programming	23	23	23	28	30	52	54	69	40	75	51	52	70	68	69	82	66	42	50	55	25	22	25	15	26
2- Simulation, gaming, heuristic	8	17	9	13	8	10	26	18	14	22	18	17	24	24	23	20	28	25	20	24	13	15	17	15	16
3- Queues & Networks.	17	14	17	13	20	38	27	37	16	35	21	23	23	32	20	25	27	17	21	31	26	23	27	28	25
4- Statistical methods.	25	25	23	30	18	23	31	52	30	41	19	10	23	22	22	19	30	19	16	10	19	17	13	8	14
5- Graph Theory.	1	1	1	7	1	1	2	5	1	2	1	2	2	1	4	4	2	3	-	-	-	-	-	1	2
6- Decision Theory.	11	8	10	13	6	6	9	17	10	23	7	8	13	15	14	14	21	36	5	11	11	14	16	14	6
7- Others.	18	18	21	20	21	29	31	31	33	30	120	121	114	113	105	74	86	96	88	127	58	68	57	76	78
Sub - Total	103	107	104	124	112	159	170	229	144	228	237	233	269	275	257	238	260	218	200	258	152	159	155	157	167
% of Total.	66.9	69.1	66.2	70.5	64.4	79.1	64.4	65.99	61.5	67.3	73.8	76.2	72.1	70.7	71	72.1	71.2	72.2	71.9	78.7	65.8	69.1	70.8	73.0	67.1
Applications																									
1- Industrial Application.	9	14	12	6	11	10	22	25	27	27	13	7	19	22	23	24	25	27	21	27	23	15	17	11	15
2- Transports & Communications.	10	2	6	8	7	5	7	2	8	7	3	2	4	8	2	4	2	3	5	2	1	5	4	5	5
3- Marketing.	7	4	3	4	4	3	11	7	4	18	15	10	18	16	17	14	15	13	10	12	12	11	10	11	14
4- Defence.	4	4	4	3	3	3	3	4	2	4	3	-	-	1	-	3	3	1	-	1	-	2	-	1	3
5- Public Sector. (Government affairs.	2	2	4	2	3	2	4	9	9	4	2	-	1	2	2	1	1	-	2	1	-	-	-	-	1
6- Health, Planning, education Public Sector Management.	6	11	12	15	19	9	28	38	27	29	29	27	30	32	27	30	28	31	31	17	20	18	17	16	22
7- Banking & Finance.	3	2	2	5	2	2	1	4	5	8	6	8	9	11	13	15	15	19	14	14	14	14	14	13	16
8- Application Pertinent to Developing Countries.	3	5	7	2	4	1	10	8	3	2	3	1	3	-	2	-	-	1	-	-	3	2	-	-	2
9- Others.	7	4	3	7	9	7	8	21	10	12	10	18	20	22	19	21	13	9	15	16	6	4	2	2	5
Sub - Total.	51	48	53	52	62	42	94	118	90	111	84	73	104	114	105	112	104	104	98	90	79	71	64	59	82
% of Total	33.1	30.97	33.8	29.6	36.6	20.9	35.6	34.01	38.5	32.7	26.2	23.8	27.9	29.3	24	32	28.6	32.3	32.9	25.9	34.2	30.9	29.2	27.0	32.9
Total.	154	155	157	176	174	201	264	347	234	339	321	306	373	389	362	350	363	322	298	348	231	230	219	215	249

number of papers written in areas like health, education, banking and finance, marketing, public sector management has been increasing since 1966. From the Table, we can also see that the relative distribution of papers among theory and application remained more of less constant with more absolute number of theoretical articales which proves bias towards theory and theoretical work. However, within the area of application, the percentage of the number of papers in health, education, etc. has grown from about 12 % to 32 % during the period 1966 - 1975, and from 24 % to 40 % during the period 1976 - 1990, which is a good approach. Also, the absolute number of practical papers in industrial applications is steadily increasing throughout the whole period which proves that O.R. techniques have fruitful results in this area. In fact, although O.R. had very impressive growth in the advanced countries, we can find from the table that the rate of implementation of O.R. models has not increased beyond 40 % (maximum percentage was in year 1974, it was about 39 %). Thus even where O.R. has been developed and accepted, the success rate is not very high. This low rate of implementation may be due to:

- The gradual decrease of the merits of interdisciplinary teams which most of the O.R. teams had in the fiftieth;

- The weak communication between O.R. specialists and managers of the organizations;
- The failure of O.R. scientists to establish the adequate models which reflect organisational problems, although sophistication in models constructions increased;
- The failure of the un-trained O.R. workers to construct model formulation for the real-life problems.

1.2. Development and Practising of O.R. in the Developing Countries:

Generally, O.R. has not taken firm roots in any of the developing countries yet. The progress of O.R. in the developing countries of Africa, Asia and South America has been relatively slow, except we may say in China and India. In the late fiftieth and during the sixtieth, China has used many of O.R. techniques, such as, mathematical programming, queueing theory, simulation approach, reliability, etc., to solve agricultural problems, transport, and industrial problems.[2] The popular use of linear programming to solve problems of agriculture and industry became a national movement in China. Although, most papers dealing with recent O.R. activities in China have been written in Chinese and thus detailed reports are not available, it is presumed that the use of O.R. is increasing in China in various fields of activities, e.g., allocation problem of petroleum and its products, allocation of crop land, optimal ship design, production plan of steel factories, optimal water release of a dame, simulation of cities bus systems, simulation of harbour transportation systems etc.(2) On the other hand, India may be considered to be the pioneer in applying O.R. to national planning. Since the fiftieth, India has been using O.R. in defence and industries, and many large industrial firms controlled by multinationals established O.R. groups in 1960s. The O.R. society of India was established in the late fiftieth, and its membership is still growing. In spite of these healthy signs in fields as health, education, transport, banking and finance little O.R. is being used in India,(3) and though O.R. is known to decision makers in the government and public sector, it has not yet been accepted seriously in these sectors.

In Egypt, a large amount of work of O.R. type has been undertaking since the late 1950s and beginning of 1960s, but with a low implementation rate. However, Egypt has a great deal of O.R. scientific experts and a relatively well-developed educational system. In Egypt, as in most deveing countries, though the decision makers may be aware of O.R. and the power of its analysis, they have very little faith an confidence in its applicability in the complex problems of the real life.

In many developing countries of Africa and Asia, O.R. is little known. It is considered to be a very sophisticated technique which is only suitable for the highly industrialised countries and can not be used where serious problems of data availability and uncertainity exist. In South American countries especially, Argentina, Brazil, Mexico, Chile and Peru, O.R. has been used to a limited extent in industry and most other areas.

A survey has been made of the articales that appear in major English language O.R. journals and other closely related journals to enumerate the reports of O.R. or O.R. related work with an application in developing countries.[4] Considering the work including a model-based approach, quantitative techniques, and direct application to a real decision problem, a total of 205 studies in O.R. field have been collected by the survey. This collection was by no means an exhaustive and unbiased set, because many O.R. Scientists do not report all their work in journals beside the survey was restricted to issues published since 1970 of some periodicals in the English language only. Although the collection is unrepresentative of O.R. work being reported and is unrepresentative of the work being actually done, however, it is an indication of the number of O.R. studies in developing countries. This total of 205 studies and the number of the studies persumed tobe implemented (in other words used) are shown in table 2.[4]

The papers have been divided into eleven groups of application areas; the last group, i.e., general and miscellaneous, included all work which could not be identified as belonging to one of the first ten groups. Macro economic models were included in "economic Modelling" group, but applications of economic theory, the less model based field, were not included in the classification since they have their own economic techniques. Socio-economic demographic models were included in " health and population" group because of their possible application to population planning.

The use of O.R. in "industry" group included applications for whole industries, as the electricity supply, fertilizer, coal, and petroleum industries, and micro-level applications, as inventory, resource allocation, and light-industry applications.

Table 2. The Number of O.R. Studies and the Numbers Implemented In Developing Countries.

(Source, Cook & Wright (4))

Application Area	Number of Studies	Number (and Percentage) Implemented
1- Industry	22	9 (41 %)
2- Agriculture	42	6 (14 %)
3- Transport	26	11 (42%)
4- Health & Population	42	5 (12 %)
5- Education and Manpower	17	5 (29 %)
6- Economic Modelling	26	8 (31 %)
7-Energy Planning	8	6 (75 %)
8-Telecommunications Planning.	7	2 (29 %)
9-Water resources Planning.	5	2 (40 %)
10- Storage, Trade & Commodities	7	1 (14 %)
11-General & Miscellaneous	12	6 (50 %)
Total	205	54 (26 %)

The area of agricultural applications is an important area of O.R. application in developing countries. Many of the researches were on the irrigation policy and few were concerned with regional issues; the interest was mainly on individual farm management decision-making.

O.R. has been applied in the transport area for managing the port operations and planning large-scale road transport investement. Also, there have been studies of transport requirements for special purposes, as public buses, health service transport, transporting fertilizer or crude oil etc.

The studies related to the health and population group were particularly in using population models for family planning programs and the evaluation of health services planning especially location and allocation aspects. Few of the mathematical models of diseases that have been developed were applied in practice.

Various kind of mathematical models have been used in the construction and operation of water supply systems. Energy supply has also received a lot of attention, especially electricity, and O.R. has also an effective impact on telecommunications planning.

From table 2, we find that the highest implementation rate was on energy planning field, and the lowest rate was on health and population planning in spite of the relatively high absolute number of studies in this field. In addition the studies in agricultural field were apparently theoretical, and agriculture has the next lowest implementation rate, and it seems that these studies- have been done to improve the art or to test the existing hypotheses of agricultural policies.

Table 3 shows the number of studies according to the country of application and by same application areas. From this table, we can see that Egypt, Nigeria, and Kenya are the predominate countries of Africa that applied O.R. work in certain fields. In Nigeria, it seems to be there is a relatively much O.R. activity, but with low implementation rate. Of course, there exist much more O.R. activity and studies in Egypt than shown in the table, since they have been published in Egyptian journals that were not included in the survey. It is a fact and clear from the table that India has much more O.R. work than any other country, specially in the area of industry; its rate of implementation is above average in any sector, except in agriculture. It is probable that much more O.R. work is actually done in India than in any other developing countries.

Table 3. Number of Studies by Country and by Application area (Numbers inbrackets are The Numbers Persumed to be implemented).

Country \ Application area,	Industry	Agriculture	Transport.	Health & Population.	Other	Total
1. Egypt	2 (1)	1 (0)	4 (1)	1 (0)		6 (2)
2. Sudan			1 (1)		2 (0)	3 (1)
3. Kenya	1 (0)	3 (1)	1 (0)	1 (0)	3 (1)	9 (2)
4. Nigeria	1 (0)	5 (0)	1 (0)	4 (0)	5 (1)	16(1)
5. Zambia			1 (0)	1 (0)	1 (1)	3 (1)
6. Tanzania		2 (0)		2 (0)		4 (0)
7. Malawi		1 (0)		1 (0)		2 (0)
8. Uganda				1 (0)	1 (0)	2 (0)
9. Botswana	1 (0)				1 (1)	2 (1)
10. Ghana		2 (0)	1 (0)			3 (0)
11. Ivory Coast					2 (1)	2 (1)
12. Tunisia			1 (0)	1 (0)	2 (0)	4 (0)
Other African				1 (0)	3 (0)	4 (0)
13. Turkey				1 (0)	5 (3)	6 (3)
14. Greece					3 (0)	3 (0)
15. Malta					-1 (0)	1 (0)
16. Iran		1 (0)				1 (0)
17. Caribbean		1 (1)	1 (1)	1 (0)	2 (1)	5 (2)
18. India	12 (4)	6 (0)	5 (4)	7 (4)	14 (7)	44(19)
19. Bangladesh		2 (0)	1 (1)	1 (0)	3 (2)	7 (3)
20. Pakistan	1 (0)		1 (0)		1 (1)	3 (1)
21. China	1 (1)	1((0)	1 (0)	1 (0)		4 (1)
22. Malaysia		2 (0)	1 (0)			3 (0)
23. Philippines		1 (0)		1 (0)	2 (1)	4 (1)
24. Indonesia				1 (0)	1 (0)	2 (0)
25. Korea				1 (0)	4 (1)	5 (1)
26. Taiwan	1 (0)			1 (0)	2 (1)	4 (1)
Other Asian		2 (1)			2 (0)	4 (1)
27. Mexico		3 (1)	1 (0)	1 (0)	5 (4)	10(5)
28. Brazil		4 (1)	1 (0)		1 (1)	6 (2)
29. Chile	1 (1)	2 (0)	1 (0)		1 (1)	5 (2)
30. Peru	1 (1)				2 (0)	3 (1)
31. Colombia				1 (0)	1 (1)	2 (1)
32. Guatem				2 (0)		2 (0)
Other American			2 (1)	2 (0)	2 (0)	6 (1)

Source: D.Kemball-Cook and D.J. Wright (1981), Ref . (4).

Also, it is noted from the table that O.R. work applied to Latin American countries is relatively scarce, with the exception of Mexico. This may also be biased indication since Latin American countries have their own O.R. journals in Spanish or Portuguese which are not easily available.

It might be true to conclude that to have more benefit from the implementation of O.R. work O.R. practitioners should be located in most organizations. Prerequists for a successful O.R. include, the existence of a well-trained O.R. team, the responsiveness-to the O.R. approach - of the management within the organization, and the existence of fruitful problem areas. One may look towards those organizations with the responsibility for the management and planning problems, as ministry of national planning agency. Furthermore, private companies provide another suitable location for practising O.R. groups. Also the local branches of multinationals in organizations are also good candidates. O.R. has already achieved good impact in Indian multinational companies, many large industrial firms in India controlled by multinationals established O.R. groups in the sixteth. In addition, since the late of fiftieth O.R. societies are being established in developed and developing countries and their memberships are still growing. By December 1976, there were 29 O.R. Societies affiliated to the International Federation of Operational Research Societies (IFORS). Out of these only seven societies were from developing countries with only 7 % of the total membership; 1500 members from developing countries out of a total 22,000 members of IFORS.[5] Some of these societies have started publishing their own journals with their own native languages to propagate O.R. Egypt, India, Brazil, Argentina, and Mexico produce O.R. journals. These journals mostly contain theoretical articles and few applications of O.R. in developing countries. In other international journals, reported studies of O.R. in developing countries represent only about 6 % of the total number of articles.

Concerning the developing countries, it seems that, among the decision-makers, both at national and private levels, there is no adequate appreciation of the potential of O.R. applications in solving the problems of development Most of the private organizations use practically no O.R., and do not have any O.R. groups, and only some large public organizations use little O.R. or have small O.R. groups. Here, we may say that national O.R. societies, wherever such societies exist, and IFORS have to play a significant role. Some efforts are in order to be directed to forming an expert group of O.R. professionals. The group should open up dialogues with national agencies of the developing countries and attempt to propose the effective and powerful appropriate O.R. techniques to solving problems of development. The group should also devise ways and means to develop the capabilities of the local-national O.R. workers.

1.3. Voluntary O.R.

Traditionally, O.R. has been carried out in organizations which are able to pay for it, and thus O.R. has been restricted for a long time to large industrial, commercial or/and governmental institutions. Consquentely, the skills of operational researchers and the effective O.R. techniques are not available to many private or small organizations. The widening scope and the increasing complex of the real-life problems and development problems should be treated by the help that operational researchers can give. Recently, some O.R. projects, as a voluntary helper rather than as a paid O.R. consultant and in voluntary organizations rather than the more usual clients for O.R., have been carried out by O.R. specialists who care about a particular voluntary organization and want to offer their skills to it.[6] In addition, there are some attempts to establishing voluntary O.R. organizations in their own, similar to traditional voluntary-service organizations as health service, mosques and churches,etc., which offer O.R. services to national and international institutions where these services are done not for money or as part of employment.

In fact, most of the O.R. workers are employees in local government or large national industrial body or work for institutional employers who buy their labour, that is, they recompense them in money for the time and effort spent in O.R. In the past and still, O.R. consultants make their living by selling O.R., they try to give their clients, e.g., governmental institutions, companies, international organizations,etc., what both parties find to be good value for money; the O.R. consultant (either external or internal) will always have wished to do the work in such a way that the client would come back to offer a new payed job. The relationship between O.R. consultant and the client (whether a person or a group set in an organization) is a kind of business relationship, i.e.,the consultant would like to leave a good impression of the value that he has received money for it, and on the other hand the client who is likely to be a person or a group set within an organization would like to show other members of his organization what good value he has received for the organization's money. This kind of relationship is temporary and at a certain time the business will come to an end. The internal consultant, i.e., in-house worker, especially in the capitalistic countries, also has to manage his saleability of O.R. . As a member of a staff work in a company, the O.R. worker always feels that he may be desposed in any financial emergency and thus his job is dependent on his pales of O.R. services. He may also be particularly interested in making sales of his O.R. work to other companies or individuals that may be helped him during the next company crisis.

Although O.R. work has been considered for such a long time as a commodity to be bought and sold, it becomes nowadays necessary to do voluntary O.R. work, that is, O.R. to be done for nothing rather than for money. This is a less clearly reciprocal relationship where an O.R. profession does work for an organization for nothing because he wants to or because he feels that his O.R. help is a national duty for the welfare of his country. This should not sound so peculiar since many national and international charities and social institutions are aided by immense helpers who give their time and effort for no monetary recompense, voluntarily. Considering the large number of people who are involved in several kinds of voluntary activities, it was recognized recently that a lot of people in the O.R. community must be participated in some sort of voluntary O.R. activities. Although it seems that some operational researchers in some advanced countries are concerned with voluntary O.R. work, there seem to be few accounts of such O.R. activities either reported in the O.R. journals or discussed at O.R. conferences. There are several reasons why voluntary O.R. is a dubious activity (see Sims and Smithin (6)). Among other reasons, there is not much of a tradition of voluntary O.R. in organizations. Operational researchers were used to be firmly associated with institutional employers and never used their O.R. skills on behalf of voluntary organizations. In addition, many O.R. consultants feel that people do not value what they do not pay for.[7]

2. The TRANSFER of O.R. TECHNOLOGY to DEVELOPING COUNTRIES

2. The Transfer of O.R. Technology to Developing Countries

For many years, it was believed that owing to the great achievements made by the developed countries in the area of science and technology, the less developed countries had no need to repeat the long and troublesome way through which the advanced countries had passed in order to reach the same present state of their high economic and technological development. Thus most of the developing countries preferred to settledown to the acquisition and application of the already existing scientific knowledge and technological skills in the advanced nations. This was briefly the essence of the idea of "transfer of technology.

During the fifties and sixties, transfer of technology and "aids" became the core of the development strategy, and moreover the military and multinational firms were considered of vital elements for effective transfer of technology. Over time, the transfer of technology has been seriously criticized, from a theortical and a practical point of view, by researchers and practitioners. It was widely argued that technology should not just be transferred but it should be adapted or made "appropriate" to the real problems and needs of the country in question. Technology is appropriate only in the specific historical, political, social and cultural context of a country. Thus, it is necessary to analyze deeply the social, cultural and political environments in which technology is to be implemented. Moreover, we would say that not only an appropriate technology should be used but also there should exist an "appropriate development strategy" inorder to run up the process of development.

Is O.R. a technology ?. O.R. can be broadly defined as the application of quantitative techniques and a model-building approach to various kinds of problems. As such, it is more akin to a technology as well as a science. Therefore, the application of O.R. should be "appropriate" to its context like any other technology. This means that it should be done in ways which are acceptable and comprehensible to decision-makers and the other interest groups involved, that it should be applied to problems which are vital and important for the development process and to which O.R. offers a major contribution. In fact, the methods and techniques of O.R. used in advanced countries have been introduced and are being used in developing countries without any particular elaboration of the methodology and basic principles. To be able to determine the possibilities and limitations of O.R. for developing countries, we need to better understand the real nature of O.R. and the problems in connection with the transfer of technology to developing countries. These will be the theme of the next section.

2.1. Nature of O.R. and Transferring Obstacles:

The question of "What is O.R." seems to be a trivial question; the answer that can be found in any standard text book gives the impression that O.R. is a "Hard" science that solves decision problems using mathematics and computers. The same impression is gained if we analyze the education of O.R. specialists and their research activities even in the advanced countries. But the practice of O.R. is something else. O.R. workers in practice, when trying to solve a real-life problem, confront with many factors which are as important, especially in relation to social and strategic Problems, as mathematics and models. In such situations, O.R. becomes a social process dealing with different opinions and conflicting goals.

Actually, there are different conceptions of O.R., and the nature of O.R. has been changing during its relatively short history. Some people conceive O.R. as soft technology, and others regard O.R. as a social process. However, two complementary conceptions and practices of O.R. can be considered: "Hard" O.R. and "Soft" O.R. or "technical O.R." and "Social " O.R. Recently, a distinction has increasingly been drawn between what are "hard" and "soft" systems. The essence of what is meant by hard and soft systems, in general, was put clearly by check-land[8] as follows:

"hard" systems are .... charactrized by easy to define objectives, clearly defined decision-making procedures and quantitative measures of performance. At the other extreme are the "soft" systems in which objectives are hard to define, decision-making is uncertain, measures of performance are at best qualitative and human behaviour is irrational ".

Essentially, moving from "hard" to "soft", in the previous sense, entials an increasing emphasis on the human aspects of the situations studied, i.e., on the personal preferences, beliefs of the various particpants etc., aspects which are not naturally amenable to objective assessment or to quantification. Real-life problems have showed that a vital role of social O.R. is to aid the user's understanding of the situation in hand, so that he can find a solution himself, including all his subjective biases, on the basis of better evidence. Hard approaches, on the other hand, aim to provide a definite answer or alternatives of answers. The field of soft or social O.R. is generally considered to be a means of aiding to understand what O.R. methods actually do as distinct from what they are, and the O.R. worker's role is to help others to solve their problems themselves. Voluntary O.R. can be considered as having similar charactristics to social O.R.

If we consider the Boothroyd's concept of an action programme which consists of three main elements, theories, proposals, and actions, the fundamental distinctions between "technical" O.R. and "social" O.R. can be summarized as shown in Table 4.(9 - 10)

Table 4 : Technical O.R. VS Social O.R.

Elements of Action Programme	Technical O.R.	Social O.R.
Theory	Actions based on prediction, i.e. a belief on positivism and a mechanical world view.	Actions based on education, i.e. the development of wisdom and a purposeful world view
Proposals	Optimization.	To offer assistance to improve the quality of actions
Actions	The scientific method (Objectivity)	Education and participation. (subjectivity.)

Experiences of the practice of O.R. in developing countries show that the O.R. transferred to these countries and the O.R. practice of native O.R. workers is technical O.R. O.R. specialists in the developing countries had no difficulty in learning about " technical " O.R., i.e. the techniques and mathematics of O.R. Conferences, O.R. journals, and books make it easy to transfer that part of O.R. technology. In addition, most of the O.R. communities in the developing countries have been educated in the advanced countries in technical O.R.; in Egypt, for example , nearly all O.R. specialists who existed by 1970 had studied O.R. abroad. Thus, the O.R. transferred to the developing countries is the "technical" O.R., but the operational researchers are now practising O.R. in their native countries by carrying out researches that have very little relevance to their own countries. Actually, the application area of O.R. is unknown and unpractised in most of the developing countries.

It is very important to learn the practice of O.R. in the native country and to pay attention to that most important part of the transfer of O.R. technology, i.e., "Social" O.R. Indeed, O.R. cannot be transferred from the advanced countries to the less developed countries without reference to the current technological level, economic situation, institutional systems and policies of the host country. It is true that O.R. is a science but it is different from the other sciences. For example, the practices of mathematics, physics, and chemistry, appear to be universal, but the practice of O.R. involves not only science but also the cultural, ethical, behavioural and bureaucratic structures that influence a country's and an individual's approach to decision-making. Thus, O.R. workers should tackle the problems of their native countries by training locally, and the developing countries should not rely only on external training for their O.R. specialists. Each country must develop its unique approach to the practice of O.R., a practise that fits within and is part of the country's cultural and managerial decision-making framework. It is reporting in a number of journals that O.R. as practised in the United States is different from O.R. as practised in U.K., Canada and Japan and in other countries.

It is clear that O.R. is a small part of the specialized technology that needed and imported from the advanced countries. Since O.R. is not a basic technology, i.e., mechanical equipments, it can be produced locally, even if as far as general tendencies and development are considered, and renewed from the countries in which research is taking place and where O.R. is used in its applications. Any technology that a country uses for its economic development must be investigated and taken into account the existing conditions; it cannot be cut off and imported from the others reality, and it will have no practical utility if it involves on outside intervention.

For O.R. in Egypt, for example, there has not been until now any investigation of which techniques were of some practical benefit and suitable to the local conditions that would be in harmony with the kind of economic development being sought. Among the O.R. methods used linear programming, for example, predominates for a long time, however, several criticisms have been raised about techniques of L.P. Many people consider that the assumptions involving in L.P. technique is far from reality and that too many hypothetical allowances are made in the formulation of the problem before obtaining a solution.

In fact there are various factors contributing to the relatively infrequent use of O.R. and to the scarce O.R. applications in the developing countries. In the following, we mention some of the problems and obstacles that pose serious constraints to the application of O.R. The obstacles may be broadly divided into two sets:

Obstacles that flow from the skill gap and defective attitudes of O.R. profressionals; and

Obstacles that flow from the unhelpful attitudes of decision-makers and factors such as the nature of the environment, data, resources and skill availability.

In the first set, the following may be mentioned:[11]

i) The use of a sophisticated technique with poor data and the limitations of models are often not understood. Problems are sometimes modified to fit the available techniques, instead of devising new tools and techniques to solve the real problem. Sometimes, O.R. scientists fail to device an appropriate methodology for problem formulation, model construction and solution for the real problem when existing techniques cannot be applied.

ii) The construction of mathematical models that are applicable only in a limited situation where resources skills can be made available, or that become useless by the time they are ready for use. As a result, time and costs are wasted in gathering data and computer calculations. Because of the rapid and uneven pace of change in the developing countries, decision must be taken in the face of high uncertainties regarding objectives, courses of action, and consequences, and although there is a need for improving decision-making process, this should not be done at the expense of delaying decision-making until the model and data are ready.

iii) Simple problems tackled in a sophisticated manner. In this case, high-powerd O.R. models are used to deal with simple problems which could have been solved by possibly quantitative common sense, e.g., solving the simplest allocation problem in terms of linear equations, linear constraints and objective functions; many other examples can be stated. In these cases, foreign consultants who often do not understand the problem and the related resource constraints appropriately in the developing country are not true helpers.

iv) O.R. scientists trained abroad generally lack the experience of working in the environment of a developing economy about which their familiarity concerning environment is minimal. O.R. scientists who are highly skilled in the use of mathematics, statistics and computer programming are often not a ware of the diminshing returns from investment in model building and thus solutions suggested are usually very costly to implement and may not be justified in the decision making process. As a result, the decision makers react negatively to such models and an unappreciated atmosphere to the use of O.R. techniques is created.

V) The use of O.R. models to justify, as derived from scientific reasoning, some predefined policies on which decision makers have already agreed. In some cases, the decision maker instructs the technical staff to manipulate the models that giving the predefined solutions, in other cases the technical staff on their own initiative and private purposes show that O.R. methods proved that the policy of the decision maker is right. In addition, some decision makers use the O.R. solutions only if they agree with their own policies and decisions

For the second set, the following among others inhibit the growth of O.R. in developing countries.[12]

(i) There are lack of relevant data and data bases.

(ii) There are lack of documentation of all facets of projects, researchers, technical reports etc.

(iii) There is a barrier between managers and O.R. scientists; they do not understand each other. This barrier and the problems of inadequate skills and improper approach to problems result in the state of rejecting O.R. application.

(iv) Decision-makers in government, business, industry and service sectors are usually not welcome the scientific analysis. Though, they are supposed to apply quantitative O.R. methods to plan the future, most of the decision-makers are more interested in day to day management.

(v) Problems of development are complex and unstructured, often multicriteria types, and not well-structured. The environment of the problems in developing countries is seldom stable, that is, it changes often and sometimes drastically with the external influences.

(vi) Time delays of projects implementation are common.

These previous problems in the use of O.R. are of course not exclusive to the all developing countries. However, it is necessary to overcome these obstacles and to place more responsibility on the O.R. professionals working in the developing countires to fully utilize the great potential of O.R. in solving the major development problems.

To make this possible certain urgent steps must be taken. One of the most important steps is the construction of an effecient and effective system of education and training in O.R. The next section deals with the problem of education in O.R. for the developing countries.

2.2. O.R. Education:

The classical description of the O.R. methods is generally a six-step process.

1- Formulate the problem;

2- Construct a mathematical model;

3- Derive a solution for the model;

4- Test the model and the solution;

5- Establish controls for the solution;

6- Put the solution to work.

Most O.R. textbooks concentrate on steps 2 and 3. with a few exceptions[13-15] step 1, the formulation of the problem, is almost ignored. Moreover, steps 1 and 4-6 are difficult to teach without real training in a practical O.R. project. In fact, partial treatment of the previous steps may lead the student to the misconception that these steps are separable stages in an O.R. approach for solving real problems. In real projects each step must be entirely investigated and constructed until the project is successfully implemented. For example, successful formulation of a problem cannot be reached without testing the effect of the remaining phases. Testing of an initial model which attempts to incorporate the interrelationships between the six phases may lead to certain adjustments to the model and thus a redefinition of the problem. Similarly, the implementation stage may indicate approaches that call for a model-reformulation. It is very important for the O.R. students to develop their own skills in O.R. solving-problem process; they need to realize that satisfacing objectives and robust solutions are often more useful than, say, maximizing models.

O.R. education may be viewed as a process involving three distinct groups:

1- Universities (and other educational institutions), that teach O.R. to
2- Students, who then take jobs in
3- Organizations.

It is a fact that O.R. education, even in the developed countries, has failed to prepare students for the transition from universities to organization, or we might say, to prepare students for the transition from the world of academic knowledge to the world of "real-life" action.

Concerning steps 1 and 4-6 above, we state the following issues:

- Universities concentrate upon techniques and avoid implementation because of the difficulty of teaching it;
- Courses are failing to keep up with the rapid changes that are occurring in the O.R. work as a result of changing computer technology;
- Universities appear to concentrate upon techniques that relatively used in practice infrequently;.
- O.R. courses have been failing to keep students up-to-date with the rapid changes in computer technology and to provide them with sufficient computing experience;
- The O.R. techniques taught at universities failed, because of the lack of accurate data and lack of money etc, to show students how to tackle ill-defined problems, the property of most development problems;
- Universities have not been preparing students for the political and working environment of organizations;

  Since this point belongs to the world of action and not to the world of knowledge, it is not possible to be taught in a traditional way but must be experienced, for example, students can be sensitized to the working environment in organizations by carring out industrial projects or applying a simulation techniques to a working environment;

- Organizations are looking to O.R. workers to produce "finished products" that can be effective immediately; and so most major companies do not maintain a cadre of O.R. analysts;
- Generally O.R. education have several deficiencies, e.g., computer technology and methodology.

To determine the contours of O.R. education relevant to a developing country and to be able to install a suitably designed education and training programme for O.R. future professionals, it may be useful to enumerate the nature of the problems that developing countries face where the application of O.R. would be beneficial.[16-17] Since O.R. can be considered as a "soft" technology, the O.R. application should therefore be "appropriate" to the developing countries, i.e. should be comprehensible and acceptable to decision-makers and the other interested groups involved, and O.R. must offer a major contribution to the important development problems.

In the following we outline some major problems in some vital areas in developing countries.

1- Problems of resource allocation at national and regional level

This is perhaps the most fertile field for O.R. applications in developing countries. The problem of limited key resources, including financial resources and foreign exchange, and therefore their allocation is critical and of utmost significance for developing countries, In addition, the measurement of the relative benefits of resource allocation in social and service sectors is often very problematic especially in developing countries. Standard sophisticated techniques may be not suitable, however, O.R. may provide the analysis of alternative plans for resource allocation. We may further classify the problems of resource allocations into the following categories:

(i) Problems of development planning at macro and micro levels. At the macro level, models could be of considerable use to government organizations charged with advising on the allocation of investment by sector. Broad plan allocation must be matched with an implementation plan at micro level, so problems of developing an adequate institutional framework for implementation review, feedback and control must be handled.

(ii) All problems of sectoral and regional development where problems of growth and removal of economic disparities among regions and among various sections of the community are aimed at. Models could be developed of the costs of alternative approaches in facility location and appropriate selection of strategies of regional development.

(iii) Problem of selecting appropriate technology for development which generates maximum yield for a given capital, for example, in transport, agriculture, communications etc.

2- Problems of Scheduling and Routing

The development of infrastructure, such as roads, airports, water and sewage systems and hydroelectric schemes takes a great amount of the government investment and results in large-scale construction projects. Network analysis and related models would be useful to the planners and managers of these projects. The management of transport systems such as railways, airways, bus companies and delivery vehicles is another area of scheduling and routing problem. These systems may be relatively smaller, however, effecient quantitative analysis can make significant rationalization in many cases.

3- Standard problems of industry and business

There are problems of production planning and control, inventory control, maintenance and reliability, and also there are strategic problems of capital investment at the corporate level. In the developing countries, the nature of production and design problems is influenced by the local environment, resource availability, monetary constraints etc. The scarcity of strategic materials and related uncertainty associated with them complicate the modelling problems much more than similar problems in industrialized countries. Thus O.R. techniques imported from the developed countries may have to be suitably modified. However, the experience of developed countries in problems of corporate planning, organization design and design of appropriate information systems may be valuable.

4- Queueing Problems

These problems exist in any environment when considering the service mechanisms in banks, shops, government offices, traffic systems, sea and airports, and the flow of items through any type of production and assembly process. An assessment of the efficient trade-off between service costs and waiting times would often result in significant benefits.

5- Inventory Problems

An important aspect in any environment is the successful management of inventory systems. In many developing countries, the problem of the modern sectors is always aggravated by a heavy dependence on imports. This implies long lead times for basic supplies and often results in holding excessive stocks or an expensive stockout if the control system is inadequate.

6- Search problems

A good example of this is the quality control or the search for errors. To be effective in the management of quality control systems, a certain statistical knowledge is essential. This knowledge is always lacking in developing countries, but O.R. would have a contribution to make.

7- Problems of development administration, development banking and finance. It has to be noted that the kind of society to be created will be influenced by policies and priorities in resource use. As such, the future may be sacrificed for the immediate short term gain of a small influential section. Thus, policies and priorities must be evaluated both in terms of their short term and long term effects, and sectors of the economy and society influenced. O.R. techniques can help in developing the appropriate framework for this purpose.

2.2.1. Criteria for Education and Training in O.R.

In the previous section we have listed some problem-areas for the application of O.R. in the developing countries. Certainly O.R. practitioners will be joined to a particular organization, thus, pre-requisites for successful O.R. applications include the existence of a well-trained O.R. worker. Education and training programmes in O.R. should equip professionals to tackle and handle the development problems more on the basis of scientific analysis and exploration of the nature of the developing countries-problems. The creation of an attitude that helps O.R. specialists to look beyond the present and to influence the nuture of an uncertain future is one of the main tasks of a properly designed O.R. education and training system.

O.R. education as it is available today has several defects; we mention some in the following:(17)

i) Education is too technique and theory based;

ii) Methodology is not given an adequate attention;

iii) A connection between theory and practice through education has not been settled;

iv) O.R. education and its philosophy has not yet widely considered.

There is a need to develop communication skills, knowledge to interpret and explore social, economic political and technical environments facing the country in the future. There should be more education of the person, as a person, to endow him with inter-personal skills and political ability. Thus knowledge of mathematics, statistics, logic, accountancy, computers may not be enough. A deeper understanding of psychology, sociology, political economy and technological processes is also necessary, and these subjects should be taught as a part of the undergraduate and graduate O.R. programmes.

Table 5 [18] gives the coverage of the O.R. techniques in O.R. education of some young O.R. workers who attended the young O.R. Conference (YOR II) held at Nottingham University in March 1982. A questionnaire has been issued to all conference attendees on the direction of O.R. education in order to gain information on the strengbhs and weaknesses of O.R. education. Although those who attended YOR II do not represent arandom sample of those engaged in the practice of O.R. and thus the conclusions that may be drawn do not give a true picture of O.R., however, the conclusions drawn may be worthwhile and interesting. In Table 5, the converage of O.R. techniques is classified by too much/ satisfactory/inadequate.

Table 5. Coverage of Techniques

	Coverage of the techniques		
Technique	Too much %	Satisfactory %	Inadequate %
Linear Programming	41	56	-
Integer Programming	31	59	3
Dynamic Program.	36	59	3
Queueing Theory	26	59	10
Simulation	6	56	38
Surveys	-	51	46
Forcasting	-	79	21
Regression	3	85	12
Statistical tests	5	77	18
Time Series analysis	-	77	23
Computing	-	59	41
Inventory Control	23	64	8
Decision Analysis	5	64	28
Heuristics	-	54	41

Source- Beasley and Whitchurch (18).

We find, from Table 5, that certain techniques are taught to excess, e.g., linear and dynamic programming, and some are taught too little, e.g., forecasting and computing. In the questionnaire, one of the questions was about the main areas which O.R. education had failed to equip people for their careers; in the following we mention some of these areas that appeared several times in the replies:

- too little about computer and computing,
- too little on management of O.R. projects,
- too much emphasis on techniques that applied to well-defined problems, and not enough emphasis on large problems with ill-defined structure and poor data,
- too little report writing,
- insufficient preparation for political environment.

There is a need for O.R. education and training at various levels, so that future decision-makers develop correct attitudes towards scientific method in solving various problems that may face. O.R. education at various levels enable the decision-makers and O.R. workers to tackle uncertainly about the future more on the basis of scientific analysis and exploration. A multilevel education and training system for O.R. has to be designed mainly for developing countries. To design an adequate system for O.R. education and training programme, first some basic assumptions must be set up:

i) no country can prosper without creating its own group of O.R. experts internally;

ii) role for international experts in the initial stages may be allowed, but it should be minimal;

iii) no education for O.R. will be effective without:

- integrating theory with real life problem solving, and
- Instilling confidence of O.R. and scientific methods into decision makers at all levels, since they will be responsible directly or indirectly for implementation and will be influenced by the results of O.R. solutions.

2.2.2. O.R. Education and Training Programmes

Besides techniques and methodology, O.R. education should develop communication skills, understanding of other persons' view points, a deeper understanding of political economy, technological processes, and sociology.[21] The following system for training and education programmes in O.R. may be considered for the following different levels:

I. <u>O.R. as a subject of undergraduate levels</u>

The training need differs greatly from context to another even in the countries where O.R. has been well advanced. The training problem is not usually handled directly at the formal educational stage, but it is being accommodated by on - the - job training after the individual has joined a particular organization. However, there should be formal instruction and guide on a set of techniques at the undergraduate levels. Adequate understanding of the basic approaches and techniques of O.R. must be offered in this stage. The scientific method of problem solving, basic statistics, linear algebra, basic of mathematical programming methods, and basic of computing and system analysis should become an integral part of undergraduate education in engineering, science, technology, economic, and commerce.

II. <u>O.R. at post-graduate level</u>

O.R. education of undergraduate levels is the essence of the immediate O.R. educational programme, however, taking a long term view research cannot be neglected. At present, graduate and post-graduate programmes in universities and institutes of technology, in most developing countries, are patterned after such programmes offered abroad, mainly in U.S.A. and U.K., and these programmes are heavily biased towards techniques & consequentely O.R. scientists trained in such courses are facing many difficulties in applying O.R. to the real-life problems. Thus, post-graduate programmes should be completely revised.

One year, out of the post-graduate programme period, should be spent in learning basics of O.R. methodology and important techniques in depth in addition to elementary subjects like economics, sociology, management theory, development planning and administration. The O.R. graduate courses may be distributed over three academic terms. Each term may cover five or six subjects as follows:

First Term

1. Statistics - I
2. Economics
3. Mathematics
4. Behavioural Sciences
5. O.R. Techniques I - Linear Programming
6. Computing (including numerical analysis)

Second Term

1. O.R. Techniques II - Nonlinear, goal, dynamic programming .
2. O.R. Techniques III Inventory and Queues.
3. Principles of management and organization design.
4. Econometrics.
5. Work study and Industrial Engineering.
6. System analysis

Third Term

1. Networks and Simulation.
2. Application of O.R. I, e.g., production control, Marketing, etc.
3. Application of O.R. II, e.g. Multilevel planning, Manpower planning, Health, Education Banking, Münicipal.
4. O.R. Methodology.
5. Decision theory including Information theory and Design of information systems.

In addition, the Master programmes should introduce a short course on "communication Skills" to produce graduates with some appreciation of the practice and application of O.R.

At the end of these three terms, students should have to engage in a project within an organization and spend one year in completing the project under the guidence of a supervisor. Team supervision consisting of staff experience on practical O.R. projects and executives from the organization where the project will be carried out should be formed wherever feasible. During the project period, seminars discussions on what form of O.R. project might be appropriate in a given situation may be carried on during which time the student would be required to obtain and interpret data, to formulate recommendations, and to present these both in written form and verbally.

Throughout the graduate courses a large number of exercises are to be introduced. The set of exercises must highlight some important issues as problem definition, setting objectives, obtaining data, handling constraints, the formulation and testing of plausible relationships, judging the relative importance of issues and factors involved, sensitivity of situations to changes, the presentation of recommendations etc.

It is to be noted that O.R. can make progress if it moves into those areas where progress has not far been made. It is a fact that the contribution O.R. has made to social and environments problems is small out of all proportion compared with that made in industrial area.

For the Ph.D. researches, it is necessary to put more control on the subjects selected for research. O. R. Ph.D. researches should be created through solution of real life problems and abstracting from such experience in developing new methodologies. It is, of course, difficult to know how successfully one is teaching something as illdefined as methodology and context, but, entering the practical world is the best way to develop methodology. This criterion will induce university,faculty and O.R. specialists in other institutions to get interested in the problems of real life organisations, problems of development, regional science, social problems and so on. On the other hand, students should learn that in spite of data handicaps, a lot of useful work can be done and participating in an actual working situation generates adequate amount of confidence and endow student with interpersonal skill. It is not normally possible for the student (at M.Sc. level) to follow every phase of every course nor to study every application area in depth, so Ph.D. student may deal with an area of vital and important application in his research.

III. O.R. at professionals level

Two kinds of programmes have to be organised for:

i. O.R. workers who had no opportunity to go in depth through courses in O.R. or related Subjects;

and

ii. O.R. professionals as refresher courses.

The programme of the first kind may be of relatively long duration including courses for people working, say, in business organisations, banking, marketing, industries etc. O. R. scientists can organize professional graduateship courses for this kind of programmes (The O.R. Society of India has already provided a two part professional programme for the needs of this group of people.[17]).

For the existing O.R. professionals, it is important that they keep in touch with O.R. academics and O.R. researchers in universities and academic institutes, so that, any tricky or ill-defined problem of real life can be referred to the experts in the universities and higher institutes for generation of new methodologies and techniques for solving the problem. Through this communication seminars and related O.R. courses can be organised.

IV. O.R. at Policy level decision makers

At this level, workshops and seminars of short duration, 2 to 3 days only, may be arranged to break the barrier and initiate the communication between O.R. specialists and decision-makers and to create faith in the applicability of O.R. in their specific areas of interest. Decision-makers should be actively involved in this O.R. programme.

V. O.R. at Middle level executives in organisations

Managers, excutives and decision-makers will not be expected to apply O.R. methodology themselves, however, they should be informed about what problems are amenable to what techniques and what methodology should be followed in solving the specific problems. They should be able to communicate with the O.R. scientists more effectively. Thus, courses to fulfill such aims must be managed.

3. O.R. Decision Making Models

3.1. Some Factors Affecting Decision-Making Problems in Developing Countries

A large proportion of the populations of most of the developing countries live in absolute, rather than relative, poverty-according to a World Bank estimates there are about 800 millions people in the world are lacking the necessities. In addition, according to the World Health Organization, 80 % of the diseases in the developing countries are caused by infected water supplies and more than 20 million children die of diseases each year and more than 12 million die of hunger. Such situations often exist in countries with great concentrations of wealth, and especially in many developing countries the gap between rich and poor is tending to increase instead of decrease.

The particular problems facing the modern sectors of most of the developing countries include, among others, severe shortages of finance for investment and of skilled technical supervisors and management. Also, the cities apparently encounter uncontrollable and irreversible migration from the countryside - it has been forecasted that by the year 2000 the urban population in the developing countries will grow to 2 billion, two and a half times the 1975 figure, while the rural population will grow only by a third from 2.1 to 2.9 billion. In the face of these figures, the problems of guaranteeing employment and maintaining services are immense. On the other hand, the particular problems facing the countryside include, a lack of infrastructure, e.g., roads, communications facilities etc., and services to satisfy the basic needs, such as education, health, and housing. These factors help to drive the process of migration to the cities.

The population growth, although a significant factor, is not the only reason of postponing the process of development. Other factors can be considered as, a lack of productive resources, an inability to exploit the scarce resources effectively, maldistribution of resources, lack of access to productive land etc.

Now the question is what contribution to development problems O.R. can and should be made. To answer this question we need to consider the factors which affect the environment in which decisions are taken in the developing countries. In the following we mention some of these factors.

a) A large cultural and communications gap between decision-makers and those affected by the decisions.

b) Uncertainty in the planning environment, both external, as prices obtainable from exports, and internal.

c) The low levels of infrastructure.

d) Shortage of financial resources.

e) Shortage of skilled supervisors and management.

f) Shortage of reliable information for making decisions.

g) The importance of political factors in making decisions

h) Significance of investment in scientific projects as a proportion of total state-expenditure.

If O.R. is to be successfully applied, and if the O.R. technology is to be successfully transferred, then the manner of application of O.R. techniques should take into account how the context in which the development problems of the developing countries and the factors affecting decisions differ from those of developed countries, specially the environmental factors mentioned above. The application of O.R. should be appropriate to its context like any other technology. This means that it should be done in ways which are comprehensible and acceptable to decision makers and the other involved sectors of the society and it should be applied to problems which are important for the development process and to which O.R.

offers a major contribution. Because of the low existing levels of investment in the developing countries, the scientific applied projects and rational management may be considered as the basic building blocks of the development process. McCarthy[22] from experience of planning in Botswana, states that the most serious constraint to the economic development in Botswana is the shortage of skilled manpower.

Many authors[22-23] have expressed their ideas about the conditions for appropriate and successful application of O.R. in developing countries. Although their ideas are differ greatly, we may say that they generally agree on the needs to apply O.R. in the areas where the potential marginal benefits are large and the problems most critical for development, and also to take account of the particular environmental factors surrounding the decision-making problems. The following problem areas have been suggested as being suitable for applying O.R. in developing countries:

i) Rural services and infrastructure, such as, health, transport etc.

ii) Urban services, such as, swerage, transport, water allocation etc.

iii) Agriculture, e.g., government policy on techniques and types of crop.

iv) Macro-level resources planning for manpower, education, water and energy, and economic policy.

The shortages of financial resources and skilled labour, together with the lack of natural resources in general in the developing countries imply a useful role for O.R. in problems of strategic resource allocation. O.R. will lead to the efficient use of scarce resources, particularly skilled manpower and financial. In addition, O.R. should be exploited in the allocation of advanced technology as well.

With regard to the complexity of the O.R. methods required, Sagasti(21) says that:

" It has frequently been argued that operations researchers should concentrate on constructing simple models and use the simplest tools of O.R. .... however .... it is necessary to use methods and decision - models that are at least as complex as the problems being tackled".

However, the shortage of the reliable data necessary for complex problems is one of the reasons why there is no place for the use of the complicated O.R. techniques in order to arrive at optimal solutions. The shortage of finance is one of the other reasons since the marginal benefit from the use of the sophisticated techniques rarely out-weight the cost of collecting data and employing O.R. specialists.

The importance of political and human factors in development problems, the uncertainties in the decision-making environment, the shortages of data, finance and skilled labour, and the large communication gaps between the planners and the planned - for all together point to the need for " approaches " which will :

- build up capacity within organisations to collect data and build a special data-base;

- build-in flexibility, e.g., by use of simulation approach rather than optimization;

- encourage 'grass roots' participation in problem definition, data collection and implementation.

3.2. Capital Model Distribution[32]

From the long history of thought concerning philosophy of knowledge and statistical interference, there floods current work in operation research and decision theory, in which mathematical structures refine the build upon the logical foundations. A very large part of manage-science or operation research concerns the application of statistical decision theory to business problems, notably those dealing with inventories, production scheduling and quality control.

The Decision Matrix

Three steps must be taken:

1) Decide the probability that each event will obtain.

2) Decide the utility which each act is expected to generate under each possible event - decide that is each possible "Consequence".

3) Select the act that promises the greatest utility.

Steps 1,2 are contained in the construction of a " decision matrix".

Step 3 is converted by a "decision rule".

Possible Consequences of Acts

(Measured in Units of Utility)

Act	Event and Probability		
	E_h	E_j	E_n
	P_h	P_j	P_n
A_1	C_{1h}	C_{1j}	C_{1n}
A_2	C_{2h}	C_{2j}	C_{2n}
.			
.			
.			
A_n	C_{nh}	C_{nj}	C_{nn}

3.3. Economic Order Quantity Model-Due Inventory

The Decision Analysis is the systematic application of decision theory to problems of choice between alternatives. As such, it has developed over the last two decades into a mature and powerfull approach. It is able to handle a large number of problems, and there are many well developed

In practice, however, a decision analyst aids the decision maker in specifying the alternatives (options generation) as well as in assessing the value of these alternatives (choice resolution). It is somewhat puzzing, then, to find that while "practised decision analysts ... report that a major part of many studies is the specification of the set of alternative courses of action", a search of the decision sciences literature indicates an almost complete lack of interest in problem specification.

Although the decision science literature does not address the options generation problem is any significant way, there are some relevant studies in other disciplines. So the attempt to understand the influence of information conditions on an individual's ability to generate option, and there results clearly indicate the focusing on the decision maker's objectives; the most successful way of generating choice.

3.3.1. Inventory Systems and Models

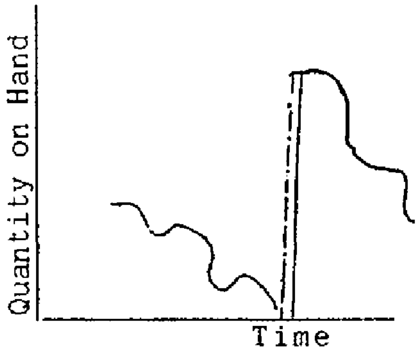
The need for inventory arises out of differences in the timing or location of demand and supply unfortunately, genies are in short supply, so inventroy is used as a buffer between supply and demand.

It is convenient to divide the study of inventory systems into two categories:

1- The deterministic demand and lead time.

2- The probabilistic demand and/or lead time.
This model focuses on the first category, in which both the demand and the lead time are known and constant. Systems having probabilitics demand or lead time involve uncertainty and risk for management.

Inventory systems are so varied and involve so many consideration that it would be impossible to develop models for every possible situation. Many inventory models will be developed. These models have been chosen to illustrate basic inventory considration.



General fixed-order quantity system.

Fig (1)

Classifying Inventory Systems

There are three major types of inventory systems:

a) Repetitive order - independent demand.

b) Single order - independent demand.

c) Repetitive order - dependent demand.

The first is the most common situation faced in business. Single-order systems, such as for Christmas trees or one-time promotional items, can be analyzed using payoff matrices.

Another way to classify inventory systems is by their relation to the over all sequence of productions.

With this method, we can distinguish four types of inventories:

a) Supplies

b) Materials

c) In-process

d) Finished goods

Classifying Inventory Models

Inventory models can be broadly grouped into two categories:

1) Fixed-order quantity models;

2) Fixed-order period models.

Operation of a fixed-order quantity model is shown in figure (2).

The fixed-order period model is shown in figure (3). Both models answer the basic questions of when and how much to order. They differ in that each provides a fixed answer to one question and a varying answer to the other.

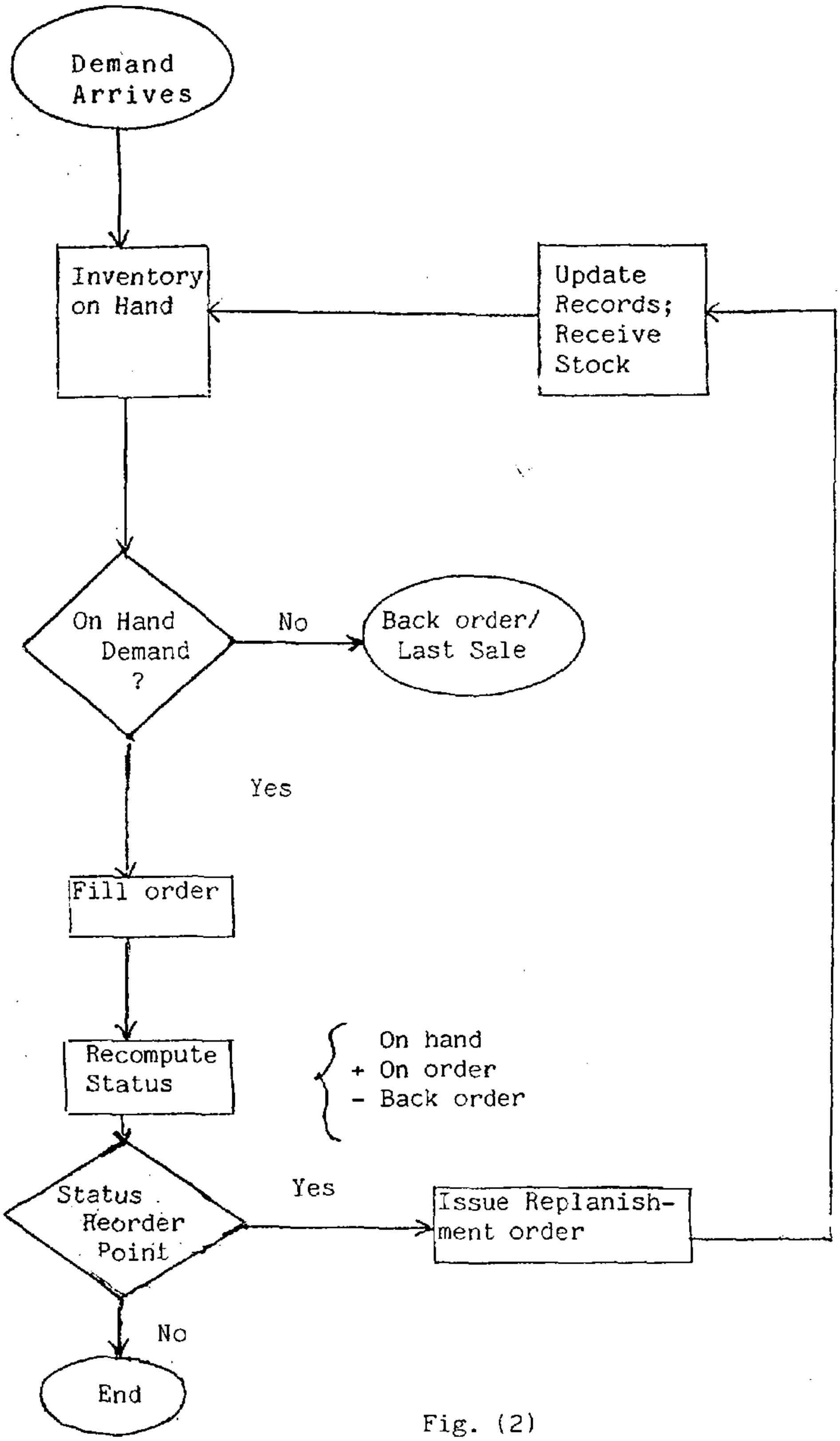


Fig. (2)
Fixed-order quantity model

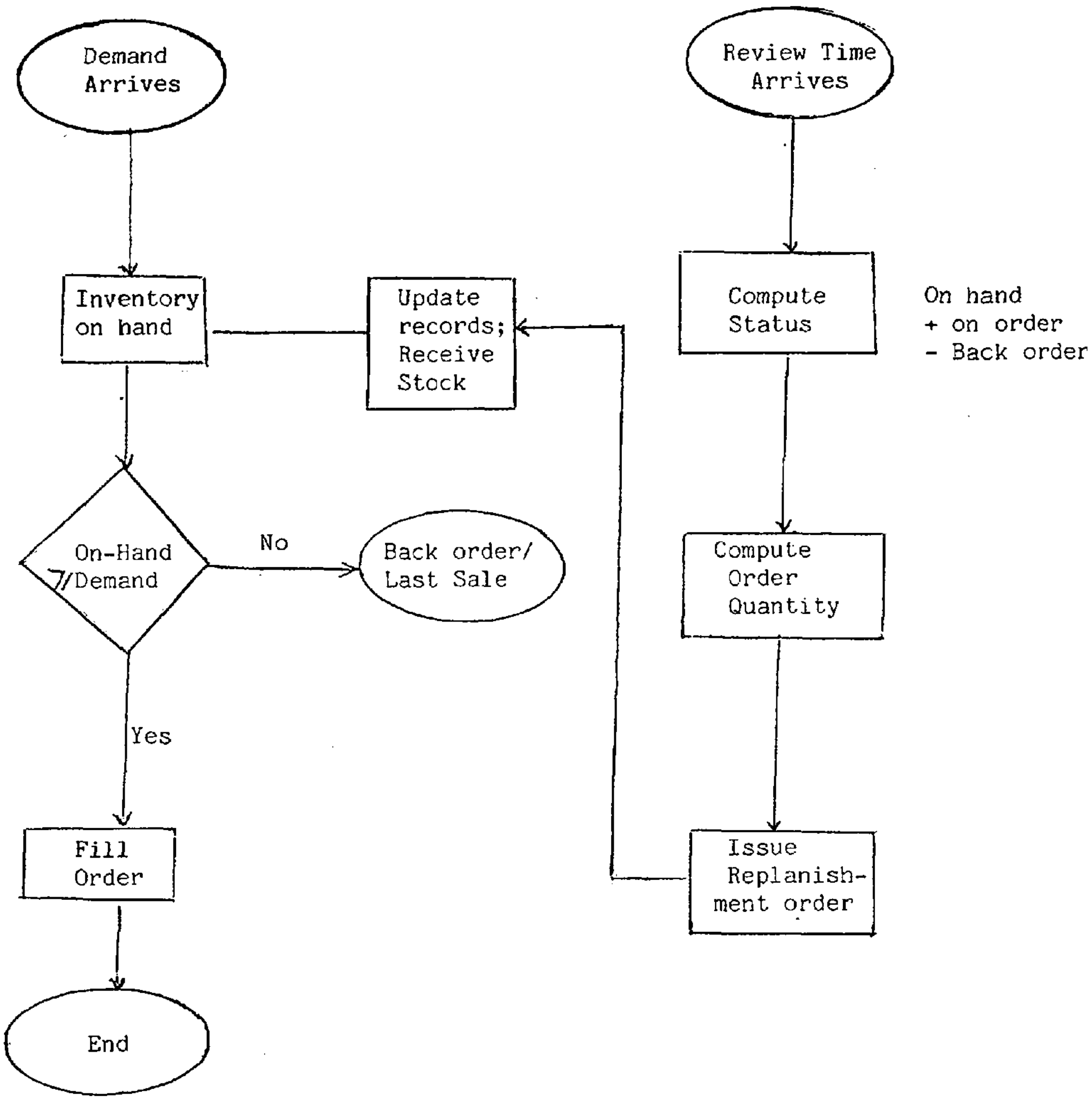


Fig. (3)

Fixed - order period model

Inventory Costs:

The inventory cost has four different cos ted with inventory are described.

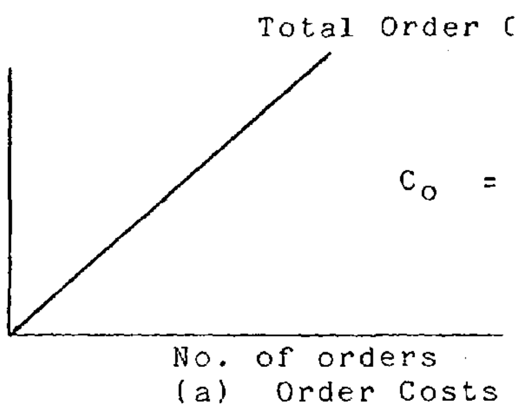
1) Purchase Cost

The cost to purchase an items' clearly This includes the price of the item plus an transportation costs. If the item is produ firm itself, then the full cost involved wc called the production cost.

2) Order Cost

It always costs something to place an

In business the order cost includes th prepare the order, postage, phone calls an direct costs. The behavior of order cost fig. (4-a) The total order costs rise lin the number of orders.



(a) Order Costs
Fig. (4-

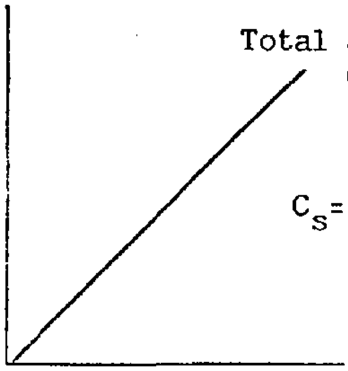
g Cost

Unit/Year

s

st

b)



(c) Shortage Cost

Fig. (4 - c)

includes several costs. It may be low for t high for large items. For examples, re- ood items, technologic and weather and metal add to the cost. Taking in considration the costs. You can imagin the number of orders d until there is one order for every unit hich point there would be no inventory at

m is out-of-stock, a consumer goes away A sale has been lost, and some good will as y not be too damaging if back orders are the item happens to be a part needed in manufacture, an entire assembly line may have to be shut dowan. Some cases is a shortage results in an opportunity cost. While it is usually difficult to determine the exact amount of this cost, it tends to vary linearly with the number of units short (fig. (4-c).

Note that there is no direct relationship between the number of orders.

The Economic Order Quantity (EOQ) Model:[34]

A fixed-order quantity is very old, dating back to F.W. Harris in 1915 and widly applied. This type of model we need to determine the fixed quantity to order each time, phus a reorder point to tell us when to place the order. To simplify the analysis, the following assumptions will be made.

1) Demand is uniform (constant and continuous).
2) Supply is received in one batch, not piecemeal (lamps Sun).
3) Lead time is constant.
4) All costs are constant.

First of all for developing inventory model is to develop a mathematical expression for total cost and seek the minimum total cost. The data need, supply, demand, average inventory and costs. Based on our four assumptions above, *fig. (5) shows supply, demand and the inventory level over time.*

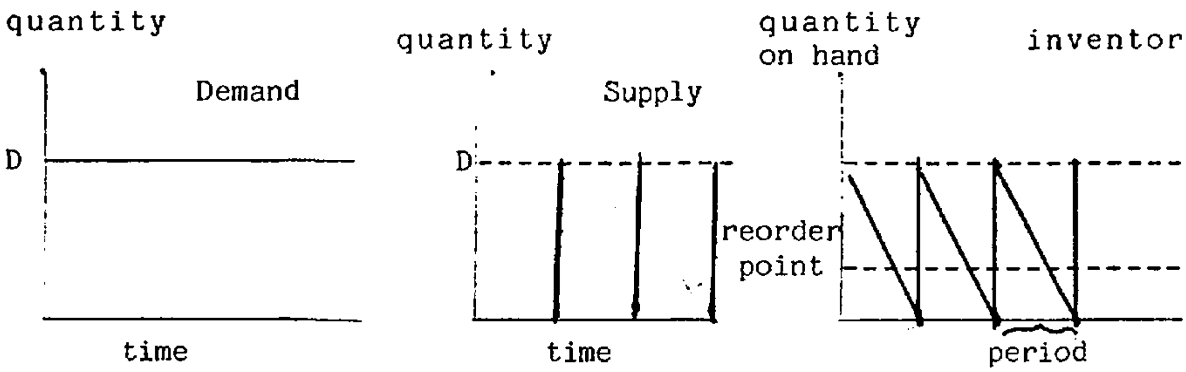


Fig. (5)

Demand is uniform at D units per unit time. Supply is received in lumps of Q units. The inventory level starts at a peak of Q units and steadily declines to the reorder point (R), at which time a new order for Q units is placed. When the order is received, it brings the level back up and the cycle is repeated. Since the lead time is constant, there is no reason for shortages to occur. Purchase cost can also be omitted since it is constant.

By considering

Total inventory cost = order cost + holding cost.

We'll put everything on an annual basis, although anytime length could be used (week, month, day) looking first at order cost

Annual order cost = number of orders
x single order cost

If the total annual demand is D units per year and we are ordering Q units at a time, then

$$\text{Number of orders per year} = \frac{D}{Q}$$

Let C_o represent the dollar cost of one order :

$$\text{Annual order cost} = \frac{D}{Q} \times C_o$$

let annual holding const = average inventory
x holding cost/unit/year

Assume for the moment that we can combine the costs of storage, absolescence, and tied-up capital into one cost for holding inventory, C_h . We are left with the task of determining the average level of inventory.

For any triangular pattern, such as that for inventory in (fig. (5)), the average over a 1-year period is one-half of the peak. Since the peak is Q, the average inventory level is Q/2 and:

$$\text{Annual holding cost} = \frac{Q}{2} \; C_h$$

So the total cost can be expressed as:

$$\text{Annual inventory cost} = \frac{D}{Q} C_o + \frac{Q}{2} C_h \qquad \text{———} \quad (1)$$

We can found Q to minimize total cost by trial and error. The total costs are minimized- without proof - when the amount ordered each time is :

$$Q = \sqrt{\frac{2 D C_o}{C_h}} \qquad \text{———} \quad (2)$$

where D is demand in unit per units per year

C_o is order cost in dollar per order

C_h is holding cost in dollars per unit per year

Q is order quantity in units

This formula gives the optimum quantity to order each time, we place an order. Since the lead time is assumed to be constant, we simply set the reorder point equal to the demand which will occur during the lead-time.

This is called the lead-time demand. Mathematically,

if L = lead time in days

D = annual demand

R = reorder point

$$\therefore \quad R = \frac{DL}{365} \text{ units} \qquad \text{———} \quad (3)$$

The only word of caution needed is to be sure that demand and lead time end up on the same time scale.

Case Study:

A manufacturer needs 2000 small parts during the next year. The units cost \$ 5 each. They are available locally with a 1-week leadtime, but the manufacturer's ordering cost is \$ 5 per period. The holding cost is \$ 1.5 per unit per year for storage, plus 10 percent per unit per year in capital opportunity cost. How many units should the manufacturer order at a time in order to minimize total inventory costs?

The solution

$$D = 2000 \text{ units per year}$$

$$C_o = \$\ 5 \text{ per order}$$

$$C_h = \$\ 1.5 + (10\ \%)\ (\$\ 5) = \$\ 2 \text{ per unit per year}$$

So

$$Q = \sqrt{\frac{2DC_o}{C_h}} = \sqrt{\frac{2(2000)(5)}{2}} = \sqrt{10,000}$$

$$= 100 \text{ units}$$

The reorder point is :

$$R = \frac{LD}{365} = \frac{(7)(2000)}{365} \cong 38 \text{ units}$$

The policy then, is to order 100 whenever the inventory decline to 38 units. The total annual cost will be:

$$\text{Annual Inventory Cost} = \frac{D}{Q} C_o + \frac{Q}{2} C_h =$$

$$\frac{2000}{100}(5) + \frac{100}{2}(2) =$$

$$100 + 100 = \$\ 200$$

This does not include the purchase cost of the items

How many orders would there be in 1 year ?

$$\text{Number of orders} = \frac{D}{Q} = \frac{2000}{100} = 20 \text{ orders}$$

How may clender days would there be between orders? If we use 365 days for a year :

$$\text{Days between orders} = \frac{365}{\text{no. of orders}} = \frac{365}{20} = 18 \text{ days}$$

This is also called the days supply or order period.

The EOQ model is the most fundamental and important result in inventory theory. The relationships is shown in Fig. 6. The minimum inventory cost occurs when the annual order cost equals the annual holding cost. This always true for the EOQ model but may not be the case for other models.

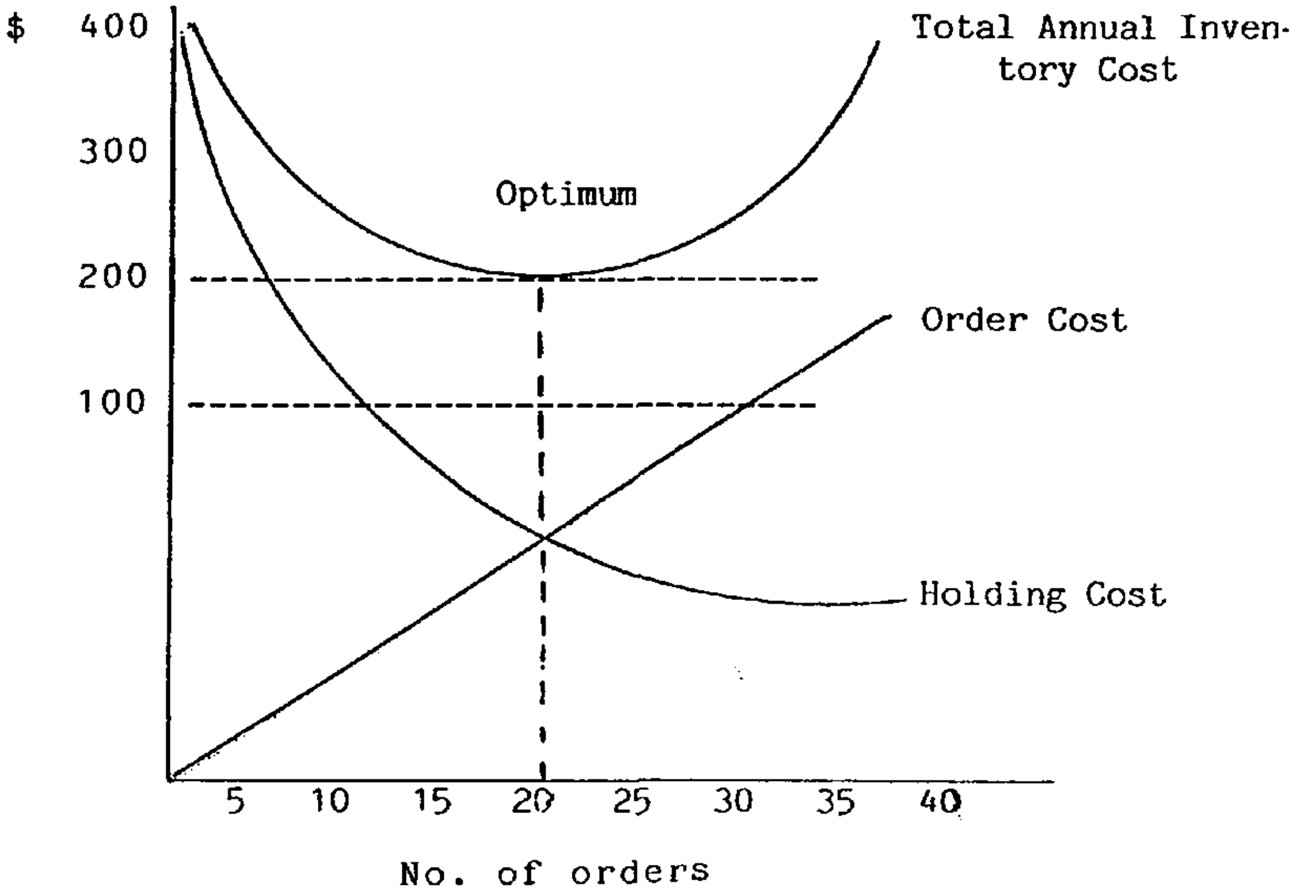


Fig. (6) Annual Inventory Cost

4. O.R. and Computer Systems:

Over the four decades of the computer ere, computational O.R. has greatly changed, the range and scale of O.R. applications have been expanding steadily. In addition, due to the development of the computers systems, the nature of the theoretical O.R. work has also changed fundamentally. Originally it was concerned with the presentation of new theortical ideas with demonstrations that they would be useful if a computer with effec tively numerical precision and speed was available. Now it is concerned with detailed descriptions of the computational experience of these ideas and how to modify the theoretical approach so as to be useful in the real world.

The use of computers in O.R. can be considered mainly under the two headings of optimization and simulation. The case with which many of the simulation/optimization - decision models have been developed and modified was largely dependant on the powerful computers. Interactive computing facilities have surely helped in this direction, however, much technical and theoretical work has been done beside. For instances, improvements in practical mathematical programming capability, matrix generation, and simulation modelling have owed to the improved computer hardware. During the last two decades, it could be learned how to reduce and control round-off errors and to exploit sparseness of matrices better, by using the triangular factors of the basis matrix rather than the original version of the Product Form of Inverse Matrix. O.R. can be considered as one of those disciplines of theory and practice whose concern may be stated as "rational intervention in human affairs". However, the intervener in human affairs must not separate theory from practice; such intervention requires a steady inter action between theory and practice in a continuous process. Figure 1. showes this feed back process.

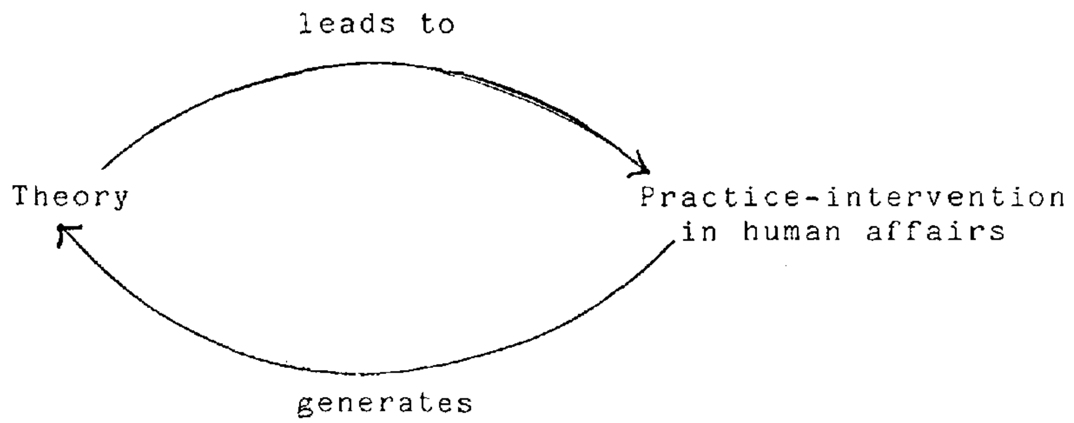


Fig. 1: Computational O.R. as rational
intervention in human affairs.

Theory leads to practice, but practice is the source of the theory, neither is prime. For O.R. as such discipline the computer and computer systems are the main body for carrying out and developing the practice aspect.

The O.R. practitioners are usually increasing their work capacity and improving their computational experiences by using the available numerous high-level programming languages and software. Also, the O.R. scientists become involved in programming by employing the previously written software and problem-packages, or using one of the existing programming languages, or generating original pieces of software as needed. Programming is an important tool for any of the O.R. practitioners and scientists. In the next section we state a review of the languages which is the most relevant to O.R.

4.1. Some Results of Review of Published Computer - Based O.R. Work.

Computer facilities are a necessity for successful O.R. work. The O.R. work requires the collection and analysis of data, and the analysis is often mathematical combined with computations. The avaliability of computers has made it feasible to allow the mathematics to become quite complex, however, the main task of O.R. work is to achieve successful implementations. The following table, Table 6, shows a number of studies and numbers, presumed to be implemented, of O.R. work according to techniques used. A total of 205 studies are reviewed. This is not an exhaustive or unbiased search, because it is restricted for the most part to issues since 1970 of periodicals in the English language which are available in some journals; many do not report their work in journals and many do not write their articles in the English language. From the table, we can see that most of the studies, about 81 %, used a computer in some way, however, this was not a necessary condition for success since studies without a computer had an implementation rate of 32 % compared to 27 % for those using computer facilities. Of the computer-based methods, LP is moderately successful in industry, transport and agriculture, and was completely unsuccessful in health and 'other'; this may be due to the more messy and less well-defined problems. The other interesting feature in the table is the high rate 76 % of apparent success of mathematical programming techniques, other than LP, application to the 'other' area. We may conclude from this figure that the problems of this area are generally too complex for the simple LP methods and they are amenable to solutions of a more sophisticated type of programming methods, however, because of their complexity, the involvement of highly practised experts is necessary.

Table 6 : Numbers of O.R. Studies (and Number Implemented) According to Techniques Used.

	Application Area					
Technique	Industry	Transport	Agriculture	Health & Population	Other	Total
Computer-based LP	9(3)	5(2)	21(2)	4(0)	8(0)	49(7)
Other Computer-based programming	3(1)	4(2)	11(2)	3(1)	17(13)	38(19)
Computer Simulation	7(2)	5(0)	6(0)	13(0)	13(4)	44(6)
Other Computer-Based Models	1(1)	6(4)	-	9(1)	32(11)	48(17)
Non Computer-Based Models or Techniques	1(1)	5(3)	2(1)	11(3)	12(2)	31(10)
No Identifiable Techniques	1(1)	1(0)	2(1)	2(0)	2(1)	8(3)

Note: "other" includes energy, water, telecommunications, education, etc.

4.2. O.R. and Programming Languages:

Programming languages can be divided into two classes - general purpose and special purpose. A general purpose language intends to be useful for programming needs. A special purpose languages are designed for an application area.

Fortran: The most used general-purpose language within O.R. is FORTRAN. The prominence of FORTRAN is primarily due to the following reasons:

1. It is the language of the scientific community. Scientists have invested time and effort in becoming conversant in FORTRAN.

2. It is well supported by the major computer manufacturers.

3. Portability of software coded in FORTRAN is comparatively good.

4. It provides for separate compilation and access to libraries.

BASIC: The original BASIC was developed for teaching purposes. The advantages of BASIC are great. For microcomputer users because:

1. Most implementations of BASIC do not distinguish between the language, its editing facilities and the run-time system, thus making the system easier to use.

2. The distinction between BASIC and the operating system is normally weak.

On the other hand, the disadvantages of BASIC:

1. It is simple language with limited data structures.

2. A lack of facilities for separate compilation make development of large programs unsuitable.

ALGOL:

ALGOL 60 is a strongly typed language. Every variable has to be explicitly declared and can be assigned to variables of the correct type. It is found in some areas of O.R. work (e.g. networks, mathematical programming) due to its powerful data-structuring techniques.

Pascal: It provides both static and dynamic data structures. It is available on microcomputers. Pascal provides facilities for separate compilation, and other techniques. Pascal allow a collection of constants, types, variables and procedures to be compiled as an intrinsic unit.

APL : A Programming Language was designed as a mathematical notation: APL is becoming increasingly important in the construction of decision support systems, as such systems tend to be changed and extended with time.

PL /1: In the mid-sixties, I.B.M. set out to produce a truly general-purposed language, and the result was programming language 1. It is still the standard language of many I.B.M. installations. It is available on micros. PL/1 appears between FORTRAN and COBOL, with additional facilities.

PROLOG: PROLOG (Programming in Logic) is a declarative language. Statements specify a goal, whereas traditional algorithmic languages are used to specify the means of obtaining a goal. It is used by artificial intelligence workers, particularly in the field of expert system.

e.g. ball (x) --- red (x), round (x)

reads, if x is red and x is round then x is a ball.

SIMULATION: O.R. workers have designed and implemented specialist languages for discrete-event simulation. Most simulation languages are simply extensions of existing general-purpose languages. This SIMSCRIPT and SLAM are extensions of FORTRAN; SIMULA of ALGOL 6o; SIMPL /1 of PL/1.

The simulation language can be implemented where a compiler of the underlying language is available, simply by storing a set of procedures in a library, or by pre-processing. Most simulation language have a methodology inherent in them. There are three opposing methodologies: the process view, the event view and the activity view.

Simulation languages and packages based now on Pascal. There is also considerable interest in the use of Ada as a simulation language. Ada includes enumeration types similar to Pascal's symbolic types.[35]

Then from these several languages we see that FORTRAN is the first choice batch language for many O.R. groups, whilst PL I and COBOL are used occasionally. BASIC is an adequate interpretive and batch language-particularly for occasional programmers - and is widely available on micros. A PL is rapidly gaining favour in O.R. departments for some applications.

The most common packages used by O.R. departments are probably LP networks and statistics. These are available on main-frames, and some statistical packages are appearing for micros.

A Microcomputer Programming Language for O.R.:

There are now several languages which are (reviewed above) available only on micros (i.e. they are not simply micro implementations of mainframe languages). Many O.R. groups will have a simple rule for language use (often to use mainframe choice- normally FORTRAN, PL/1 or APL).

If there is a choice to be made, the following criteria[35] should help:

1- Ease of Use: Most users require a language that is easy to learn and use. A simple language may be easy to learn, but it can constrain the programmer as his knowledge and requirements grow.

2- Security: It is generally accepted that strongly typed languages, such as Pascal and Ada, are a good thing. Security is enforced by the compiler. FORTRAN is insecure- a wrongly entered variable name may be compiled as a further variable. Also BASIC is insecure, e.g.

```
IF   FNA > o   THEN  60
```

may be passed as correct, even if the function FNA and the line 60 do not exist.

3- <u>Facilities:</u> Most programming requires decent procedure mechanisms, file access, data structures and control constructs. These are all weak in BASIC and limited in FORTRAN. The importance of other facilities depend on the job in hand.

4. <u>Separate Compilation</u>: Such a facility aids software development and maintenence. A particular package can be altered or replaced at any time, without the need to recompile programs that use the package, so its public declarations remain unchanged.

O.R. scientists will need simulation languages, a mathematical programming system, and special matrix generator. It may not be convenient for the operator of even a large mini-computer to provide all these things. So specialists bureaux provide services to enable O.R. clients to use computers effectively without themeselves being familiar with the latest developments in computational O.R. The development of small models of systems that are solved routinely will often lead to a requirement for solving larger models for planning purposes.

4.3. Integrated Software for O.R. Techniques:

Integrated packages create a much more personal involvement in the total flow of work. They make the process of producing output such as graphs, tables and reports significantly easier. Now they are also taking on many of the burdensome tasks of personal management and organizational activity.

More powerful microcomputers are allowing software writers much greater scope to make packages that are integrated and easy to use.

O.R. workers should develop their skill to embarce the advantages of integrated packages with the objective of increasing their personal and departmental productivity. There would seem to be the opportunity for many more O.R. techniques to be included in this integration process.(36) Integrated packages are helping to create work environments that lead to greater individual autonomy and dispersion.

Practical Mathematical Programming Systems:

Mathematical programming (MP) the main core of O.R., has been extending beyond computing. As O.R. grew up from the fiftieth onwards, powerful new mathematical programming techniques have been developed to solve complex problems often using the power of the continuous developments of electronic computers. It became obvious that significant progress in computational efficiency of mathematical programming has been achieved by the incorporation of the computer science, beside other related disciplines, and so the development of computers is critical to the development of mathematical programming. Over the past fourty years, the computational aspects of mathematical programming, translated into computer packages, i.e. software, evolved in parallel with the development of computer hardware. This allows the O.R. scientists to develop more MP models giving much more guidance to computational efficiency than was previously possible. The development in computers provided the chance for solving many optimization problems with relatively large number of variables and constraints. The permitted number of constraints, other than simple bounds on individual variables, reached 1000 in the early 1960s, and there was no definite limit on the number of variables. Now, current algorithms impose no definite limit, in principle, on the numbers of either constraints or variables. In practice, problems with over 2000 constraints are still considered large, and in some systems the number of constraints plus variables is limited to 32,000, which is the largest signed integer that can be stored in 2 bytes. However, the size of the problem that can be solved on the computer depends on the understanding of how to exploit sparseness of the problem-data.

To see how the solution of MP model is dependent on the availability of computing facilities, let us consider a linear programming (LP) problem with 100 constraints and 300 variables as an example. In full simplex tableau form, we require about 40,000 real storage locations, i.e. 160 Kb to store the matrix and inverse. In addition, for this size and larger the number of iterations carried out to solve the problem will be huge such that consideration must be given to round-off errors. If we use the eta-vectors technique, the data-storage required, in Kb, is likely to be:

Matrix	4.5
Eta-vectors	15
Working area	4
Objective and R.H.S.	2.5
Status markers, etc.	1.0
That is	27 Kb.

Thus, the addressable memory of the machine is a key factor, and only problems of small scale should be considered for solution on machines which do not allow the user to access to more than 64 Kb of memory.

For the years to come, mathematical programming systems must be applicable to large-scale complex problems. The last years have revealed a steady advance in the computational aspects and applicability of large-scale MP models, especially LP - based mathematical programming. Linear programming remains the central feature of today's MP systems. The reason, among others, that LP - simplex method has retained its central position in mathematical programming systems is that successive implementations of simplex method have exploited sparseness property more and more efficiently.[38] The steady increase in the size of real-life problems has led as much to a better understanding of how to exploit coefficient matrix sparseness as to larger and faster computers. In fact, large-scale problems are nearly always very sparse in data, so computational MP must use algorithms that exploit sparseness efficiently.

The simplex algorithm has been exploiting the sparseness of data more and more efficiently. In the original simplex algorithm, the whole tableau was computed and updated explicitly. A part from the accumulation of round-off errors, this approach takes no advantage of the sparseness of the coefficient matrix A. Later, the revised simplex algorithm took an advantage of the sparseness of A by storing it as a sparse matrix by columns where in each column the positions of each non-zero coefficient and its value are defined. The inverse basis is updated by premultiplying it by an elementary column transformation. Many improvements were being made at the time in the inversion routine so as sparseness was better exploited and no more nonzeros can be formed in the basis and its inverse, e.g., by making the basis matrix as nearly lower triangular as possible by permuting the rows and columns.[39-40] Some other developments were made in cases where the same numerical values occur many times in A; A could be stored more compactly by having a "pool" of distinct numerical values and defining each nonzero in a column by a row number and a pointer to the appropriate pool element; this saves storage space if the elements can be defined in 8 bytes and the pointers in 2 bytes. By this way the components a_{iq} of the elementary column transformations can be stored rather than $-a_{iq} / q_{pq}$. Where a_{pq} is the pivot element, and many of the elements created in the inversion routine can then be defined by pool pointers These developments in data storing played a major role in changing the programming technique from "out-of-core" codes, in which A was always held in backing store, to "in-core" codes in which all data are normally held in the main memory.

Other packaged software providing facilities for special linear programming, integer programming, non-linear programming, automatic column generation, branch and bound techniques, seperable programming are also involved in most MP systems. In fact there are tremendous improvements in the MP computer packages, specially those concerning the L.P. and C P M techniques. Because of the high efficiency and ease of using those packages, it becomes an everyday tool in many organizations and in many cases there is no need to have knowledge of the history or development of the MP techniques or O.R. people to make the packages work. However, the O.R. practitioners are increasing their work capacity and improving their experiences by using programming computer languages. There are other reasons why an O.R. practitioner may be concerned with programming languages:

(i) Required software may simple not be commercially available.

(ii) Sometimes, there may be savings in computer time to tailor a package program for a specific problem and its associated data.

(iii) Since the cost of the software increasingly dominates that of the hardware, then a piece of software may be produced at a lower than the purchase price of equivalent commercially available software.

Generally, programming is an important tool of the O.R. scientist.

The last years have revealed a steady advance in the computational scope and applicability of large-scale MP problems, especially LP-based MP computational complexity and special data structure are two main areas that are fundamental to the design and analysis of effective MP algorithms. The seventieth have seen an explosive growth in the study of the inherent complexity of various MP problems.[41-42] It is generally agreed that the computing problems that O.R. workers face can be divided into two categories: "easy" and "hard". "Easy" problems are those for which a polynomial time bound exists, i.e., given a problem of size n , a problem - solving algorithm exists and in the worst case the solution process will require a computer time no longer than $C\ n^p$. where C and p are some constants. On the other hand, "hard " problems do not have any algorithm that is guaranteed to converge in a reasonable time, the time of the solution procedure is going up as exponential function e^n. Concerning the computational complexity, a major success has been in the classification of a huge variety of MP problems as being equivalent, i.e., if a good algorithm for one of the MP problems can be found then all the other equivalent ones can be shown to be "easy" too. On the other hand, the study of data structures[45] has received a major impetus from developments in computer science. Typically, data structures have applications in various parts of an MP system, since topics as tree searching, the representation of graphs and sorting are not fundamental to MP but can speed up the system if they are done efficiently. Perhaps the most directly useful idea taken from special data structure is the element "pool" concept and its applications in super-sparse data codes. It is possible to save large amounts of core, and get a whole problem into the computer memory where previously complicated input/output schemes were necessary by using the "pool" concept mentioned previously in this section. This idea was taken from computer science practice, i.e., from compiler designers who use the concept in the generation of "symbol tables". In some cases implementing the straight forward primal simplex technique code using an effective tree traversal data structure may be the best.

MP systems have been unefficient and uneffictive in the past for their exhaustive use of computing resources, i.e., memory and execution time. However, the growing reliability of operating systems and the continuous improvement in computer hardware have led to a great reduction in costs of computing power. Most existing MP systems are hosted by mainframe computers, but a recent significant development was the movement to "minis" machines. An implementation of a large-scale code on a 16-bit computer was difficult and has not been achieved for many models. However, with the appearance of "mega-minis" with 32 bit architecture, the possibility of large-scale problem codes has become more likely. With the reducing costs of computing the tendency in MP will often be towards larger MP problems.

4.4. The Relationship Between O.R. and Computer Programming

Some O.R. scientists may be involved in the design and coding of packages. The solution of mathematical programming models is rarely achieved without an appropriate package. Statistical analysis and financial planning are other areas that rely heavily on packaged software. Also, some O.R. departments package developed software.

Some techniques of O.R. will often involve the design and coding of a piece of original software. The results of an O.R. study are incorporated into a computerized system , As an example, work on inventory policy can be incorporated into a computerized stock control system. Responsibility for the programming of such system has traditionally been outside the domain of O.R.

Scientist, residing within data processing. Increasingly, O.R. groups are responsible for the production and maintanence of an entire computer-based system, particularly information systems.

So, powerful mini and micro-computers are becoming widely available, to O.R. scientists among others. The main effect of this is likely to be an increase in the amount of computer simulation work and particularly of interactive simulation used to give managers qualitative information about a system.

Conclusions, Recommendations, and Personal View of Future Trends

5. Conclusions, Recommendations, & Personal View of Future Trends:

I. Conclusions:

The relationship between O.R. and economic development is considered obvious and robust. It is implicitly accepted that O.R. has made a contribution towards the development of the economy of the developed countries. In the advanced countries O.R. made a profound impact on how to manage all facets of business, industry and government, and the most important is that the philosophy of the O.R. decision model has changed the process by which the decision problems are defined and analysed. Where in the developed countries the O.R. scientists have financial and other incentives to pursue O.R. applications and have organizational structures that encourage them to apply O.R. techniques to improve organizational efficiency, in the developing countries O.R. scientists and practitioners have a bureaucracy that does just the opposities. Where O.R. practitioners in the advanced countries must be geared to cause changes for making improvements and taking risks, this is not so in the developing countries; no one wants to be in charge or take risks or make decisions. It is true that O.R. has not yet taken firm roots in any of the developing countries; this is because it faces particular problems there, such as, lack of data, lack of understanding on the part of managers, lack of experienced O.R. personnel, lack of O.R. education, etc. In addition, the principles of practice of O.R.

derived during the last forty years, mainly in the developed countries, have been transferred to the developing countries. However, there were differences in the way that O.R. was applied in the developing countries, because of the different social, cultural, and economical context. O.R. should be viewed as specialized technology, soft and hard, which developing countries need and import from the other countries. If it is viewed as "soft" technology, then it should be made appropriate to the situation in which it is used, i.e., the cultural, ethical behavioural and bureaucratic structures of any particular country need to be taken into account; O.R. practice involves not only mathematics and statistics but also these things which infleunce a country's and individuals' approaches to problems - solving. The application of O.R. should be appropriate to its context like any other technology, i.e., it should be done in a comprehensible and acceptable way to decision-makers and it should be applied to problems that are important in themselves and to which O.R. offers a major contribution. There is no difficulty in learning about O.R. techniques and mathematics, i.e., "hard" O.R., but what is difficult is learning the practice of O.R. To just transfer O.R. models and solutions from a country to another will in general not work out. Each country must develop its unique approach to the practice of O.R., a practice that fits within and is part of a country's cultural and managerial decision-making framework, and frequent implementations in vital areas are necessarily.

In most of the developing countries, there is strict separation between theory and application, and therefore most of the O.R. applications are very academic, often based on master or doctoral thesises; this is due to lack of data besides many other factors. The gap between theory and practice can be filled up by using and encouraging interdisciplinary studies.

We could say that there is no place for the use of complicated sophisticated mathematical techniques in the developing countries unless the data necessary for the long and detailed O.R. research work are available, and the benefits which accrue from applying O.R. have to out weight the considerable cost of O.R.

In the social sector, the utility of O.R. is taken for granted in the advanced countries. However, in the developing countries the application of O.R. to the social sector appears, referred to O.R. literature, very limited. This is due to the special characteristics of social problems and to the difficulties arising from their ill-structured nature. How O.R. can help to solve social problems and influence their nature and change their structure is a matter that needs serious investigations. In this subject we may say that problem-oriented and interdisciplinary approach is positively needed in the developing countries. Definitely O.R. has a role to play in the developing countries; O.R. can be carried out at the micro-level seeking to improve the performance of particular aspects of economic and social structure, and at the macro level where help can be given to people making strategic decisions.

Unfortunately, education for O.R. provided in developing countries is often not appropriate. O.R. lecturers have heavy teaching loads, often lack project experience, and are isolated. Many students of O.R. from the developing countries have been going to the developed countries for education. It is important that their education includes some appreciation of the socio-economic problems to be faced when they return home. But, in the advanced countries, no much attention has been paid to the O.R. applications in the developing countries, and thus there are few teachers of O.R. who have extensive Third World experience. In addition, there is a shortage of relevant teaching materials in general. Usually, O.R. high-education consists of set of lectures on particular techniques, such as linear and nonlinear programming, simulation, queues theory, etc. This gives the impression that O.R. is a set of techniques from which a selection can be made for each particular problem.

However, the real-life problems are highly diverse in type and do not fall exactly into a specific class, and the important factors are often organizational or behavioural which are not taught. Thus, the re-installation of an efficient system of O.R. education and training is needed for each particular developing country.

Significant progress in computational efficiency has been acheived in the last two decades because of the enormous computer power and flexibility. Powerful computer packages are readily available for many of the O.R. techniques. However, the cost of using the models and associated computational problems still make real applications difficult. Concerning the MP systems, the recent history of MP has been one of gradual progress. There has been a steady increase in the size and in the type of problems that can be solved by today's MP systems. In addition, there has been a great increase in the extent to which the application of MP has become more automatic. The computational aspects of O.R., translated into software, have evolved in parallel with computer hardware over the past 40-years; however, the cost of software increasingly dominates the cost of hardware and thus the competition among producers is on software rather than the hardware. In fact, O.R. application has increasingly depended on availability of computing facilities. Although, simulation has made great strides, the computer packages for simulation technique are still lagging behined the other O.R. packages.

In the following, we summerize some of the reasons for the low rate of O.R. implementation and the causes that make O.R. not to take firm roots in the developing countries:

1- The breakdown of communication between O.R. specialists-workers and decision-makers.

2- The absence of the merits of interdisciplinary team work that most of the O.R. teams had in the fiftieth.

3- The failure of O.R. scientists to anticipate the changes required in model formulation and solution for successful implementation.

4- O.R. education at undergraduate and graduate level is failing to keep up with the rapid changes that are occurring in O.R. work as a result of computer technology changes.

5- O.R. education avoid implementation and thus no practical O.R. projects are carried out even at post graduate level.

6- O.R. education ignore the social aspect of O.R. (soft O.R.)

7- O.R. education concentrate upon "hard" O.R. applied to well-defined problems.

8- O.R. education has too little concern of methodology dealing with ill-defined problems.

9- Universities failed to prepare O.R. persons for the political and working environment of organizations and with inter-personal skills.

10- O.R. technology is transferred without adapting it into the particular cultural, political, historical, and social context of the imported developing country.

11- Lack of properly trained O.R. workers.

12- Shortage of financial resources for O.R. projects.

13- Shortage of reliable and relevant data necessary for studies.

14- Lack of documentation at all facets of researches, projects reports, articales, etc.

15- Most major organizations do not hire and maintain a cadre of O.R. analysts and workers to rationalize things in their units.

16- Bureaucratic structures in most of the developing countries.

17- Low levels of infrastructure ingeneral.

II. Some Recommendations:

1) A large number of O.R. scientists are often unwilling to come back from abroad to their own developing countries may be because they find that the salary compensation is not attractive enough, compared to developed countries' standards, and the working environment is not pleasant. Therefore, groups of O.R. scientists would not come from abroad in a large number and consequentely the developing countries usually suffer from the shortage of native O.R. experts. To handle this issue, some arrangements must be made. For example, a number of O.R. centres could be established where initially some junior scientists / practitioners/ post-graduate students/ researchers work under a senior O.R. expert. The responsibility of these O.R. centres could be :

   - Helping national organizations to solve their problems until O.R. teams are to be set up there;
   - Setting up units of trained O.R. workers in the national organizations;
   - The senior scientist attached to a centre has to provide the necessary leadership and build up the necessary leadership skills in the O.R. juniors;

- Managing a bridge between universities and national institutions;
- Organizing seminars, workshops, conferences at senior and middle management level; (decision-makers from various levels should particepate in these seminars).
- Conducting researches in new methodologies and techniques suitable for developing economies.

The number of these O.R. centres will depend on the size of the country and the present status of O.R. in it. In the case of Egypt, it is felt that four or three such O.R. centres are needed to tackle the development problems. These centres can be attached to the universities/institutes or may be independent. Initial finance may come either from government, trusts, or science foundations or through funds from international agencies. O.R. scientists (senior or junior) in the centres should be local as far as possible, however, if local experts are not available, persons from abroad can be seconded to serve as senior experts for some times. Such proposed O.R. centres would maintain a close contact with professionals in organizations, in universities within the country and in other countries.

2. Universities should teach O.R. students how to conduct simple projects prior to alerting them to more sophisticated

methodological issues, e.g., a course on "communication skills" within O.R. - Master programmes may be involved.

3. O.R. students, at various levels, should have the opportunity of participating in the analysis, discussion, and presentation realistic problems. The only way in which students can be exposed to the full variety and complexity of the real world is to be involved in real-life projects with some organizations (it is not difficult to find organizations that are ready to cooperate).

4. O.R. research work should be directed towards filling the gap between theory and practice.

5. Interdisciplinary systems-oriented research must be encouraged and emphasized as a characteristic property of O.R.; for successful O.R. the concept of interdisciplinarity should be extended.

6. The O.R. specialists need a deep under standing of the process of socio-economic development. This understanding of a development process cannot be a part of the training received from an O.R. course in a developed country. The training of O.R. practitioners must be provided locally, in the developing country itself, thus, training facilities have to be set up within the developing countries themselves, e.g., effective real-life projects within national organizations may be carried out.

7. O.R. has to operate at all levels (mentioned in section 2.2.2).

8. Simulation attitude rather than optimization has to be extended in order to build-in flexibility.

9. Communication gap between decision-makers and O.R. specialists has to be broken down by instilling faith and confidence in O.R. and scientific methods through successful real-life projects within various organizations.

10. Facilities within organizations have to be available and capacities have to be built up to collect data and construct local data bases.

11. Generally, there is a shortage of relevant teaching materials in O.R. in the developing countries. So, we need to encourage the contact between O.R. people (teachers, specialists, scientists, practitioners, etc.) in both the developing and developed countries in order to exchange ideas, materials, and experiences. O.R. people travelling from the developing countries to the developed countries, or in the opposite direction, have to be invited to make this contact, either through their national society or through the international conferences. International agencies, as IFORS, could provide some

services in this respect such as:

(i) encourage interchange of O.R. specialists and faculty among developing and developed countries by providing travel grants, fellowships, etc;

(ii) provide appropriate financial help to set up O.R. research centres in developing countries;

(iii) identify suitable O.R., experts who would volunteer to serve in developing countries for a certain time

12. With the unsatisfactory productivity levels in the developing countries compared with the developed countries, inflation and low standard of living are becoming serious problems. One of the most powerful tools to combat these problems is more intensive use of computers.

III. Personal View of Future Trends:

It is expected that some O.R. work, projects, researches, lectures, etc., will be done in the future not for sake of money or as part of employment, but as voluntary service. Some voluntary O.R. will be done for, may be, highly insturmental reasons, such as to prepare material for a conference paper, while some others may be done for their own sake, for example some O.R. workers who care about a particular voluntary organization may want to offer their O.R. skills to it. At the same time, many O.R. specialists in the developing countries will have the desire to provide their O.R. helps to their national organizations as national duties. The familiar framework of O.R. employment may not play as important a role in O.R. in the future as it has in the past. The time will come when voluntary O.R. plays an important role in our life. This prediction may be reasonable as the growth of free economy is increasing, in which people feel enough confidence to be sure that they are actually doing something useful when they do it for the sake of their nations and for their voluntary organizations. There will be a motive in the future, especially in the developing countries, for O.R. researchers to get involved in voluntary O.R; not only may O.R. workers be doing a good turn to their countries through some organization that they care about, but they are also preparing themselves in an effective way and increasing their own experiences. This prediction will be some where near the truth, if the future will lie with smaller, more individualistic and less bureaucratic forms of work. In addition, O.R. voluntary organizations, similar to the usual voluntary organizations, are expected to be constructed in their own and increased in number. Those O.R. voluntary organizations will contain O.R. volunteer members who contribute time and energy without monetary recompense, for sake of national benefits. The aims of those organizations will be to provide some sort of O.R. help to different national institutions for the sake of accelerating the socioeconomic development programmes.

In the future, O.R. techniques will be a part of everyday life process. The continuous increase of the very powerful computers packages for O.R. methods emphasizes this direction. Although, the cost of using O.R. models and associated computational problems nowadays make O.R. applications difficult, in the future the spread of the powerful mini and micro computers will make real applications more easier and cheaper. There is a move, also, to "user-friendly" packages which will make O.R. model building easier and less expensive. Unfortunately the software is still lagging far behind the hardware, but, it will catch up and the computer power will be enormous and less expensive and the cost of running O.R. models will be negligible compared to the cost of management time. Because of the increasingly readily available computer O.R. packages, managers will increasingly try to use computer packages of the shelf of many of the traditional straight forward applications, e.g., LP and CPM , will be used by managers and their employees with less assistance on O.R. specialists. It is expected that a gradual move in this direction, that is, less dependence on O.R. experts in certain traditional areas, will happen, and O.R will actively act in the education role. Interactive solutions which can answer the "what if" type of question, which depends greatly on a powerful computer machine, will be possible rather than textbook imagination of today. O.R. techniques will be the strategic planning tools for the future needs of management for many years to come.

The computers have been around us for a long time, however, up to the present the computer has had little effect on the work of management. But micro comupters are transforming this situation now, and in the future a managerial revolution will take place when powerful mini and micro computers and information storage become so cheap and efficient that every manager can have his own micro and data-information bank. The spread of different types of computers will lead many of in-house teams to develop their own special working O.R. software packages for their organizations. This will increase the competition among computer producers on the production of more sophisticated O.R. software.

Computer simulation will be the most commonly used technique for predicting the consequences of decision-making models. Effective computing is more than just having access to suitable hardware; within any field of application one needs access to specialist software, specially simulation programmes in the future, and advice about how to use it. O.R. scientists will need efficient simulation languages, effective mathematical programming systems, special matrix generation, etc. Therefore, there will be heavy work and investements in computer packages for carrying out particular sophisticated techniques, or in patent computer languages that facilitate the writing of simulations techniques and building mathematical programming systems. Also, there will be some service to enable O.R. clients to use computer packages effictively without being, themselves, familiar with the latest development in computational O.R.

Computational O.R. has changed and developed over the four decades of the computer era, and it will progress more and more in the future. The use of computers in O.R. can generally summarized under the two general headings of optimization and simulation. Much more valuable work will be done on techniques for problem formulation, matrix generation, and/or report writing, especially in the corresponding processes of simulation modeling The simulation modeling is the favorite field of the future. So intensive work will be done for inventing new easier and effective simulation languages.

The round-off error, generated in the computations of the large-scale problems, will be greatly reduced in the future by using the expected more powerful computers with extended lengths of computer words.

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سلسلة من القضايا صدرمنها :

(١) دراسة الهيكل الاقليمي للعمالة في القطاع العام في جمهورية مصر العربية (ديسمبر ١٩٧٧)

Adverse Economic Effects Resulting from Israeli Aggressions and Continued occupation of Egyptian Territories, April 1978.

(٣) الدراسات التفصيلية لمقومات التنمية الاقليمية بمنظمة جنوب مصر (ابريل ١٩٧٨)

(٤) دراسة تحليلية لمقومات التنمية الاقليمية منظمة جنوب مصر (يونيو ١٩٧٨)

(٥) دراسة اقتصادية فنيه لافاق صناعة الاسمدة والتنمية الزراعية في جمهورية مصر العربية حتى عام ١٩٨٥ ٠(ابريل ١٩٧٨)

(٦) التغذية والغذاء والتنمية الزراعية في البلاد العربية٠ (اكتوبر ١٩٧٨)

(٧) تطور التجارة الخارجية وميزان المدفوعات ومشكلة تفاقم العجز الخارجي وسياسات مواجهتة (٦٩/١٩٧٠ ــ ١٩٧٥)٠ (اكتوبر ١٩٧٨)

Improving the position of Third World Countries in the International Cotton Economy, June 1979.

(٩) دراسة تحليلية لتفسير التضخم في مصر (١٩٧٠ ــ ١٩٧٦) ٠ (اغسطس ١٩٧٩)

(١٠) حوار حول مصر في مواجهة القرن الحادي والعشرين٠ (فبراير ١٩٨٠)

(١١) تطوير أساليب وضع الخطط الخمسية باستخدام نماذج البرمجه الرياضية في جمهورية مصر العربية٠ (مارس ١٩٨٠)

(١٢) دراسة تحليلية للنظام الضريبي في مصر (١٩٧٠/٧١ــ١٩٧٨)٠ (مارس ١٩٨٠)

(١٣) تقييم سياسات التجارة الخارجية والنقد الاجنبي وسبل ترشيدها٠ (يوليو ١٩٨٠)

(١٤) التنمية الزراعية في مصر ماضيها وحاضرها (ثلاثه اجزاء)٠ (يوليو ١٩٨٠)

(١٥) A study on Development of Egyptian National Fleet, June 1980

(١٦) الانفاق العام والاستقرار الاقتصادي في مصر ١٩٧٠ ــ ١٩٧٩ ٠ (ابريل ١٩٨١)

(١٧) الابعاد الرئيسية لتطوير وتنمية القرية المصرية٠ (يونيو ١٩٨١)

(١٨) الصناعات الصغيرة والتنمية الصناعية٠
(التطبيق على صناعة الغزل والنسيج في مصر)٠ (يوليو ١٩٨١)

(١٩) ترشيد الادارة الاقتصادية للتجارة الخارجية والنقدية الاجنبية (ديسمبر ١٩٨١)

(٢٠) الصناعات التحويلية في الاقتصاد المصرى (ثلاثة أجزاء). (أبريل ١٩٨٢)

(٢١) التنمية الزراعية في مصر (جزئين). (سبتمبر ١٩٨٢)

(٢٢) مشاكل انتاج اللحوم والسياسات المقترحة للتغلب عليها. (أكتوبر ١٩٨٣)

(٢٣) دور القطاع الخاص في التنمية (نوفمبر ١٩٨٣)

(٢٤) تطور معدلات الاستهلاك من السلع الغذائية وآثارها على السياسات الزراعية في مصر. (مارس ١٩٨٥)

(٢٥) البحيرات الشمالية بين الاستغلال النباتي والاستغلال السمكي (أكتوبر ١٩٨٥)

(٢٦) تقييم لاتفاقية التوسع التجاري والتعاون الاقتصادي بين مصر والهند ويوغوسلافيا. (أكتوبر ١٩٨٥)

(٢٧) سياسات وامكانيات تخطيط الصادرات من السلع الزراعية (نوفمبر ١٩٨٥)

(٢٨) الافاق المستقبلية في صناعة الغزل والنسيج في مصر . (نوفمبر ١٩٨٥)

(٢٩) دراسة تمهيدية لاستكشاف أفاق الاستثمار الصناعي في اطار التكامل بين مصر والسودان. (نوفمبر ١٩٨٥)

(٣٠) دراسة تحليلية عن تطور الاستثمار في ج.م.ع مع الاشارة للطاقة الاستيعابية للاقتصاد القومي. (ديسمبر ١٩٨٥)

(٣١) دور المؤسسات الوطنية في تنمية الاساليب الفنية للانتاج في مصر (جزئين). (ديسمبر ١٩٨٥)

(٣٢) حدود وامكانيات مساهمة ضريبة على الدخل الزراعي في مواجهة مشكلة العجز في الموازنة العامة للدولة وأصلاح هيكل توزيع الدخل القومي. (يوليو ١٩٨٦)

(٣٣) التفاوتات الاقليمية للنمو الاقتصادي والاجتماعي وطرق قياسها في جمهورية مصر العربية (يوليو ١٩٨٦)

(٣٤) مدى امكانية تحقيق اكتفاء ذاتي من القمح (يوليو ١٩٨٦)

(٣٥) Integrated Methodology for Energy Planning in Egypt, Sept. 1986.

(٣٦) الملامح الرئيسية للطلب على تملك الاراضي الزراعية الجديدة والسياسات المتماثلة باستصلاحها واستزراعها (نوفمبر ١٩٨٦)

(٣٧) دراسة بعنوان مشكلات صناعة الالبان في مصر (مارس ١٩٨٨)

(٣٨) دراسة بعنوان آفاق الاستثمارات العربية ودورها في خطط التنمية المصرية . (مارس ١٩٨٨)

(٣٩) تقدير الايجار الاقتصادي للاراضي الزراعية لزراعة المحاصيل الزراعية الحقلية على المستوى الاقليمي لجمهورية مصر العربية عامي ٨٠، ١٩٨٥.

(٤٠) السياسات التسويقية لبعض السلع الزراعية وآثارها الاقتصادية (يونية ١٩٨٨)

٤١ – بحث الاستزراع السمكي فى مصر ومحددات تنمية — أكتوبر ١٩٨٨

٤٢ – نظم توزيع الغذاء فى مصر بين الترشيد والالغاء — أكتوبر ١٩٨٨

٤٣ – دور الصناعات الصغيرة فى التنمية
دراسة استطلاعية لدورها فى الاستيعاب العمالى — أكتوبر ١٩٨٨

٤٤ – دراسة تحليلية لبعض المؤشرات المالية للقطاع العام الصناعي التابع لوزارة الصناعة . — أكتوبر ١٩٨٨

٤٥ – الجوانب التكاملية وتحليل القطاع الزراعى فى خطط التنمية الاقتصادية والاجتماعية — فبراير ١٩٨٩

٤٦ – امكانيات تطوير الضرائب العقارية لزيادة مساهمتها فى فى الايرادات العامة للدولة فى مصر . — فبراير ١٩٨٩

٤٧ – مدى امكانية تحقيق اكتفاء ذاتى من السكر — سبتمبر ١٩٨٩

٤٨ – دراسة تحليلية لاثر السياسات الاقتصادية والمالية والنقدية على تطوير التنمية للقطاع الزراعى — فبراير ١٩٩٠

٤٩ – الانتاجية والاجور والاسعار – الوضع الراهن للمعرفة النظرية والتطبيقية مع أشارة خاصة للدراسات السابقة عن مصر . — مارس ١٩٩٠

٥٠ – المسح الاقتصادى والاجتماعى والعمرانى لمحافظة البحر الاحمر وفرص الاستثمار المتاحة للتنمية . — مارس ١٩٩٠

٥١ – سياسات اصلاح ميزان المدفوعات المصرى للمرحلة الاولى — مايو ١٩٩١

٥٢ – بحث صناعة السكر وامكانيات تصنيع المعدات الرأسمالية فى مصر — سبتمبر ١٩٩٠

٥٣ – بحث الاعتماد على الذات فى مجال الطاقة من منظور تنموى وتكنولوجى وتكنولوجى — سبتمبر ١٩٩٠

٥٤ – التخطيط الاجتماعى والانتاجية — أكتوبر ١٩٩٠

٥٥ – مستقبل استصلاح الاراضى فى مصر فى ظل محددات الارض والمياه والطاقة ..

٥٦ – دراسات تطبيقية لبعض قضايا الانتاجية فى الاقتصاد المصرى — نوفمبر ١٩٩٠

٥٧ – بنوك التنمية الصناعية فى بعض دول مجلس التعاون العربى — نوفمبر ١٩٩٠

٥٨ – بعض آفاق التنسيق الصناعى بين دول مجلس التعاون العربى — نوفمبر ١٩٩٠

٥٩ -	سياسات اصلاح ميزان المدفوعات المصرى (مرحلة ثانية)	نوفمبر ١٩٩٠
٦٠-	بحث اثر تغيرات سعر الصرف على القطاع الزراعى وانعكاساتها الاقتصادية	ديسمبر ١٩٩٠
٦١-	الامكانيات والافاق المستقبلية للتكامل الاقتصادى بين دول مجلس التعاون العربى فى ضوء هياكل الانتاج والتوزيع	يناير ١٩٩١
٦٢-	امكانيات التكامل الزراعى بين مجلس التعاون العربى	يناير ١٩٩١
٦٣-	دور الصناديق العربية فى تمويل القطاع الزراعى	ابريل ١٩٩١
٦٤-	بعض القطاعات الانتاجية والخدمية بمحافظة مطروح(جزئين الجزء الاول : القطاعات الانتاجية	اكتوبر ١٩٩١
٦٤-	بعض القطاعات الانتاجية والخدمية بمحافظه مطروح(جزئين) الجزء الثانى: القطاعات الخدمية والبنية الاساسية	
٦٥-	مستقبل انتاج الزيوت فى مصر	اكتوبر ١٩٩١
٦٦-	الانتاجية فى الاقتصاد القومى المصرى وسبل تحسينها - مع التركيز على قطاع الصناعة (الجزء الاول) الاسس والدراسات النظرية	اكتوبر ١٩٩١
٦٦-	الانتاجية فى الاقتصاد القومى المصرى وسبل تحسينها - مع التركيز على قطاع الصناعة (الجزء الثانى) الدراسات التطبيقية	اكتوبر ١٩٩١
٦٧-	خلفية ومضمون التطورات الاقتصادية الحالية والمتوقعة بشرق اوربا، ومحددات انعكاساتها الشاملة على مستقبل التنمية فى مصر والعالم العربى	ديسمبر ١٩٩١
٦٨-	ميكنة الانشطة والخدمات فى مركز التوثيق والنشر	ديسمبر ١٩٩١
٦٩-	ادارة الطاقة فى مصر وضوء ازمة الخليج وانعكاساتها دوليا واقليميا ومحليا	ديسمبر ١٩٩١
٧٠-	واقع وافاق التنمية فى محافظة الوادى الجديد	يناير ١٩٩٢
٧١-	انعكاسات ازمة الخليج (١٩٩١/٩٠) على الاقتصاد المصرى	يناير ١٩٩٢
٧٢-	الوضع الراهن والمستقبلى لاقتصاديات القطن المصرى	مايو ١٩٩٢
٧٣-	خبرات التنمية فى الدول الاسيوية حديثة التصنيع وامكانية الاستفادة منها فىمصر	يوليو ١٩٩٢
٧٤-	بعض قضايا تنمية الصادرات الصناعية المصرية	سبتمبر ١٩٩٢
٧٥-	تطوير مناهج التخطيط وادارة التنمية فى الاقتصاد المصرى فى ضوء المتغيرات الدولية المعاصرة	سبتمبر ١٩٩٢
٧٦	السياسة النقدية فى مصر خلال الثمانينات " المرحلة الاولى ميكانيكية وفعالية السياسة النقدية فى الجانب المالى والاقتصاد المصرى	سبتمبر ١٩٩٢
٧٧-	التحرير الاقتصادى وقطاع الزراعـــة	اكتوبـر ١٩٩٢

٧٨ ـ احتياجات المرحلة المقبلة للاقتصاد المصرى ونماذج التخطيط واقتراح بناء نموذج اقتصادى قومى للتخطيط التأشيرى ـ المرحلة الاولى ٠	يناير ١٩٩٣
٧٩ ـ بعض قضايا التصنيع فى مصر من منظور تنموى تكنولوجى	فبراير ١٩٩٣
٨٠ـ تقويم التعليم الأساسى فى مصر	مايو ١٩٩٣
٨١ـ الآثار المتوقعة لتحرير سوق النقد الأجنبى على بعض مكونات ميزان المدفوعات المصرى	مايو ١٩٩٣