العنوان:	SCIENCE TECHNOLOGY AND ECONOMIC DEVELOPMENT IN THE MIDDLE EAST
المصدر:	مجلة مصر المعاصرة
الناشر:	الجمعية المصرية للاقتصاد السياسي والإحصاء والتشريع
المؤلف الرئيسي:	Tuma, Elias H.
المجلد/العدد:	مج74, ع391,392
محكمة:	نعم
التاريخ الميلادي:	1983
الشهر:	ابريل
الصفحات:	27 - 52
رقم MD:	663761
نوع المحتوى:	بحوث ومقالات
قواعد المعلومات:	EcoLink
مواضيع:	العلوم والتكنولوجيا، التنمية الاقتصادية، الشرق الاوسط
رابط:	http://search.mandumah.com/Record/663761

SCIENCE, TECHNOLOGY AND ECONOMIC DEVELOPMENT IN THE MIDDLE EAST

By

ELIAS H. TUMA

University of California, Davis and

the American University in Cairo

I. The Problem. The relation between science and technology and economic development has been known and accepted as positive and significant for most of the modern period. What may have been in dispute and subject to investigation is the nature of that relationship and the role science and technology play, especially in the late-comer countries to development[1]. The uncertainty regarding the role of technology may have been aggravated by the misleading appearances of development and modernization and the relatively high growth rates in most countries of the region. These appearances, however, are contradicted by a big lag in labor productivity, an inability to compete on the international market, a relatively high degree of dependence on the technically advanced countries, and the predominance of traditional economic structures, all of which cast doubt on the reality of development and structural change which should result from advancement in science and technology. The apparent ineffectiveness of the attempts to develop through new technology has led some experts to question the relevance of these «foreign» technologies and to call for «appropriate» technology instead, often without explaining what appropriate technology means.[2] I suggest that the limited impact of science and technology in the Middle East is not due to the use of inappropriate technology but to more serious and deep factors, including the lack of use of technology altogether. This reasoning is explored in the form of hypotheses, as follows :

1. The relatively slow economic development and the lag in structural change in most countries of the Middle East are

due to the lag in introducing new and advanced technology, especially where such steps would be fully justified by the economic environment prevailing.

2. The lag in introducing new technology is due primarily to a misconception of the meaning and role of technology in development in general and Middle East development in particular. For example, the use of the product of technology is often mistaken for the transfer of the technology itself.

3. These misconceptions and lags are embodied in the philosophy on which the development policies are based and the institutions responsible for the implementation of those policies and therefore the effects are bound to be limited, as indeed they have been.

4. Economic development and structural change in the Middle East can only come about if major technological changes are introduced at a rapid enough rate to cause perceptible changes in labor productivity, economic structure, and competitiveness on the international market, the dislocations incurred therefrom notwithstanding.

Before we deal with these hypotheses it is necessary to clarify certain concepts and relations. First, science and technology are related in the same way as theory and application are. Up to a certain level, it is possible to have one without the other, but beyond that level the effects on development are bound to be limited. Second, there is a distinct difference between the use and the transfer or diffusion of technology. The use is mainly the consumption of the technique or its product. The transfer of technology is a process which leads to the domestication or nativization of the technique and its production. The transfer or diffusion of technology, as a process, may be summarized in three stages : In the first, acquaintance with the technique or the machine takes place so that interest is aroused; in the second, absorption of the technique is consumated, including the acquisition of the right to produce the machine domestically; and in the third or the assimilation stage the machine is produced and marketed by a local firm and thus becomes a part of the local technology.[3] Third, the successful invention of technology and its transfer are closely related to the education and graduation of sufficient numbers of qualified scientists, technical experts and craftsmen to render the economy relatively independent of foreign expertise. The failure to graduate such qualified people or to invent and/or transfer technology may be sufficient to cripple the economic development of the country, as seems to have been the case in most countries of the Middle East.

The following section will survey the major advances made in science and technology in twenty countries of the region over the past two decades, as listed in Table 1. Section III will discuss the forces of technological change operative in this period and environment. The final section will present a summary of the observations and their implications for the future of development in the Middle East.

I. Advances in Science and Technology in the Middle East. Very little new scientific knowledge has originated in the Middle Eastern countries, outside Israel, during the recent past. This judgment can be easily illustrated by the rarity of patents and scientific publications by Middle Eastern scientists who reside in the Middle East. Hardly any serious research is conducted in Iraq, Jordan, Libya, or Syria and up to the mid 1960s, only some research of an applied nature was carried out in Lebanon and Egypt.[4] The same may be said of the Gulf area, Saudi Arabia, Iran, Algeria, Morocco and Tunisia. In all these countries, the universities are transmitters and not creators of knowledge; they cater to undergraduate teaching while research remains undeveloped. The only exception in the region is Israel, although more recently the universities in other countries have started to emphasize science education and encourage enrollment in scientific disciplines, as shown in Table 1.

As the figures show, a dramatic increase has taken place in enrollment in science, both in absolute and in relative terms, throughout the region. Algeria's science student body, for example, increased from 1,545 in 1965 to 13,486 in 1976 or by 772.8% in that period. Yet this rate of change was surpassed by each of Saudi Arabia, Iran and Kuwait. Iran's student body in science went up to 27,317 in 1976 from a low of 2,030 in 1965. The change, on the other hand, seems to have been modest in Egypt, Tunisia, Sudan and Israel. Except for Sudan, the modest change may be explained partly by the relatively high level these countries had already realized in the base year.

Most of the technical efforts in the Middle East have been devoted to applied research and experimentation. Engineering, the medical sciences and agriculture account for much of the technical training in these countries; Israel again is an exception. As the figures of Table 1 show, the size of the student enrollment in engineering sciences has increased dramatically. In Algeria the enrollment increased from 359 students in 1965 to 5,284 in 1975 or by 1,372.9% in that period. Iran comes next with a 973% increase or from 3,207 students to 34,411 in 1976. However, relative to the population, the largest increases were in Iraq and Syria, in contrast to the relatively modest change in Egypt of only 80.5%, in Jordan 78.2%, in Sudan 39.8% and in Israel 118.1% (1974 as latest for Israel).

These expansive enrollment figures can be misleading since most of them are undergraduate enrollments, including those in level A which is below the first university degree. The majority in all cases are enrolled in level B or in the first university degree program. Those who for practical purposes may be associated with research and advanced science, as in level C, are relatively small in number, as shown in Table 2. In 1975 Egypt had 336 post-graduate students in science; Iran had 113, all the way down to none in many other countries, while Israel could boast of 533 in 1973.[5]

Another way of assessing the place of «science in the Middle East» is to look at the periodical publications devoted to science. Table 2 shows that, of those reporting, Israel is far ahead of all the others; Iran and Iraq follow, though it may be suspected that Egypt would come after Israel had the data been available. Lebanon may also be ahead of many others. These figures, however, except in Israel, are quite modest and clearly betray the underdevelopment of scientific programs in these countries. This same conclusion may be reached by discovering that few of the Middle Eastern countries are equipped to offer graduate or advanced degree programs in science and engineering and depend on foreign universities for advanced training.

Table 1.—**Students in Post-Secondary Education in Science and Engineering**

NATURAL SCIENCE				ENGINEERING		
	(1)	(2)	(3)	(4)	(5)	(6)
	1965	1975	Change (%)****	1965	1975	Change (%)****
Algeria	1,545	13,486 (1976)	772.8	359	5,284 (1976)	1,371.9
Bahrain					268	
Egypt	7,075 (1967)	16,307	130.5	29,632 (1967)	53,495	80.5
Iran	2,030	27,317 (1976)	125.7	3,207	34,411 (1976)	973.0
Iraq	3,916	8,395	114.4	3,245	15,157	367.1
Israel	3,634	6,742 (1976)	88.0	3,421	14,161 (1976)	336.9
Jordan	282 (1966)	1,101 (1974)	290.4	142 (1966)	253 (1974)	78.2
Kuwait	86 (1966)	1,650 3	1,818.6		127	
Lebanon	871			771		
Libya	278	740 (1974)	166.2	200	1,394 (1974)	597.0
Morocco	700	2,443	249.0	325	1,075	230.1
Qatar						
Saudi Arabia	157	1,565	896.8	255	2,121	731.8
Sudan	733	1,528	108.4	929	1,298	39.8
Syria	2,248	7,816	268.8	1,375	10,453	660.2
Tunisia	1,384	3,083 (1976)	122.8		1,799 (1976)	624.2
United AE						
Yemen AR		80				
Yemen PDR						

Source : UNESCO Statistical Yearbook 1977, Table 5.2

* F.I. Qubain, Education of Science in the Arab Countriss, Johns Hopkins, 1966, p. 505.

** Last year reported - 1965 or year after, divided by that year.

*** UNESCO Statistical Yearbook 1980, Table 3.12.

**** % Change = (1975-·976) 1965.

Technical advance may also be assessed by estimating the expansion of skills. Most of the Middle East countries suffer from the shortage of skilled labor which is made more serious by institutional means. Instead of expanding efforts to train middle level technicians, it appears that fewer students in secondary education are enrolled in vocational programs. Table 3 shows the trend since 1960. In most countries the percent of secondary school students enrolled in vocational training either went down, as in Algeria, Egypt, Saudi Arabia and Tunisia, Sudan, and Syria or it fluctuated slightly around a low level as in Iraq, Jordan and Kuwait. The only big jump, even from an already high percentage, was in Israel in which 29% of the secondary school enrollment was in vocations in 1960, 45% in 1970 and is still close to that at 44% in the most recent estimates. Egypt comes next with 18%, although this represents a decline from 1960 and from 1970, and Tunisia with 17% as the most recent estimates, which is an increase over 1970 after a major decline from 1960. On the other hand, eight countries have 3% or less of the secondary school enrollment in vocational training. In other words, given the low rates of vocational training and the declining trend of enrollment observed in the larger countries, it seems that the prospects of overcoming the shortage of supply of skilled labor in the next few years are rather dim.

Looking at the creation and/or transfer of technology by the countries of the Middle East indicates a high rate of consumption of new technology but not of making it. In terms of this concept, none of the Middle East countries, with the possible exception of Israel, have mastered the diffusion or transfer of technology. On the contrary, they have mistakenly pursued the transfer of technology by acquiring the product or the machine that makes the product, but rarely the knowledge and/or the skill to make the machine. The oil and petrochemical industries illustrate this pattern of acquisition clearly. Between 1963 and 1976, the Arab countries established 567 new projects, but virtually in none of them was there any technology transfer in the sense of acquiring the knowledge and/or the skill to gradually be able to build similar projects independently of the foreigners. The university graduates and native technicians are trained simply to operate the imported machinery, to be caretakers, and to

Table 2.—**Other Indicators of the Level of Science and Technology**

Country	(1) Post Graduate (level C) 1975 **		(2) Students Abroad Variable*		Periodicals in *** 1975		
	Science	Engineering	Years, 1973-75	Math.	Net. Sci.	Med.	Inclusive
Algeria	7		7,968			2	
Bahrain			1,427				
Egypt	336	310	7,188				
Iran	113	450	33,021	1	1	16	6
Iraq	70	31	4,219		6	7	11
Israel	533 (1973)	228	5,729	3	21	30	16
Jordan	6 (1974)		11,601			3	3
Kuwait	4		1,548			2	
Lebanon			7,321				
Libya			2,126				
Morocco	3		9,344				
Oman			132				
Qatar			230				
Saudia Arabia			3,835				
Sudan	26	1	2,778				
Syria			6,069			2	
Tunisia			8,460		2 (1973)	3	
United AE			392				
Yemen AR			1,176				
Yemen PDR			1,022				
Palestine (Refugees)			6,201				

Source : UNESCO Statistical Yearbook, 1977, Table 5.7

Ibid. * Table 5.7, Graduate and Undergraduate.

Ibid. **Table 5.5.

Ibid.***Table 12.3.

Table 3.—Vocational Training. – Vocational Enrollment % of Secondary School Enrollment

Country	1960	1970	MRE*	% of Change**
Algeria	29.0	20.0	2.5	—.87
Bahrain				
Egypt	22.0	19.0	18.0	—.05
Iran	3.0	3.0	7.0	1.33
Iraq	6.0	3.0	5.0	.67
Israel	29.0	45.0	44.0	—.02
Jordan	3.0	3.0	4.0(1)	.33
Kuwait	2.0	3.0	2.0	—.33
Lebanon	2.0	2.0		
Libya		6.0	3.0	—.50
Morocco		2.0	3.0	.50
Oman			10.0	
Qatar	31.0	5.0	4.0	—.20
Saudi Arabia	13.0	2.0	2.0	.00
Sudan	3.0	1.4	1.0(2)	—.28
Syria	6.0	3.4	4.6	.35
Tunisia	24.0	12.0	17.0	.42
UAE		14.0	4.0	—.71
Yemen AR		2.0	2.0	.00
Yemen PDR	5.0	3.0	2.0	—.33

Source : World Bank Tables, The Johns Hopkins University Press, 1980, Table 4.

*Most Recent Estimate

**% of Change = (MRE-1970) 1970

East Bank only

Data are not comparable over time because of changes in duration of primary and secondary education.

depend on imports for spare parts and expertise to make sure the machine remains in operation.[6] This false pattern of technology transfer is probably encouraged by the sellers of technology, according to whom technology transfer is any «transaction which effects a transmittal of any form of technical knowledge from one country to another» including «hardware, software, goods, services and information.»[7]

A survey of contracts for technology transfer to OPEC and to Egypt between 1970 and 1975 shows that most plants are transferred as turnkey projects, that the financing is conditional upon foreign participation in the construction and operation of the plants, and that native participation in the major operations is secondary to that of the supplier countries. Exceptions to this pattern have only recently been observed in Algeria, Syria and Iraq which insist on the training of nationals as a part of the contract. The plants transferred to the Middle East are in the fields of oil, transportation, cement making, manufacturing, power equipment, computers, drainage, and nuclear energy. Page after page lists the projects and the contracts but nowhere are there agreements leading to the building of machinery, the making of machine tools, spare parts, or engines of any sort which are basic to the assimilation or diffusion of the technology. A few projects for the assembly of cars and tractors have been established in Iran, Egypt and Syria, but these are limited in number and impact.[8] The pattern has not changed since 1975, although the partners may have varied. Similarly the pattern of industrial imports by the Arab countries has remained relatively constant, with barely any evidence that local production has been substituted for imports, especially east of the Mediterranean.[9]

The pattern in the North African countries and Iran has been a little different. In Algeria, the import of machinery and transport equipment more than tripled between 1960 and 1976 while the import of other manufactured goods declined by more than 60%. At the same time there was a decline in the import of other manufactures, which suggests import substitution in «other» than machinery and transportation. The same pattern can be seen in Syria and Iran and Morocco. Tunisia follows the same pattern except that its exports of other manufacturers have increased. Here too we see no evidence of transfer of technology leading to the building of machinery and production plants but an increase in the use of the imported plants to make finished products for local use. Again, Israel follows a pattern of its own : a decline in the import of machinery and transport equipment, and an increase in the import of other manufactures, but also an increase in the export of both machinery and other manufactures, as shown in Table 4.

The general picture which emerges is the following. With few exceptions, interest in science and engineering at the universities has increased dramatically, but it has remained limited at the level of advanced research and creativity. Most of the research is applied, largely in agriculture. Except for Israel, the Middle Eastern countries are major consumers and users of acquired products of technology. The transfer of technology in the sense of assimilation has remained peripheral and has not changed the status of the Middle Eastern countries vis-a-vis the machine producing, technologically advanced countries, in spite of the heavy expenditure on technology, education, and «industrialization.» It is not surprising, therefore, that labor productivity in local industry has remained low, the per capita output limited, and dependence on foreign technology relatively high. In other words, underdevelopment has remained a logical consequence of the low level of science and tchnology practiced in the region. [10] Why have science and technology remained at this low level in a region which has the need and presumably the capacity to advance ? This is what we turn to next.

III. The Forces of Technological Change. The emphasis on the use of technology rather than on its actual transfer and adoption has been criticized as a fundamental reason for failure of the Middle Eastern economies to catch up with the developed countries. [11] This criticism is based on the assumption that there is a desire for higher technology in the Middle East, that the achievement of higher technology is feasible, but that the effort to apply diffusion has been short of expectations. Let us assume for the moment that a higher technology is desirable. Let us agree also that the shift to higher technology has been short of expectations. But can we be certain that the adoption of higher

Table 4.—Transfer of Technology Through Trade

Country	% of Imports Machinery and Other: Transp. 1960	Equip. 1976	Manufacturing 1960	Manufacturing 1976	% of Exports: Mach. & Transp. 1960	Mach. & Transp. 1976	Other Manuf. 1960	Other Manuf. 1976
Algeria	14	47	54	30	1	(.)	6	1
Bahrain								
Egypt	25	30	25	29	(.)	1	3	9
Iran	23	45	61	41	0	0	3	(.)
Iraq		47		34	0	0	0	(.)
Israel	28	22	27	41	2	11	51	60
Jordan		30		30	0	1	4	16
Kuwait						2		1
Lebanon								
Libya	40	35	32	44	0	0	10	0
Morocco	19	35	39	27	1	(.)	6	6
Qatar								
Saudi Arabia		44		40				
Sudan	14		58					
Syria	14	34	48	35	0	2	17	2
Tunisia	23	35	44	32	1	1	8	13
United AE								
Yemen AR		31		35				
Yemen PDR								10

Source : World Bank, World Development Report 1979.

technology is feasible, given the economic, social, and political forces that impinge on it in the region ? To answer this question, let us look at the conditions, the favorable and the unfavorable, for technology transfer.

(a) **Favorable Conditions.** Many factors seem to favor making the Middle East a technology producer, as it is a user. (1) On the economic side, there is relatively high demand for the products of advanced technology, backed by high purchasing power, as illustrated by the expenditures on machines and transportation equipment, and on the acquisition of know-how from both east and west. The income in the Middle East, especially in the oil-producing countries, the increasing population, and consequently the higher effective demand for the products of technology suggest that the demand for technology production, as a derived demand, should be expected to rise. Actually, the sustained levels of contracting for machines and plants between the Middle East countries and the producers and sellers of technology are strong indications of relatively high future demand for new technology and spare parts. Similarly high demand expectations may be generated by tracing the pattern of expenditure on the products of technology in the form of finished consumer products as suggested by Table 4. Therefore, the profit expectations, or reduction of production cost and foreign currency expenditure may be considered highly favorable for the domestic diffusion and expansion of technology.

(2) The economic demand arguments for domestic technology production are reinforced by socio-political arguments. First, higher technology confers prestige, increases independence, and generates political legitimacy. Whether to produce war material or to reduce dependence on imports, or to gain access to the export market, the leaders in all countries of the Middle East stand to gain by transforming their countries into producers of technology. They would no longer be at the mercy of other countries for the products of technology, for foreign exchange, or military security and war equipment. Second, the ability to produce the technology has nationalistic significance as it renders the Middle East country independent or at least interdependent on equal grounds with current producers of technology.

As a producer country, the new Middle East producer of technology will be able to compete, negotiate, and bargain on relatively equal terms, compared with their current pattern of one-sided dependence on the producer-exporters of technology. Third, the fact that the Middle East countries have been educating many of their students to handle the new technology makes it imperative for them to absorb the graduates in appropriate jobs to practice the new skills, escape unemployment and avoid restlessness, as well as to realize the returns on the public and private investment in technical education. One might argue that the supply of the skilled people should generate demand for these skills. Furthermore, the leaders cannot afford to have these skilled and educated people unemployed for a long time because they become restless and a danger to the leadership, or else they leave the country and leave a vacuum behind them as a technical and scientific drain on the resources.

(3) As latecomers to development and industrialization, the Middle East countries have a large backlog of technology at their disposal to borrow from. [12] The range of available technology is wide and each country in the Middle East has options as to what to borrow and adopt, according to their own requirements, as indeed they have discovered. The Egyptians, for example, have recently resorted to the egyptianization of selective machinery by copying it for local production in a form that fits the local economy at relatively low costs. This practice has been somewhat common in the field of agriculture although still on a very limited scale. [13]

(4) The supply of technology as physical capital and/or know-how has also been facilitated, at least nominally, by technical assistance programs from other countries. Point IV assistance from the United States is a case in point. More recently the European countries and Japan have become active in supplying technology, while Russia and Eastern Europe have continued to be active suppliers. The terms of supplying technology, however, have varied, but in most cases, they have been politically oriented and supplier-interest directed. Often the technology transfer has been facilitated through loans, grants by the supplier country, although the pattern of expenditure on such assistance,

however, leaves much to be desired. About 50% of the aid usually goes for technicians and capital projects imported from the outside and very little is used to advance local technology. This pattern is evident in most Middle Eastern countries, especially in the oil-rich countries. But even the not-so-rich like Egypt, Morocco, the Yemens and Syria have been hosting large numbers of technical advisors, as package deals for economic and military assistance, presumably with high potentials for the transfer of technology. [14]

In general, then, both the forces of demand and the forces of supply tend to favor the diffusion of technology and its assimilation into the domestic economy instead of importing turnkey plants or finished products as has been the pattern. Why then has this pattern persisted and how does it affect the transition to takeoff and sustained development ? Apparently the unfavorable conditions far outweigh the favorable conditions, as can be seen below.

(b) **Unfavorable Conditions.** Several factors have mitigated against technology transfer. (1) An important obstacle apparently is the «prevailing confusion in the Arab mind between science and technology, which is an **activity**, with the **hardware products** of this activity. Arab governments and individuals wish to secure tanks, airplanes... in the form of a turnkey job... We do not want to sit down and figure the device out **ourselves, design** it or even make it...» [15] According to another observer, «one of the reasons, if not the main reason, why western technology... fails in the Middle East, is that both parties fail to understand what technology is, and what one may justifiably expect to do with it.» [16] In other words, the failure has been due to the misidentification of the problem and the inability to select the appropriate method to deal with it, as well as to the inability to understand the implications of technology transfer in order to maximize its benefits and minimize its costs. In a sweeping generalization to explain why the New International Economic Order may not succeed, Aziz El-Bindary observes the fascination with and emergence of «Industrialism and not industrialization, and of modernism and not of modernization» or the dominance of the image over the reality in the Middle East, which applies equally well to their attitude to technology. [17]

(2) Another possible detractor from technological advance is the confused relationship between religion and science and technology in the region. Is it true, for example, that Islam, the predominant religion in the Middle East, looks with disfavor on scientific advance and a more thorough transfer of technology ? In its traditional all-encompassing predominance of individual and social behavior, Islam may have been a discouraging force against secularism, rationality, objectivity, and the unrestricted search for knowledge, as would be demanded by science and the follow-up technology. As if to justify the current trends in Islam, some argue that Islam encourages the search for the «unrevealed» knowledge, while the «revealed» knowledge is acquired from the prophets and cannot be researched. Therefore, according to this view which goes back to **The Book of Knowledge** by Abu Al-Ghazahi (1058 - 1111 A.D.), science is bound by its social relevance and should not be pursued beyond the limits of that relevance, and the scientist must be responsible to society, since objectivity is a myth. The pursuit of knowledge must be subject to the belief in the creed that «Allah is Omniscient,» or Allah Akbar and there is no other God but Allah. [18] The problem with this interpretation is that social responsibility and consistency with Islam are themselves left to be determined by non-scientists, and there is little assurance that they would permit scientific advance that might challenge their authority. On the other hand, the relevance or usefulness of new knowledge can hardly be determined before it is discovered, and therefore any prior restriction is bound to interfere with the discovery of such unknown knowledge. As long as secularism is denied, objectivity is restricted, and religion governs the search for new knowledge and techniques, Islam (as well as other religions) will most likely act as a hindrance to the development of science and technology, in the Middle East and elsewhere.

(3) However, assuming away for the moment the alleged confusion and possible negative impact of religion, one major handicap in the way of adoption and production of technology is a complex of forces which may be called **time.** According to this conception a new technology requires a certain amount of time for gestation, adaptation, and growth, and the Middle East countries cannot and must not rush into the new and advanced

technology before they are ready for it. This is the type of force which Rostow described as the take-off or the shift from the pretake-off into the stage of sustained growth, which required variable periods of time by the different countries that have passed through it.[19] However, to explain the slow process of change as a function of time is quite simplistic and must be possible to explain analytically; otherwise the process seems deterministic. Indeed the transition requires more than time; it requires a change of philosophy and attitude. The new industrial technology tends to be somewhat in contradiction with the traditions of the Middle East countries, since it is based on rationality, calculation, precision, objectivity and economic efficiency or cost minimization. The Middle Eastern student who goes abroad to acquire the relevant scientific knowledge and technical skills returns to the Middle East to find a different concept of time, of punctuality, or precision, and of objectivity. All of a sudden informality replaces formality; proteksia or «whom do you know» replaces efficiency criteria; and a certain degree of mysticism and confessionalism or religiosity replaces rationality and confidence in the power of the individual and the people as responsible for their destiny. The returning graduate finds himself/herself surrounded by a mass of illiteracy, traditionalism, arbitrariness, and the cruel choice of reverting to that culture, or of being left out. Those who are aspiring and would not revert seek open horizons elsewhere, and thus the brain drain begins. Those who remain and struggle for science and technology are in the minority.[20]

(4) Another rather serious handicap faced by both the returning and the home-educated expert in science and technology is the inadequate support they receive from the middle level skills and craftsmanship. Qualified technicians are in short supply, partly because of the lack of facilities to train technicians, but also because such work is looked down upon in the various countries of the Middle East, or because of the «skill» drain to other countries. Therefore, the scientist-engineer-researcher-innovator may find it difficult to recruit the technicians needed to sustain serious projects. An easy way out is not to undertake such projects, do them at lower levels of sophistication and with lower expectations, or join the army of emigrants to the developed

countries. Vocational schools are still in very short supply and training on the job is the most common but limited approach to acquiring such skills. [21]

(5) However, one of the most debilitating though unintended obstacles against the technology shift is political in nature. On one hand, the political leaders are anxious to create political stability. On the other, they are apparently uncertain as to what concept of development they should follow and how. They vacillate between a market approach and planning, and between discipline through the plan or discipline through competition and self-interest. Thus, while the leaders call for catching up with the developed countries, they apply policies that are inconsistent with that call. They allocate large investments for advanced education but very little to put it to use. They call for independence from foreign producers of technology but continue to mortgage their capital resource and markets to those same producers. In other words, their proclaimed doctrines and their policies and actions are inconsistent with each other. Therefore, the realized results are different from those that should have been anticipated, regardless of the commitment to science and technology. [22]

(6) An even more shattering argument against a genuine transfer of technology is the apparent diseconomy of scale such transfer would encounter. While the regional aggregate demand for the products of technology may be highly stimulating to change, the economies of the Middle East are by and large market-segmented, so that few countries can individually generate high enough demand to economically justify technological expansion. The large underdeveloped sector in each country, and the lack of economic unity between countries tend to give the impression that the demand for new technology is limited and would not justify production by any one of these countries. This impression is reinforced by the apparent tendency by various countries to duplicate production, in petrochemicals, steel, car assembly, and textiles, at relatively high costs which often lead to protectionism to sustain the industry. An excellent illustration of this problem is the Arab steel industry. The developing countries in general and the Arab countries in particular require three or four times more investment per unit of output than the

developed countries, because of «13» different conditions they encounter, ranging from the weak infrastructure to the lack of killed workers and the higher cost of acquiring the necessary resources. [23] Why these reasons should persist is not clear, but in the meantime, the bias in favor of importing in general continues.

In other words, the transfer of technology is discouraged by the arguments for comparative advantage. Many people are persuaded that since the present producers of technology are specialized, well-established, and enjoy a comparative advantage, it should be more efficient for the Middle East coutries to buy the products of advanced technology, and specialize in products in which they have comparative advantage such as raw material, services, etc. This may be true in the short run and in the prevailing condition, but not in the long run or if the Middle East countries are willing to alter those conditions. It should be noted in this regard that no country in the history of development has managed to advance technologically, especially the late comers, on the basis of short-run comparative advantage. In the early stages of development, France, Germany, Scandinavia, and Japan made sure that their infant industries are protected and that favorable conditions are created to permit their technological transformation. Unfortunately the arguments for comparative advantage are closely tied to the vested interests of business groups and political leaders and planners. The package deals for purchases from the developed countries made with the leaders of the receiving country often include political rewards, kickbacks, or hopes of military supplies and alliances. Or the foreign producers go into partnerships with local economic interests such as local contractors, dealers, or large business interests which would be dislocated by a shift to technology production in place of importation. This kind of structural dependence may have become firmly established, with the «aid» of multinational companies which have little to gain from the technology transfer and probably much to lose. And yet the Middle East buyer countries may have no option but to take these package deals, as they have actually done for many years.

This same pattern of structural dependence is highly reinforced by the programs and foreign missions in general. The assessment of technical assistance to Iran over the first 15 years of its life shows that there were many handicaps with costs that far outweighed the benefits, and yet the assistance was agreed to. The technical experts of these missions were either poorly qualified or uninterested, or at least unfamiliar with the country and its needs. They were in poor communication with their native counterparts who often were uncooperative because they were poorly compensated compared with the foreign experts. Even the people of the country were not always ready to adopt new technology, especially when the transfer of technology was carelessly selected, badly planned and executed, and was not always supported enough by the environment or the community for it to succeed. As a result the Iranians were usually disappointed, had resentment for the invading technologies or cultures, and were more uncertain toward the future than they had been before the assistance.[24] The attitude of the Iranians in the late 1970's was little different from the attitudes described by Amuzegar for the early 1960's with regard to technical assistance. They still believed that «to have a vacation and high pay were the major incentives» why foreign experts went to Iran on technical assistance missions. These observations may even be an understatement of the defects of the technical assistance programs, as I have personally experienced them in the Middle East. Syrian experts, for example, complained bitterly to me because as counterparts to foreign technical assistance specialists, their position was nominal, and had little to do with policy making or substance. On another occasion a high-ranking AID official who was pushing for mechanization and decentralization of Egyptian agriculture became furious when I asked about the studies on which he based his recommendation. There is «no need to study; it is obvious,» he quickly asserted. When I pressured him for an explanation on economic and rational grounds, he retreated behind the barricade of «I don't make policy, I just apply it.»

Israel offers a major contrast with the above situation. Israel has been the only country to escape these formidable obstacles, mainly because it started at the level of high technology, and as an extension, rather than as a transfer of technology from the developed countries. The Jews who came from the Western world were not encumbered by tradition and the handicaps noted above and, moreover, they had all the facilities. Therefore, they were able to continue, build on, and advance the levels of science and technology they started with, especially to bolster their military security before and after the establishment of the state of Israel. And unlike the other countries, they had a shortage of labor and, therefore were always anxious to resort to advanced technology to substitute for labor and to maintain the levels of productivity and living the European Jews had enjoyed before they came to the Middle East. Furthermore, as an extension of the Western world, the Israelis had easy access to the technologies they wanted. The producers in the West considered it a privilege to help Israel in its efforts to remain scientifically and technologically superior in the Middle East region. Therefore, as the Israelis were anxious for and capable of inventing and innovating, they succeeded in maintaining and raising the levels of development and productivity they had started with. It is not surprising, in view of these various contrasts, that Israel and the rest of the Middle East have been so far apart in their technological and scientific achievements.

IV. The Implications. The picture presented above should cause anxiety among policy makers and developers in the Middle East. It is true that there has been a fair increase in the number of students graduated in science and engineering in recent years and extensive acquisitions of machinery and industrial products from abroad. Yet, these achievements are embarrassingly limited in terms of their impact on the assimilation and making of machinery as the final stage in the diffusion of technology process. And while there were many favorable conditions for technological diffusion, the unfavorable conditions were even more numerous, and both of them were differentially distributed among the countries of the Middle East. Hence, the results were also differentially distributed, as illustrated by the ranking of these countries in Table 5.

The rankings have been made on a scale of 1 to 10, representing the range between the highest achieved on each criterion and the lowest in the region, divided into ten equal segments. The rankings on education are self-explanatory and show the distribution of skilled persons per one hundred thousand people, at least as represented by formal education in science and engineering.

The technological advance may also be seen in terms of vocational training, as shown in the table. Israel leads with the highest score, but the second highest, in Egypt and Tunisia, is so far below that a major gap in vocational training is evident between these two ranks. The gap obviously is larger between Israel and other countries, most of which have a score of 1, implying that the vocational training is totally inadequate for technological diffusion and takeoff.

A more revealing ranking is that of the changing balance of trade in machinery and transportation equipment and in other manufacturing between 1960 and 1976. The scores represent the degree of improvement or deterioration in the specific balance between those two years, with a score of 1 representing the largest deterioration and a score of 10 the largest improvement among the countries of the region. Algeria experienced the worst and Israel the best change in the balance in machinery and transport equipment. In other manufacturing, Libya had the worst and Algeria the best record. It seems that Algeria has increased its imports of machinery and transport equipment but has used these imports to produce manufactured commodities for export or import substitution, including oil and gas products. Only Israel and Libya have improved their balance of trade in machinery and transport, with Egypt barely removing the deficit. Israel seems to have reduced its imports and increased its exports which implies an increase in the diffusion of technology. Libya, on the other hand, has only reduced its imports, with no change in exports and no apparent advance in technology diffusion. On the side of manufacturing, Algeria, Iran, Morocco and Tunisia have achieved positive balances as the exports of manufactured goods have increased and the imports have decreased. Again Egypt is on the border line between deficit and surplus. All the other countries have experienced a deterioration in their position in 1976 relative to 1960, and little diffusion of technology in any of them can be detected. This means that these countries are still in stage one or at most in the early segment of stage two of the diffusion model, during which patent rights or adoption rights are to be acquired.

To get an overall idea of the science and technology context for takeoff, an average score on a scale of 1 to 10, reflecting the

Table 5.—Weighted Ranking of Technological Capability Scale 1-10 on Each

Country	Post-graduate Students Per 100,000 People, 1965-1975 Average Natural Sci.	Engineering	Vocational Enrollment in Secondary Education As Per Cent of Total; MRE	Improvement in Balance of Trade Between 1960 and 1976 Machinery	Other Manuf	Average
Algeria	3	1	1	1	10	3.2
Bahrain		4				4*
Egypt	2	5	4	7	6	4.8
Iran	3	3	2	3	10	4.2
Iraq	4	4	1			3
Israel	10	10	10	10	5	9
Jordan	2	1	1			1.3
Kuwait	5	1	1			2.3
Lebanon	4	2				3*
Libya	2	2	1	8	1	2.8
Morocco	1	1	1	4	9	3.2
Oman			3			3*
Qatar			1			1*
Saudi Arabia	1	1	1			1
Sudan	1	1	1			1
Syria	5	4	1	3	5	3.6
Tunisia	3	1	4	4	10	4.4
UAE			1			1*
Yemen AR	1		1			1*
Yemen PDR		1	1			1*

Columns 1 and 2 are based on Table 1: Column 3 on Table 4; Columns 4 and 5 from Table 3, in Column 4, a score of 7 is the dividing line between improvement and deterioration in the balance of trade; in column 5 a score of 6 is the dividing line ; the higher the score the more improvement, or less deterioration.

* = data incomplete; score may be unrepresentative.

five indicators summarized above, has been constructed and is shown in the last column of Table 5. The wide spread of scores is quite representative of the technological environment in the Middle East. However, the more significant feature of this distribution is the wide gap between Israel, the most advanced, and the next highest, Egypt, which has a score of only 4.8 compared with Israel's score of 9. Tunisia follows with 4.4 and then Iran, Syria, Algeria, and Morocco follow in that order but only Iran has a score higher than 4. While no minimum score has been identified as the threshold for takeoff, it seems that no country other than Israel has achieved a high enough level of technology to suggest readiness for takeoff.

Several implications can be drawn from these observations. (1) It appears that the countries of the Middle East are suffering from backward technology and therefore have a poor technical environment which is not conducive to economic development or to the transition to takeoff.

(2) There is a great need to change the conception of technology transfer to diffusion to encourage the idea of adoption and domestication of the techniques and machine making. (3) Large investment will be needed in technology and science in order to acquire the knowledge and the ability to produce technology as dictated by the technology transfer conception. These activities will no doubt be at the expense of other types of expenditure. Therefore the priorities have to be rearranged in favor of science and technology assimilation and long term objectives. Until such changes have been implemented, it would be unreasonable to expect rapid economic development or a transition to takeoff in the near future, regardless of how much they spend on imports of machinery. It is imperative to recognize that economic development in the Middle East or elsewhere is dependent on the technological revolution which is a long way from becoming a reality in the Middle East outside Israel.

(4) There is need to plan on reducing the technological gap between the required level and the level which exists in the countries of the Middle East in a systematic way so as to raise labor productivity, increase per capita incomes, and raise the capacity of the economy for saving and investment. The reduction of

that gap is necessary also to increase the Middle East competitiveness on the international market, and to raise incentives for innovation and technical change.

(5) In other words, a vicious circle is embedded in the existing technological context of development. Without changing this level of technology, the vicious circle will continue to prevail and the Middle East economies will remain dependent and underdeveloped. And as long as they are dependent and underdeveloped, they will not be able to break out of that technological backwardness. The breakthrough must be planned and executed thoroughly and carefully in order to get out of that trap.

FOOTNOTES

(1) Alexander Gerschenkron, ECONOMIC BACKWARDNESS IN HISTORICAL PERSPECTIVE, New York : Praeger, 1962.

(2) Dr. Nadia El-Chichini, «Technological Dependence and Industrialization in Developing Countries, » L'Egypte Contemporaine, Jan. 1981, No. 383, pp. 31 - 43 (Arabic) Ismael Sabri Abdallah, TOWARDS A NEW INTERNATIONAL ECONOMIC ORDER, Cairo : Al Hay'a al Masriya al 'Amah Lilkitab, 1976, pp. 96 - 9, 168 - 9, 176 - 7, and 221 - 8 : Hans Singer, TECHNOLOGIES FOR BASIC NEEDS, ILO 1977; Rutherford M. Poats, TECHNOLOGY FOR DEVELOPING NATIONS : NEW DIRECTIONS FOR U.S. TECHNICAL ASSISTANCE, The Brookings Institution, 1972.

(3) Jennifer Tann and M. J. Breckin «The International Diffusion of the Watt Engine, 1775 - 1825, «**Econ. History Review**, XXXI 4 (1978) p. 546 - 7. For other models of technology transfer see Nathan Rosenberg, «Econ. Development and the Transfer of Technology : Some Historical Perspectives,» **Technology and Culture**, XI (1970), and «The Diffusion of Technology,» **Exploration in Economic History**, X (1973), E. M. Rogers and F. F. Shoemaker, **Communication of Innovation**, 2d ed. 1971.

(4) F. H. Qubain, **Education and Science in the Arab World**, Baltimore, MD : Johns Hopkins Univ. Press, 1966, pp. 83, 230, 260, 316, 492, and 356.

(5) All these were enrolled in national universities. While large numbers were in foreign universities, the data on those studying abroad include graduates and undergraduates in science and other fields, and therefore it is not possible to estimate how many were studying science at level C. It should be noted, however, that Israel, Egypt, Syria and Tunisia discouraged undergraduates and encouraged graduates to go abroad to study.

(6) A. B. Zahlan, «Established Patterns of Technology Acquisition in the Arab World,» in A. B. Zahlan, ed. **Technology Transfer and Change in the Arab World**, Pergamon Press, for the United Nations, 1978, pp. 16-17.

(7) U. S. Congress. House, Science & Tech. Comm., **Technology Transfers to the Middle East O. P. E. C. Nations & Egypt**, Washington U. S. Govt. Printing Office, 1976, p. 1 - 2.

(8) An illustrative summary of the types of technology transfer may be seen in Ibid, various pages.

(9) R. van der Graaf, «The Status of Science and Technology in the Western Asian Region,» in A. B. Zahlan, op. cit., 1978, pp. 52 - 53.

(10) For illustrative data see my «Development and Underdevelopment in the Middle East,» **L'Egypte Contemporaine**, 384, Apr. 1981.

(11) A. B. Zahlan, «The Strategies for the Utilization of High Level Manpower in the Arab Countries, UN, ECWA, 1974, in A. B. Zahlan, op. cit., 1978, esp. pp. 1 - 28.

(12) Gerschenkron, op. cit.

(13) Based on my own field observations.

(14) J. Amuzegar, op. cit., p. 66 for details.

(15) A. B. Zahlan, «Science, Technology and Development,» presented at the Iraqi Physical and Mathematical Society Meetings, Baghdad, Iraq, February 5 - 8, 1979, p. 6.

(16) Harold E. Hoelscher, «Technology Transfer : A Complex Problem Imperfectly Understood,» **Arab Economist**, X, 3, December 1978, p. 15.

(17) Social Aspects of the NIEO in «the Middle East,» in Jorge Lozoya and Hector Cuadra, eds., **Africa, the Middle East and the New International Economic Order**, Pergamon Press, 1980, p. 94. Both the definition and the implications of technology transfer are treated as they relate to the Arab countries in Ismail Sabri Abdalla, «A Keynote and An Overview Paper,» United Nations, Economic Commission for Western Asia. E/ECWA/WG, 16/8, Dec. 1979, esp. pp. 138 - 171; agrees much with Zahlan, op. cit.

(18) Ziauddin Sardar, **Science, Technology, and Development in the Muslim World**, London : Croom Helms, 1977, p. 30 ff.

(19) W. W. Rostow, **The Stages of Economic Growth**, NY : Cambridge University Press, 1960.

(20) According to one observer, the returning graduates are often «alienated» from their own cultures and the research they do is more relevant to the countries in which they had acquired their training rather than to their native countries. A. A. Sabet, «The Role of Science and Technology Policy in Technological Change in Developing Countries,» in A. G. Zahlan, op. cit., 1978, p. 34.

(21) Emphasis on vocational training was apparent in **Education in the Arab Region Viewed from the 1970 Marrakesh Conference**, by M. A. E.-Ghannam, UNESCO, 1971. For more recent efforts in vocational training see **World Higher Education Communique**, Vol. 2 2, 1980.

(22) No doubt the leaders in the Middle East are aware of the problems facing them and they make recommendations and pass resolutions to cope with them, but without committing the resources or initiating the actions prescribed by those recommendations. See, for example, O. A. El-Kholy, «The 1976 CASTARAB Rabat Meeting : A Review,» in A. B. Zahlan, **op. cit.**, 1978, especially p. 150; abbreviations refer to the Conference of Arab Ministers Responsible for the Application of Science and Technology to Development.

(23) O. Grine, «Transfer of Technology in the Arab Steel Industry,» in A. B. Zahlan, **op. cit.**, 1978, pp. 455 - 56.

(24) J. Amuzegar, **Technical Assistance**, **op. cit.**, Chapters 11 and 13 respectively detail the weakness and the lessons to be learned. Similar observations, though less adequately documented have appeared in recent months in Arabic in **Al Ahram Al Iktisadi** in Cairo, Egypt.