Bridging the Knowledge Gap

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Introduction

Knowledge and science are universal activities. Every society, however, has its own problems and its own challenges. An essential feature of knowledge is that it requires human capital for both its production and its application.[1] Although knowledge can be stored indefinitely on paper or discs, it is of little value unless appropriately educated and skilled persons can access and transform this knowledge.

Even then, knowledge is ineffective unless the persons seeking to use it are appropriately organised and supported by suitable institutions and policies. Thus, a knowledge gap between countries may arise because of a variety of reasons, such as:

- A shortage of human capital
- Limited access to recorded knowledge
- An absence or weakness of the organisations necessary to enable human capital to function
- An absence of the vital economic and science policies by which to enable the acquisition, accumulation and application of a particular knowledge,
- An absence of the organisations and/or supporting institutions that provide the necessary legal and financial services.

This conference is primarily concerned with Arab countries. Thus, our first task is to pin-point the causes of the prevailing knowledge gap between Arab and industrial countries; and then to figure out how to bridge this gap.

My paper is organised in three parts:
The first part presents data and analysis through which the nature and extent of the Arab knowledge gap can be pin-pointed.
The second part presents measures that, if adopted, would enable the Arab countries, singly and collectively, to work towards bridging the knowledge gap.
The third part discusses the special case of GCC countries which are undergoing rapid demographic growth and which possess considerable financial resources.

Part I: The Nature of the Arab Knowledge Gap

Knowledge is a complex entity. The indicators that specify the relative standing of countries include: human capital; funding of R&D; number of publications in refereed journals; and number of scientific and engineering workers; the educational system; the number of patents registered annually; the export of products of advanced technologies; and the rate of change of these indicators. In this paper, I will refer to only the first four of these indicators.

[1] The term human capital is used to refer to an “educated person.” Another term in common use today for university graduates is: Highly Skilled Personnel (HSP). Several decades ago, before gender issues became important, the term in use was High Level Manpower.

It is difficult to define the magnitude of those indicators which are associated with specific levels of development. However, there is universal acceptance that certain countries have attained take-off in terms of economic growth. It is, for example, accepted that China and India are in such a state of "take-off". International discourse today is no longer concerned with the under-development of China and India, but rather with when they may be expected to join the club of industrial nations. Thus these two countries provide a useful yardstick with which to compare other countries.

The Organisation of Islamic Countries (OIC) is publishing a volume on scientific activities in all Islamic countries which account for roughly 25% of the world population. The OIC reports that their share of the world's research output during the past decade was roughly 2.5% of world output.[2] The UNESCO Science Report 2005 has an account of science in the Arab world.[3] Additional sources of information will be cited in this paper to enable us to compare and contrast the performance of Arab countries.

Comparative Status of Arab Human Capital

Arab countries emerged from their colonial period with very low levels of human capital. After independence, all Arab states expanded their educational systems dramatically, investing heavily in infrastructure and study abroad. When I was a university student in 1949, there were only 10 universities in the Arab world and some 30,000 university graduates. Since then, over 300 universities have been established and they have graduated an estimated 15 million students. Table 1 shows that enrolment in national universities in the Arab world per million inhabitant was higher than that of either China or India (year 2000).

Research and graduate work in Arab universities, however, are still on a limited scale. Teaching loads are at a high level and research funding (as I will show later) is almost non-existent. As a result, Arabs have continued to depend on study abroad for their post-graduate education. According to UNESCO's latest (1999) statistics, the total number of Arab students enrolled in universities outside the Arab world was 120,602, compared with 106,036 Chinese and 52,932 Indians (Table 1). Clearly, then, there are far more Arabs undertaking foreign study than either Chinese and Indians. About 82% of these Arab students are pursuing post-

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[2] S.T.K Naim and Atta-ur-Rahman (editors), Status of Scientific Research in OIC Member States, COMSTECH, Pakistan, (in press, 2006). The volume includes a chapter on each member country which covers basic information on: population, changes in literacy during past decade, information on the top ten scientific disciplines, areas of scientific research during past five and 10 years, productive universities, names of leading authors by university, number and trends in scientific publication during the past decade, exports and GDP,

[3] UNESCO, UNESCO Science Report 2005, UNESCO 2005.

graduate education in OECD countries. European universities are the major destination of Arab students.

On the basis of rather incomplete UNESCO statistical information, I estimate that 12,000 Arabs earn PhDs abroad annually. I also estimate that 85%, or more, of these do not return home: they brain drain. This is a loss to the Arab world of around 10,000 PhD graduates annually. There are 60,000 to 80,000 Arab PhDs working in the Arab world, compared with an estimated 150,000 abroad.

Of the scientific human capital holding a PhD in the Arab world, only about 10,000 publish one or more scientific paper in a refereed international periodical per annum. Most of the remainder have no opportunity to become research active because of poor working conditions and a lack of R&D funding. I was amazed to find that working conditions for professors in GCC universities are not much better than those in non-oil producing Arab countries.

Doctoral graduates are the most precious human capital. When provided with an enabling environment, they can educate large numbers of additional human capital and much needed intellectual and research output.

China and India are currently considered the champions of rapidly developing countries. They have taken the place of Korea and Taiwan who have now joined the ranks of OECD countries. As we note from Table 1, Arab countries have invested more in education, at home and abroad, than either China or India. Obviously, it is not the amount of human capital that is making China and India the champions of development and the Arab countries slow developers. As we shall note later in greater detail, it is rather the national science and economic policies adopted by Arab states that deprives them of the benefits of their rather substantial human capital.

It is important to note that the Arab brain drain in absolute terms is comparable to that of China and greater than that of India, despite the striking demographic differences.

Table 1: Study Abroad for Arab and Selected Countries

			Population	Study Abroad	Study at home	
Country	1999	1999 Corrected	(1997, m.)	Per million		Per million
ARAB TOTAL	111,854	120,602	253.4	476	3,168,445	12,474
CHINA	95,899	106,036	1,227.0	86	7,364,000	6,002
INDIA	48,348	52,932	962.0	55	9,834,000	10,223

Source: Compiled from UNESCO statistics and others. The second column contains UNESCO data. The third column was obtained by correcting the UNESCO data with EU statistics.

The total number of Arabs who brain-drained to OECD countries by 1999 was 967,548, which is roughly 300,000 more than Indians, and only slightly lower than Chinese. (Table 2)

Table 2 -Number of HSP in OECD Countries, 1999

Country	Total number of Expatriates	% of which are HSP	Number of HSP
Arab World	4,462,391	22	967,548
China	1,928,199	51.9	1,000,735
India	1,649,711	39.6	653,286

Source: Table II.A2.6, SOPEMI 2004, Trends in International Migration Annual Report, OECD, 2004.

On a per capita basis, the Arab brain drain is 4 times greater than that of China; and 5 times that of India. Overall emigration from China and India is 3.6 million compared to 4.5 million from the Arab world. Thus, China and the Arab world export an equal number of HSP. But in terms of total emigration (skilled and semi-skilled, and dependents) the Arab world exceeds China and India combined.

Arab professionals perform very effectively in OECD countries; this is attested to by the continuing brain drain as well as by the prominent positions held by Arab professionals in OECD countries. No comparative surveys of the performance by national groups are available; although there are major differences between different groups, one cannot say that any one group has out-performed another.

Deriving economic growth from human capital depends on the methods utilised during the execution of economic activity and specially investments. Investments made through turnkey contracts that make little provision for technology transfer to national and regional organisations do not generate local employment. They result in a low multiplier factor. If we examine the behaviour of India, China, Korea and others we find that these countries pursue specific patterns and policies which use every activity as a mechanism to acquire and accumulate technology They thus learned to maintain, operate, innovate, upgrade and duplicate all their investments.

This is the main reason for the rapid growth registered by China and India. Their adoption of the requisite science and economic policies has promoted the utilisation and development of national organisations to acquire, accumulate, apply, and adapt technology. Arab countries have not yet adopted similar policies and practices.[4]

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[4] A, B. Zahlan, Science and Technology in the Arab World: Progress without Change, Centre for Arab Unity Studies, Beirut, 1999 (in Arabic) Henceforth, Zahlan (1999)..

Comparative R&D Funding

In Table 3, I summarise some of the comparative data presented in the UNESCO Report. We find that the Arab countries, along with the less developed countries (who happen to be the poorest in the world) allocate the lowest proportion of their GNP to R&D. The GCC countries are amongst the lowest supporters of R&D in the Arab world. The major area where the Arab countries are in deficit in comparison with China and India is in research funding. The Chinese and Indian governments devote (see table 3) far more towards R&D than any Arab government. This is, of course, an important reason why the Arab brain drain is much higher, on a per capita basis, than that of China or India. China spends 10 times more than the Arab countries on R&D per inhabitant; India spends 3 times more.

Comparative Research Output

A useful gauge for assessing scientific activity is to compare research publications in refereed international journals per country and per million population (Table 4). From such comparisons, it can be seen that Arab output increased from 11 publications per million population in 1981 to 33.2 in 2003. The Republic of Korea output was only 6 per million in 1981, it equalised with the Arab world in 1985 and was 13 times larger in 2003. India's output appears to have remained constant at 17 to 19 publications per million over the period 1981-2003; while that of China increased from a low of 1 to 36.1 in 2003. China equalised with the Arab world in 2003.

The Arab countries are at roughly the same level as India and China in R&D output and human capital. China, like Korea before it, is moving very briskly ahead. It is very likely that within a few years, it would have moved far ahead of the Arab world.

Regional and International Co-operation in R&D

International co-operation between scientists and technologists takes many forms. One of the most basic forms of cooperation are the exchanges that take place at

Table 3: Comparative Support for R&D (2002)

Country	Gross Expenditure on R&D, $billion	GERD as % of GDP	GERD per inhabitant, $	Researchers per million inhabitants
World	829.9	1.7	134.4	894.0
Developed countries	645.8	2.3	540.4	3.272.7
Developing Countries	183.6	1.0	42.8	374.3
Less-developed countries	0.5	0.1	0.7	4.5

Arab States Africa	1.2	0.2	6.5	159.4
Arab States Asia	0.6	0.1	6.2	93.5
All Arab States	1.9	0.2	6.4	136.0
Brazil	13.1	1.0	75.0	314.9
China	72.0	1.2	56.2	633.0
India	20.8	0.7	19.8	112.1
Israel	6.1	4.9	922.4	1,395.2

Source: UNESCO, op.cit. Table1, p.4.

scientific meetings: in 1995, for example, about 18,000 scientific meetings whose proceedings were published took place around the world. These meetings provided opportunities for scientists to meet and exchange information.

Scientists based in Arab countries do not have a satisfactory rate of participation in such meetings. They contributed only a total of 200 papers to the 18,000 meetings that were held worldwide in 1995. In other words, the connectivity of Arab scientists with the international community is at a low level.

Table 4: Publications per Million Population

Country	1981	1985	1990	1991	1992	1993	1994	1995	2003
Arab World	11	15	21	21	21	21	24	26	33.2
Brazil	16	19	25	27	31	31	34	42	74.8
China	1	3	7	7	8	8	9	11	36.1
India	17	15	16	17	17	17	18	19	19.4
Republic of Korea	6	15	42	48	58	74	97	144	433
France	496	593	628	627	686	721	768	840	826
Netherlands	567	768	932	920	1009	1098	1166	1252	1,209
Switzerland	1,202	1,406	1,352	1,361	1,525	1,622	1,780	1,878	2,005

Source: Compiled by the author from information at the Institute of Scientific Information, Philadelphia, USA.

Another level of co-operation consists of research collaboration between scientists in two or more countries. I undertook a detailed analysis of Arab scientific output, and discovered that co-operation between Arab scientists is almost non-existent, despite the presence of a number of Arab regional organisations whose objective is to promote such co-operation. Neither national nor regional Arab organisations devote serious resources to promote co-operation.

The Arab countries share a wide range of common scientific and technical problems. Thus there are considerable incentives for co-operation. Most of the Arab world is in a dry zone where water is scarce; this dictates certain research issues in water use, in agriculture, and in water management. Likewise, several

Arab countries are oil and gas producers; this provides common technological challenges and opportunities for sharing experiences. Moreover, they all share a number of problems, in health, in the application of codes and standards, and many others.

Scientists in GCC universities published 1,722 papers in 1990 and 2,716 in 1995. Of these, one quarter were co-authored with scientists in non-Arab institutions. In 1990, collaboration within the GCC was only 2.7% of all co-authored papers; this increased to 6% in 1995.[5]

Scientists in the Maghreb exhibit a high level of international collaboration, but only a very low level of regional collaboration. The level of international collaboration in four Maghreb countries underwent some changes between 1990 and 1995: Algerian collaboration fell from 80% of all publications to 69%; Libya increased from 31% to 60%, Morocco from 64% to 74%, and Tunisia from 29% to 64%. The average rate of international collaboration for the Maghreb increased from 54% to 64% during this period.

Scientists in Algeria, Morocco and Tunisia published a total of 1,264 papers in 1995; of these, some 804 were co-authored with scientists outside their own countries. Very surprisingly, only 11 of the 804 publications involved scientists from two Maghreb countries. Of these 11, only <u>one</u> paper was conducted by Maghreb scientists. Regional collaboration is thus exceedingly meagre.

The rate of international co-authorship in the Mashreq countries is close to the world-wide average of 25%. Co-operation within the Mashreq is very limited.

Arab Science and Technology Systems

The crisis in Arab development arises from the fact that Arab countries are not receiving the returns normally expected from their investments in human resources, R&D and GFCF. This is largely due to the underdeveloped condition of their national science and technology systems (S&T-System).

The S&T-System consists of a complex, knowledge-intensive system of organisations and institutions. An important function of the S&T-System is to produce, accumulate, acquire, diffuse and convert knowledge into useful and desired outputs.

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[5] Detailed information on R&D regional and international collaboration is provided in Zahlan (1999).

The quality and efficiency of the connectivities that link the various components of the S&T-System are as critical as the components themselves. In other words, the components are of little benefit without the associated connections.[6]

A factor impeding the formation of connectivities is the prevailing national economic and science policies combined with the weaknesses of Arab professional societies and scientific associations, and the lack of funding to support travel of Arab scientists to participate in national and international scientific conferences and activities.

The extent of articulation of the skills, education and management of labour with the S&T-System determines labour productivity and the ability to acquire and accumulate new technologies. A concern with labour productivity and performance is central to the competitiveness of a nation's economy.

In 1970, the Arab states were close to European and Japanese levels of labour productivity. It is interesting to note that the decline took place after the first oil boom in 1974, after "an investment" of $2,000 billion in GFCF by 1992, and after a massive expansion in educational systems at all levels.[7]

The declining performance of Arab labour is a unique phenomenon. It is related to the increasing dependence on turnkey and client-in-hand forms of contracting which have grown alongside the increasing numbers of professionals and financial resources! This illustrates the lack of integration between education, the economy and the labour market.

It is clear then that increasing the expenditure on higher education under present conditions will not improve economic performance. It will merely increase the brain drain. Any Arab country wishing to modernise will need first to urgently address its S&T-System.

Very briefly, the main barriers to the development of an effective S&T-System in the Arab countries are:

- Public sector policies of pursuing technology-free turnkey contracts with international Consulting Engineering Design Organisations (CEDOs), with limited attention paid to the acquisition of knowledge;

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[6] These issues are discussed at length in: A. B. Zahlan, The Arab Construction Industry, Croom Helm, London, 1983; also published in Arabic by the Centre for Arab Unity Studies, Beirut, 1983; A. B. Zahlan , Acquiring Technological Capacity: A Study of Arab Consulting and Contracting Firms, Macmillan, London, 1990; also published in Arabic by Centre for Arab Unity Studies (CAUS), Beirut, 1990; and Zahlan (1999).

[7] A. B. Zahlan, "Labour Productivity and Competition," Al-Mustaqbal al-Arabi, no 2, pp 98-112, 1994;

- The vertical integration of major national industrial firms and their heavy dependence on international Industry Related Services suppliers, thereby giving little attention to national and regional organisations;
- The limited adoption of out-sourcing and sub-contracting by parastatals and private firms;
- The weaknesses of national and regional professional and scientific societies;
- The limited efforts to un-package technology and undertake reverse engineering;
- The very limited number of science policy studies undertaken in the region;
- The limited number of science and technology parks around universities and technical schools to promote technology transfer to small and medium enterprises;
- The poor quality of statistical and technical information services;[8]
- The low level of incentives to encourage innovation;
- The low level of mechanisms to promote the diffusion of best practice;
- The limited attention paid to the promotion of competition;
- The low level of concern for labour productivity and quality control.[9]

Part II: Measures to Bridge the Knowledge Gap

It has been noted in Part I above that Arab human capital, R&D capabilities, financial and natural resources are equal to, or higher than, those of China or India on a per capita basis. Yet the performance of the Arab countries is inferior to them. The reform of existing policies cannot take place without a thorough understanding of the causes for the poor comparative performance of Arab countries.

Studies of Arab technology behaviour indicate the lack of essential science and economic policies to allow them to benefit from available assets. In other words, the knowledge gap does not arise from a shortage of human or financial capital or natural resources, but rather from the inadequacy of vital policies.

The adoption of appropriate economic and science policies would promote the bridging of the knowledge gap. In other words, socio-economic progress may be achieved through improving the utilisation of available brainpower, rather than by making additional investments in human and physical capital. What it means is that, currently, there is an abundance of under-utilised human capital and until these resources are mobilised increasing them will only lead to brain drain.

Methods for Overcoming Existing Difficulties

Fortunately there are numerous methods for improving the management of existing human capital and for introducing appropriate science policies. The fastest

[8] There are of course some exceptions to this.
[9] There has been some effort in several Arab countries to improve standards and quality control.

and least expensive method would be to sponsor “summer schools” in science policy, targeting senior staff in the private and public sectors. Here the objective would be to provide advanced and focused knowledge to experienced officials. A wide range of government programmes and policies can be upgraded since we already know a great deal, from worldwide experience, of the measures that need to be adopted. It is assumed that senior officials would have the know-how to adapt these policies to the prevailing system.

A second important measure that would contribute to bridging the knowledge gap would be independent research in science policy at universities and research institutes. Such independent research is essential to develop an expertise in science policy, to evaluate the measures taken, and to assess the difficulties encountered. The cost of these two measures is insignificant when compared with the benefits.

A third measure would be to encourage (and or direct) national financial organisations to adopt standard financial services that would serve the needs of consulting, contracting, and industrial firms. Financial organisations (in the private and public sectors) would learn the appropriate methods for undertaking these tasks profitably and with minimum risk. Once again, the know-how is available. This service would be very profitable.

A fourth measure, one of considerable long term importance, would involve increasing the funding for R&D at an annual rate of 25% until it reaches 1% of GNP; after that, to continue to increase support for R&D at an annual rate of 10% until the 3% level is reached.

A fifth measure is essential to increasing employment and reducing cost: this is the training and certification of the labour force. The objectives of this measure would be to increase labour skills and productivity in technologies which are in high demand; and to increase their mobility.

Reflections on Sequencing and Priorities

To make this discussion more concrete, I will present a few illustrative examples. Needless to say, all countries have different priorities.

The first measures that need to be adopted would be those leading to rapid economic growth and to an increase in public revenue. The construction industry is the largest economic activity in the Arab world. The wealthier the country, the larger its construction sector.

Some $150 to $200 billion are devoted annually to all types of construction (civil, military and industrial). It is estimated that more than 70% of this is spent outside the Arab economies on imports of labour, technical services (consulting and contracting), supplies and equipment, and financial services.[10] At present, Arab industries provide only 20% of the supplies used in construction.

Consulting and contracting organisations are basic instruments for converting investments in education and R&D into economic benefits. Thus measures that would enable the Arab consulting and contracting industry to increase its market share should have the highest priority. This would entail increasing the ability to compete with international contractors in the home markets. The measures include financial services, an efficient legal, labour training and certification, accurate and efficient statistical and information services on the construction industry. The cost of such measures is estimated to be less than a few percentage points of the increase in annual revenue.

The economic impact of such measures would be dramatic: the creation of some 12 to 15 million jobs; the dramatic increase of Arab GNP through the multiplier effect (around $200 billion has been estimated); and the expansion of industries which supply construction supplies.

Currently the linkages between contracting and consulting firms, professional organisations, universities and Arab human resources are weak to non-existent.[11]

Outsourcing

The Arab world is the world's largest exporter of oil and phosphates; it is also a major producer of cement and textiles. These industries provide an enormous internal market for a vast range of technical services, products and supplies. Considerable technological expertise is locked into major Arab industrial firms, such as oil companies; phosphate, desalination, airlines and cement industries and many others. Outsourcing some or all of their technological expertise could be undertaken to the mutual benefit of the major industrial firms, the outsourced services and the economy.

Such outsourcing should provide strong opportunities for the pursuit of international sub-contracting by small firms. A country does not need to manufacture an entire car to have a stake in the automobile industry. On a national scale, the annual cost of car maintenance (including spare parts) exceeds the annual investment in new cars. The capital and know-how required to manufacture car parts are less demanding and risky than making an entire car.

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[10] The lack of adequate policies to promote technology transfer are discussed in: A. B. Zahlan, The Arab Construction Industry, Croom Helm, London, 1984; and in Acquiring Technological Capacity: A Study of Arab Consulting and Contracting Firms, Macmillan, London, 1991.

[11] *Imad Mustafa,* "Organizational Context of Knowledge Acquisition, Transfer, Management and Localization of Technology," background paper prepared for AHDR 2003, 2002. (np)

Hobday shows how Newly Industrialising Countries (NICs) in Asia progressed through various stages of subcontracting, licensing, own design manufacturing and finally launching own brand manufacturing.[12] The major industrial output of NICs is performed under sub-contracting arrangements. It is easier to manufacture under sub-contracting arrangements than to market under own label.

Sub-contracting involves less risk than embarking on initiating a new industry single-handedly. It provides a "ladder" for the entrepreneur to climb at his own pace. The more innovative the entrepreneur, the faster the pace of development.

Outsourcing and sub-contracting facilitate technology transfer because they reduce the size of each transfer and eliminate the need to acquire large-scale technological capabilities in one stroke.

Judging from international experience, the adoption of positive policies towards outsourcing in the Arab world could make a dramatic contribution to the development of forward and backward linkages. It would also be self-financing: the programme would contribute to economic growth and pay for itself.

Available Human Capital

Arab countries have substantial numbers of highly educated and research-competent university professors. Some schools of engineering employ up to 1,000 professors each. Scientists and engineers are capable of learning new technologies very quickly. There have been no systematic efforts to benefit from such capabilities. Funding could be provided to universities and research centres to enable them to assess their staff in relation to current technological requirements. These assessments could also recommend ways and means to make their organisational capabilities available.

Funding Scientific Meetings

The paucity of scientific cooperation and collaboration between scientists in the Arab world is a major obstacle to benefiting from available human capital. Scientific meetings provide a low-cost mechanism to effect exchanges between professionals. An increase in the funding of scientific conferences in the Arab would enable scientists to network more effectively.

Information Communication Technology (ICT)

Arab countries lag behind other nations in developing their ICT sectors. Yet they are purchasing a wide range of ICT services and hardware for their military, telecommunications, TV and radio services, industries, government departments, airlines, banks, airports, etc Most of these ICT purchases are hidden components of large contracts.

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[12] Michael Hobday, Innovation in East Asia, Edward Elgar, London, 1995.

A concerted effort to un-package the ICT components of contracts would promote local participation in technology transfer and innovation in this vital domain. Many Arab universities have departments of computer science, and their professors should be encouraged to participate in this process of un-packaging.

Health and Medical Research

Medical and pharmaceutical research is of critical importance. It is a well known fact that 90% of scientific research in the world is undertaken to meet the needs of rich countries. Large numbers of diseases afflicting the Arab, Islamic and Third Worlds receive very little attention. Many diseases that are endemic to the Third World do not attract the attention of international pharmaceutical companies because of the low expected profits.

Some 40% of Arab R&D is in medicine. There is therefore substantial medical know-how in the region. Despite the high level of clinical and pharmacological expertise available, these regions lack the capabilities to organise and mange their medical R&D effectively. Many efforts are fragmented and often go to waste.

Moreover, the tradition of first-cousin marriages is still fairly strong; inter-family marriages lead to a profusion of genetic disorders and diseases. Medical research would facilitate the isolation of the responsible genes and contribute to the development of cures.

It should be feasible for Arab governments and Arab pharmaceutical companies to plan and organise an R&D health programme with a view to mobilising and focusing existing activities.

The Private-Public Interface

All economic activities involve the private and public sectors in a complementary manner. The combination of a colonial past, underdevelopment and the tradition of extensive utilisation of the turnkey contract have distorted the interface between the Arab private and public sectors. Considerable attention to this interface would enable them to overcome many difficulties.

Economic activity is essentially competitive. National organisations and companies in developing countries are at a great disadvantage when competing with firms from industrial countries since they lack almost every support system that is available to international firms. The enabling infrastructure is heavily dependent on public policy in the domains of finance, information, R&D, scientific societies and associations, standards, legal system, and so on. A considerable of science policy research is needed to normalise the relationships between the private and public sectors.

Part III: The Special Case Of Rapidly Growing Countries Possessing Considerable Financial Resources

It is always easier to solve problems as they arise. For example, the population of Egypt was around 3 million in 1800. During most of the 19th century, Egypt suffered from a shortage of labour and a surplus of land and water. It failed to address and solve these problems when it was easy to do so. The problem mushroomed during the second half of the 20th century and has become enormously more difficult and complex; it has also become endemic.

Japan, by contrast, has sought to avoid problems by studying other countries. It has opted against immigration, and has relied instead on exporting its manufacturing plants; it has thus avoided having to import labour. This is not a new policy; the Phoenicians pursued similar policies in the first millennium BC, always seeking to sub-contract and outsource.

The GCC countries had tiny populations until the 1950s, since when they have grown dramatically. The national population of the GCC is forecasted to reach around 50 million by 2050. Such a large population should seek to be fully knowledge-based in order to remain economically independent by the end of the oil and gas abundance towards the end of the 21st century.

Obviously, even within the GCC different countries need to pursue different types of policies. But in order to make the most of their resources and capabilities, the GCC countries will need to cooperate closely.

Two parallel challenges have to be addressed by GCC countries.

The first and easy challenge is to acquire the advantages of the modern world at a minimal cost. The GCC can afford to purchase all necessary services and supplies. But in doing so they could miss the opportunity of acquiring the knowledge implied in the provision of these products and services. The adoption of turnkey policies would provide the people of these countries with the benefits without acquiring the associated knowledge.

The implication of such a pattern is that the societies will be shaped by the process of acquisition and the characteristics of the products rather than by the moulding of knowledge to yield products optimally designed to serve GCC requirements.

All Arab countries are being moulded by the large-scale acquisition of imported technologies. For example, the types of transport systems invented in industrialised countries resulting in a Western type of cities and living space. Arab countries have missed the opportunity to innovate and invent a type of city that may be more suitable for the climatic and environmental conditions that prevail in their region. We cannot tell whether this could have been achieved; only actual experimentation and creative innovation at the highest level could inform us of such a possibility. The same applies to many other social and economic activities.

I would like to illustrate this point further by providing two examples. The GCC countries currently contribute substantially to the GDP of the Arab world. They all fall in the arid zone. They all have imported labour and technologies to develop some agricultural activities in their countries and at the same time they are all major importers of food products.

The GCC countries could develop policies to optimise agricultural activity at home consistent with sound economic principle and employment needs of the national population. Obviously, the output of local agricultural production will not suffice to meet national requirements. Investors from the GCC have already become major producers of meat and other products in many countries. These initial efforts could be expanded profitably in developing countries and could be designed to reduce poverty and diffuse good will. Such efforts will need powerful capabilities in science and technology as well as in finance and management.

In other words, private and public investors in the GCC could, while serving national needs, develop organisational capabilities to manage world-class agricultural companies. These companies would be based in countries with generous supplies of labour and natural resources.

Another example that may be highlighted is the intensification of current efforts: to project globally the financial resources of the GCC. The trillions of dollars possessed by the private and public sectors of the GCC countries can provide major resources for both employment and income for the post-oil period.

Fifty years from now the major employer in GCC countries could very well be financial organisations. But to achieve such a state of affairs effort has to begin today by establishing innovative and secure financial services. Though some of these services may be learnt from existing firms; others may have to be created for the 21st century to suit the needs of the Third World that is very poorly served by financial organisations.

Naturally, all of these activities imply managing national resources on the political, economic and technological levels on an international scale. Discovering the most sensible approaches will require the widest national participation in research and reflection on the issues at hand. The wider the national debate on the cultural and technological opportunities the better the adopted solutions.

World class learning and research organisations are needed to facilitate the search for long-term solutions. Establishing such organisations will not be a simple matter since these will have to be capable of handling creatively the major areas of politics, economics, science and technology. This will require capabilities in research and scholarship at the highest level.

Science policy research provides a powerful tool for developing, applying and monitoring the range of measures needed. Furthermore, it is an inter-disciplinary skill that can be undertaken by a wide variety of professionals such as scientists, economists, engineers, medical personnel, sociologists, etc. Science policy research also requires an in-depth acquaintance with global development and is strongly rooted in national culture.

Clearly, then, bridging the gap would be relatively simple and straightforward. The required effort is low in cost and would contribute immensely to national well-being, self-reliance, and prosperity.